Surgical Life
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Number 60

A Message from the President

Mr Neil Welch

Freedom day! As I'm writing this, we have been promised that national mandatory COVID19 lockdown rules will end on 19th July, and later that those who are doubly vaccinated and without symptoms will not have to isolate and may be able to go on holiday – or maybe not. I think most of us are unable to predict what will happen nationally, but in the NHS we are seeing a slow restart of activity just as everyone is taking their delayed but well earnt breaks. The NHS waiting list gets bigger every time I look at it, our workforce shortages have become more obvious, and patient expectations are being raised by government.

However, ASGBI has had an exciting year so far. The virtual 2021 Congress in May was a great success.   Christian Macutkiewicz, the Director of the Scientific Programme, put together a great and varied programme and I hope you all experienced a great educational event, that you can still catch up with on the congress platform until November. We will then migrate the recordings to the members area of the website for future access. Your Board learnt a lot from this experience, and there are elements that can be used in the future face to face Congress which we are planning to hold in Liverpool ACC May 3-5th "Reset and Recharge". Please reserve the dates in your diary. As usual special offers will be available for early bookings and the planning of the programme has already started!

Our webinar series has continued with some fascinating and well attended webinars available free to members and we are incredibly grateful to our sponsors

Many of your directors have been involved with these but special mention to Sonia Lockwood and Gill Tierney with Siong Liau for all their effort. We have showcased a wealth of talent and wisdom and continue to do so. If you have not yet attended one, then please check out the website for a list of upcoming events. As a member you can view the recordings of past webinars through the members area of the website.

The annual Emergency General Surgery conference led by your Director of Emergency Surgery Sonia Lockwood, will be held virtually on Wednesday 29th Sept and the topic "Surgery in the Developed World, Developing World and Real World" is enticing and the programme is great. This is free to members so I do hope you can find time to join us.

During the last 6 months Susan Moug h,as been developing her research portfolio and the future looks very exciting, with some seed corn grants from GUTS UK, and a diverse, enthusiastic and experienced research committee to help drive this agenda forward. This is complimented by the involvement of our recently formed trainee group the Moynihan Academy which has a comprehensive action plan for the next year, including a training and education aimed at trainees, supported by our Director of Education and Training Chris Lewis.

For those with long memories, you will recall that ASGBI changed from a Charity to a Limited company in 2009. This meant that ASGBI charity was left as an organisation although most of the work of the Association shifted to the ASGBI Ltd. ASGBI charity was named "The Surgical Foundation" (TSF) and this became a standalone organisation but has remained as ASGBI Ltd.'s charitable arm. The TSF provides international bursaries and education and training opportunities presently in sub-Saharan Africa. The Trustees have been concerned that the TSF needs re-invigorating and as part of this drive we are completely overhauling the Memorandum of Understanding and the Articles of Association so that it reflects what it now is and not what it was before 2009. Part of this change will involve a change of name from The Surgical Foundation back to ASGBI Charity because this seems to be a better brand to use to seek more donations. I hope that these will be accepted by our membership at ASGBI Ltd AGM on 20th July and the Trustees can continue with their plans.

ASGBI Ltd. is also making some minor changes to its own "Mem & Arts" mainly related to changing to gender-neutral terminology. The Executive Board is also considering what changes should be made to reduce any barriers to application from our diverse membership and it is likely that we will be holding a separate Extraordinary AGM later in the year to present our suggestions to the membership. Nuha Yassin, your Director of Inclusivity and Diversity, with her new committee, has been heavily involved with the issues around EDI. Working with sibling organisations we have responded to the Kennedy report from RCSEng, and are working to make sure ASGBI is open to all, and members are valued and respected.

I'm delighted to report that our financial situation is much improved, due to the hard work of all Directors led by Siong Liau your Director of Finance. I am very grateful to all our Strategic Business partners some of whom have been supporting ASGBI for many years, and some are more recent. The most recent collaborative partner is Incision, the creators of Incision Academy with an online library of over 500 video training courses on common surgical procedures to enhance and complement training opportunities for our members.

Part of the improvement in the financial situation is the increase in membership over the last 18 months and I'm delighted that ASGBI is appealing to so many new colleagues. I welcome you all.

ASGBI Executive Board Directors work hard on behalf of your organisation, and we welcome feedback. The surveys we put out are there to inform our decisions so please take a few minutes to complete them.

I'm pleased to welcome Ravi Vohra as our latest Executive Director. For the last 6 months he has been working with Vassilios Papalois your Director of Communications, and they have now divided the roles between them, so Vasilios concentrates on the publications, including Surgical Life and ASGBI Surgery, and Ravi on the media and engagement communications. Ravi is a general and OG surgeon and I am happy he has decided to give ASGBI his time and energy.

We have two ASGBI Leads coming to the end of their term of office. Gordon Carlson demits at the AGM on 20th July this year and my enormous thanks for his time on ASGBI Executive as Director of the Scientific Programme and then Lead for Medical-Legal. We will be advertising for a new Lead in Medico-Legal in the future so if this interests you then please get in contact. Euan Dickson will come to the end of his 4 years as ASGBI Lead for Major Trauma later in the year, and I thank him for the work he has done for ASGBI. Likewise, we will be re-advertising this role.

One of the pleasures of being President is being involved in the awarding of Honorary Fellowships of ASGBI. This year at the AGM we awarded 2 such fellowships. Julio Mayol has been a great supporter of ASGBI having been a Guest Editor of ASGBI Surgical Life, ASGBI BJS Lecturer and Secretary of the BJS Society with which ASGBI has had long-term historical links. Raghu Ram Pillarisetti has been a fellow since a trainee in the UK and has been President of our affiliated organisation the Association of Surgeons of India, fostering the relationship between our 2 organisations. I am delighted to welcome them both to our list of distinguished Honorary Fellows.

ASGBI Executive is ably supported by our secretariat without whom we would not be able to deliver so much for our members. Bhav as General Manager is a lynch pin of our organisation. I would like to extend my thanks to them all for their work on your behalf.

ASGBI's future is bright, and exciting. I look forward to seeing you all face to face when this is achievable.

Best Wishes

Mr Neil Welch
President, ASGBI

June 2021

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A Letter from the Editor

Professor Vassilios Papalois, ASGBI Director of Communications

Dear Colleagues, Dear Friends,

Welcome to the summer 2021 issue of ASGBI Surgical Life!

We all enjoyed a most successful virtual 2021 ASGBI Congress and we hope that you had some rest over the summer. It is difficult to say how things are going to evolve with the COVID 19 pandemic but one can sense an intention and see all sorts of efforts to design the "new normal" by implementing the lessons we learned and we will continue to learn from this massive challenge.

A most moving obituary for Sir Patrick Forrest (former President of the ASGBI) by Sir Barry Jackson (also one of our prominent former Presidents) gives a strong opening to the issue and reminds us the wise quote often attributed to Isaac Newton: "We look tall only because we stand on the shoulders of giants!"

As it is always the case for the summer issue, the first major section has some most insightful articles that reflect on the content and the discussions that took place at our last Congress. The articles analyse topics related to the use of innovative technology in modern surgery, challenges in day to day surgical practice, projects focusing on improving clinical pathways and offer quality assurance, the importance of international collaborations and the effect of the pandemic on our professional life and practice.

I will then draw your attention to another superb Guest Editor Section. For this issue, our Guest Editor is Professor George Tsoulfas who is Chair of the Department of Transplantation Surgery of the Aristotle Univeristy of Thessaloniki, World President of the International College of Surgeons and Chair of the International Relations Committee of the American College of Surgeons. Professor Tsoulfas along with a team of esteemed authors from Greece, Europe (including the UK!) and the USA, put together 17 top class articles presenting their perspective related to challenges and opportunities in modern surgical practice. The current Guest Editor Section is a most successful continuation of the one in our previous issue which was led by Lord Ara Darzi and demonstrates most clearly that things around us are changing rapidly and we need to see future surgery and surgical practice under a completely different prism. Professor Tsoulfas and his co-authors have my most grateful thanks for their superb contributions to this issue.

We have now accumulated over the last 4 ½ years some amazing material from the Guest Editor section. It is our plan to get those articles together in an updated electronic publication.

The current issue continues with the fascinating story of Dr Suhaila Siddiq, a prominent female surgeon in Afghanistan and champion of women's rights, and a feast of photographic art by surgical colleagues and concludes with the most insightful CORESS feedback.

I am also delighted to say that, following open advertisement and robust selection process, we have now an enhanced Editorial Board for the publications of the ASGBI. The first meeting of the new team has already taken place and they are some very exciting new initiatives coming soon that will take our publications portfolio to the next level.

I would like to emphasize as always that the publications of the ASGBI are open for contributions by all members of our historic Association and by the broader surgical community and they aim to serve as vehicles that allow colleagues to present their views, challenges, achievements and aspirations, connect, build bridges and learn from each other.

The editorial team is always open to your suggestions, keen to have your submissions and ready to support you all the way to publication.

My most grateful thanks to all the authors of the summer 2021 issue of the ASGBI Surgical Life and to Ms Vicki Grant, our Communications and Events Manager, for her great work for this issue and for our whole publications portfolio.

Enjoy reading!

Sir Patrick Forrest

Professor Sir Andrew Patrick McEwen Forrest (always known to his friends as Pat), internationally known for his signal contributions to breast cancer and breast cancer screening, died on August 7th aged 98. In 1988, he became the 67th President of the Association.

Born in Glasgow and educated at the High School of Dundee, he studied medicine at the University of St Andrews qualifying in 1945. After national service as a medical officer in the Royal Navy, he spent a year in Rochester, Minnesota as a Mayo Foundation Fellow. In 1954, he became a lecturer and then senior lecturer in surgery at the University of Glasgow during which time he obtained the ChM University of St Andrew's in 1954 and in 1958 the MD, both with honours and gold medal. He was appointed to the Chair of Surgery at the Welsh National School of Medicine in 1962 with honorary consultancy at the Cardiff Royal Infirmary. In 1971, he was appointed by the University of Edinburgh to the Regius Chair of Clinical Surgery, a position he held until his retirement.

During his distinguished career, Pat held many high offices including Chief Scientist to the Scottish Department of Home and Health, Civilian Consultant Surgeon to the Royal Navy, Chairman of the Scottish Cancer Foundation, President of the Surgical Research Society and Chairman of the Department of Health working group on the implementation of the NHS Programme on breast cancer screening. He was elected a fellow of The Royal Society of Edinburgh in 1976 and was the recipient of many honorary fellowships and university degrees. The author of over 250 peer reviewed articles, mainly on breast cancer, he was awarded the Lister Medal in 1987 in recognition of his outstanding contribution to surgical science, particularly in the field of breast cancer. He received the Umberto Veronesi Award for the Future Fight Against Breast Cancer in 2000. He was knighted in 1986.

Pat first became associated with ASGBI in 1971 when he was elected to Council serving for three years but it was during his presidential year 1988/9 when he made his major contributions to the Association holding an outstanding annual meeting in Edinburgh and a smaller but equally successful overseas meeting in Amsterdam held jointly with the Association of Surgeons of the Netherlands. He was one of the first surgeons to formally recognise the rise of specialism within general surgery and the concomitant importance of the specialist associations. He therefore ensured that in the Edinburgh meeting there were parallel sessions specifically devoted to vascular, upper GI, lower GI, hepatobiliary and breast surgery as well as plenary guest lectures by distinguished experts in their field. Similarly, he was early to recognise that the four Surgical Colleges needed to change their examination structures to accommodate the increased specialism within general surgery and counselled the Association membership on its views. He also recognised that as the Association grew in size the time was fast approaching when the tradition of the President hosting the annual meeting in their home town would need to be replaced by the use of professional conference centres. He initiated the discussions which two years later led to the first meeting to be held in a conference centre (in Jersey).

Pat was gregarious, easy to be with, a man without side or pretence and a generous host. Sadly, he lived for many of his retirement years with the side effects of a stroke but bore his affliction with stoicism.

Sir Barry Jackson

ASGBI 2021 Annual Congress feedback and prospects for "Reset and Recharge"

Director of the Scientific Programme, Mr Christian Macutkiewicz

Future Surgery REBOOT
ASGBI VIRTUAL CONGRESS 2021
4TH - 8TH MAY 2021

The 2021 Annual Congress was fully virtual, something that has never happened in the history of the association. To say we were nervous is an understatement, which is why it was such a relief when over 900 delegates registered for the congress, with 849 abstracts presented, and over 500 delegates providing feedback on their experience.

The 2021 congress was organised with the theme of "Future Surgery - Reboot" in mind. The content of the congress featured symposia on trainee matters, patient matter and innovation. The symposia on robotics, incisional hernia surgery, human factors and resilience, and "Bad Day On Call" were very popular. The impact of COVID-19 on surgical practice was discussed with fantastic talks from the COVID-19 research collaboratives. For the first time ever in an ASGBI congress, the final day was dedicated to trainees and we had the launch of the ASGBI Moynihan Academy with the introduction of the inaugural committee.

The congress day started with some pointers to forthcoming talks by Rupert the Bulldog, our congress mascot, and then to keep everyone from having bad backs, Dr Divya Sivaramakrishnan took us all through 30 minutes of yoga. The short paper sessions were very well attended with good questions from the audience and had tremendous feedback from the delegates.

The overall feedback was very positive, with over 93% of responders rating the programme good or excellent, and 94.8% rating the event platform as good or excellent. Not surprisingly, the biggest failing was the lack of networking, with 35% of responders rating the event as neutral to very poor for networking. The feedback on the choice of topics was very good, although there were many comments that there was "too much COVID" present in the programme, I guess that's a reflection of the times we were under, and hopefully there will be very little COVID-19 for the 2022 congress.

So, the theme for the ASGBI 2022 congress is "Reset and Recharge", and reflects the need to address the stress, burnout and burgeoning waiting lists that have grown over the last year. We will be continuing the emphasis on robotics and innovation but also addressing the more common conditions we all face as general surgeons. The importance of training and looking after our trainees will be at the forefront, as well as new prizes and symposia from the Research Committee. I hope that 2022 will also signal the return to a face-to-face congress but with a virtual element to it as many attendees felt a hybrid approach would be beneficial. I hope we can make 2022 a very special congress.

Delivery of care in limited resource setting

Dr. Raghu Ram Pillarisetti OBE
MS, FRCS (Eng), FRCS (Edin), FRCS (Glasg), FRCS (Irel), FACS,
Hon. FRCS (Thailand), Hon. FCSSL (Sri Lanka), Hon. FCCS (China)

Padma Shri conferred by Hon'ble President of India (2015)
Dr.B.C.Roy award conferred by Hon'ble President of India (2016)
Officer of the Most Excellent Order of British Empire (2021)

Founder, CEO & Director, Ushalakshmi Breast Cancer Foundation, Hyderabad, India
www.ubf.org.in

Founding Director, KIMS-USHALAKSHMI Centre for Breast Diseases, Hyderabad, India
www.breastcancerindia.org

Immediate Past President, The Association of Surgeons of India
www.asiindia.org

Introduction

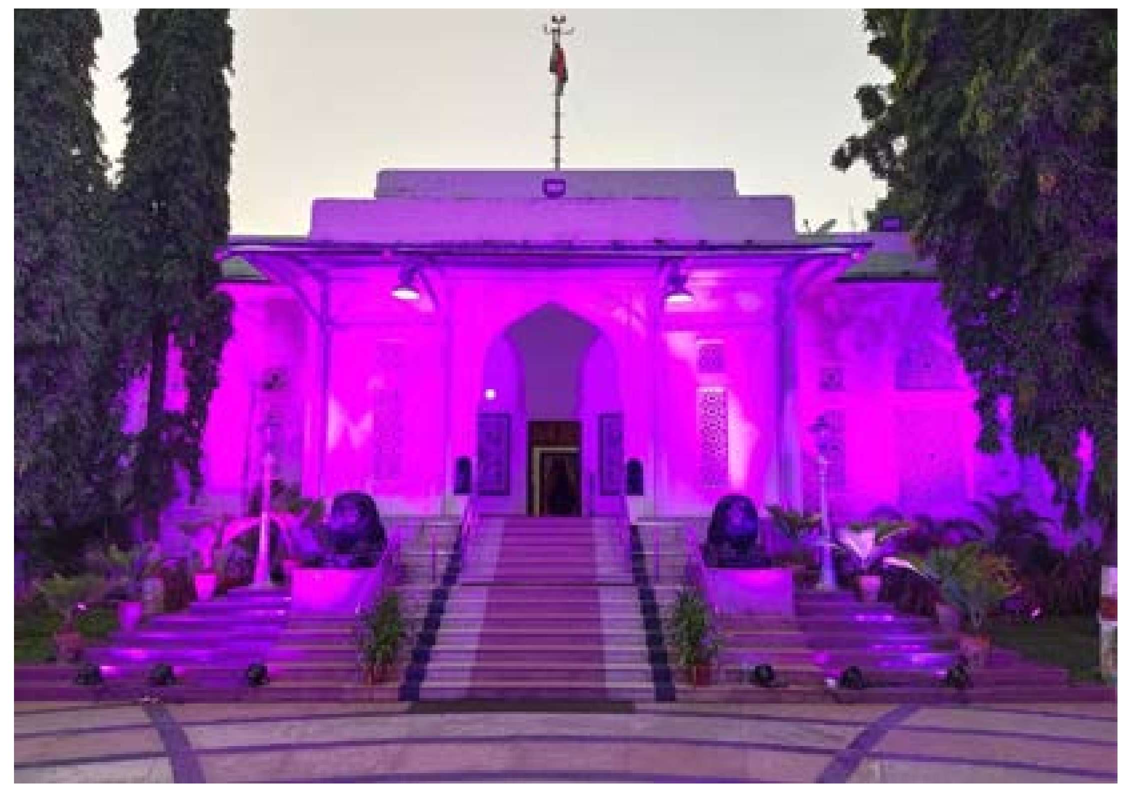
With some 165, 000 new cases being diagnosed every year, breast cancer is the most common cancer affecting women in India. What is more alarming is that it is being increasingly diagnosed at a younger age (a decade earlier) in India when compared to the West. With 87, 000 deaths per annum, tragically, a woman loses her life to breast cancer every ten minutes in India. Due to lack of awareness & absence of an organized population based Screening Programme, more than 60% present in the advanced stages, and as a consequence, majority succumb to the disease within a year of being diagnosed.

Some of the innovative initiatives championed in a resource limited setting with an earnest endeavor to improve breast healthcare in India have been highlighted.The full presentation @ ASGBI virtual Congress can be accessed from the Link: https://www.youtube.com/watch?v=ET-QRmXWzeA

Breast Cancer advocacy

The innovative "PINK RIBBON CAMPAIGN" was launched in 2007 under the auspices of Ushalakshmi Breast Cancer Foundation (www.ubf.org.in), which is a 'not for profit' breast cancer Charity. Over the past 14 years, the Foundation (which bears my mother's name who 'conquered' breast cancer) has been working with missionary zeal to create the much-needed awareness about the importance of "Early Detection" through a number of unique initiatives in the southern Indian States of Telangana and Andhra Pradesh.

Glimpses from the annual Pink Ribbon Walks held in major cities & towns in Telangana & Andhra Pradesh - Hyderabad, Warangal, Vijayawada and Visakhapatnam in October- International Breast Cancer Awareness month (2008 – 2019).



Paint the City Pink Campaign - Charminar, Buddha statue, Legislative Assembly, United States of America Consulate, Raj Bhavan & many other prominent buildings in Hyderabad are illuminated annually in PINK during International Breast Cancer Awareness month (2010 – 2020).

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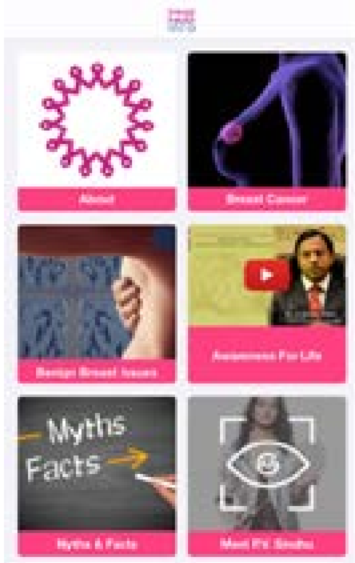

ABCs of Breast Health
World's first mobile app on Breast health launched by Mr. Amitabh Bachchan (2017) in English & 11 commonly spoken Indian languages (Hindi, Marathi, Gujarati, Punjabi, Bengali, Telugu, Tamil, Kannada, Malayalam, Oriya & Assamese).
This App, which is freely downloadable in both Apple and Google Play Store, aims to digitally empower people, particularly in rural India about every aspect of breast health in simple easy to understand format.

Links for free download

https://apps.apple.com/us/app/abcs-of-breast-health/id1482487468
https://play.google.com/store/apps/details?id=devatech.kims.avantari

Population based Breast Cancer Screening Programme

Mammography is not a viable option for population-based screening in India. Reasons are enormous costs, early age at diagnosis, huge variation in mammographic reporting and quality assurance issues. To ensure early detection and explore an 'Indian solution' that would save many lives, particularly in rural India, Ushalakshmi Breast Cancer Foundation in partnership with the Governments of Telangana and Andhra Pradesh implemented South Asia's largest Clinical Breast Examination (CBE) based Breast Cancer Screening Programme. Between 2012 – 2016, over 200,000 underprivileged women between the ages of 35 and 65 spread across 4,000 villages have been screened for early signs of breast cancer by way of CBE performed by over 3000 trained healthcare workers. Cancers detected through this initiative have been treated free of charge by the State Government. This milestone project made huge impact and is being rolled out nationwide by the Government of India since 2017.

The Association of Breast Surgeons of India (ABSI)

Recognizing the need to standardize delivery of breast healthcare in India, I was the principal driving force in establishing ABSI, which represents General Surgeons, Surgical Oncologists & Plastic Surgeons treating patients with Breast Disease. During my Presidential term (2015 – 2017), to ensure uniform delivery of standardized care in Resource limited settings, the 'ABSI Module' was implemented to empower General Surgeons in smaller towns across the Country about the evidence based management of Breast disease. Over the years, ABSI has rapidly emerged to become the 'voice for Breast Surgery' in India (www.absi.in).

Conclusion

For well over a decade, I feel immensely proud to have been be a 'living bridge' between the UK and India replicating the best of British practices in a country that I was born and raised.

ASGBI Surgical Innovation Award

A novel 3D printed organ perfusion chamber for prolonged normothermic machine perfusion of transplant kidneys

Sarah Hosgood, Senior Research Associate in Surgery, University of Cambridge

The NHS continues to face a serious mismatch between supply and demand in kidney transplantation. Last year there were 4,757 patients on the UK active kidney transplant list, yet only ~3,000 transplants were performed[1]. The use of organs from marginal donors including circulatory death donors (DCDs) has gone some way to meet the organ shortage but there are several unresolved problems[2]. In particular, DCD kidneys develop delayed graft function (DGF) in up to 70% of cases. DGF adversely affects allograft survival and is costly because it prolongs in-patient stay[3]. Furthermore, several hundred kidneys from marginal donors are discarded annually because of concerns over their quality.

Our research has introduced normothermic machine perfusion (NMP), which uses existing cardiopulmonary bypass technology to perfuse kidneys with a warm, oxygenated, blood solution for a period of 60 minutes. NMP can improve early allograft function[4] and provides an accurate pre-transplant kidney quality assessment tool[5]. We now intend to develop NMP as a unique platform to deliver pre-transplant therapies[6]. In order to achieve this, we need to significantly prolong the current 60-minute normothermic preservation period. This will require the design of a novel organ perfusion chamber.

The main aim is to design and manufacture a novel, 3D printed, benchtop organ perfusion chamber that can maintain kidneys in a safe and sterile environment for a number of hours.

Our NMP system is based on existing, commercially available cardiopulmonary bypass technology and utilizes the principles of extracorporeal membrane oxygenation. The NMP circuit consists of an organ perfusion chamber, a centrifugal pump, a membrane oxygenator, a heat exchanger and a venous reservoir all connected by PVC tubing. The system incorporates a bioconsole that includes a speed controller, a flow transducer and a temperature probe (Figure 1A). The current circuit is very functional but has limitations that require modification before it can be considered for commercial development as a prolonged perfusion machine. At present the kidney is placed in a separate chamber made of stainless steel. This leaves the kidney relatively exposed to the external environment, which has a number of disadvantages (Figure 1B, 1C).

1. There is difficultly in maintaining the temperature of the kidney.

2. Exposure of the kidney and renal vessels increases the risk of infection and loss of moisture leading to tissue dessication.

3. The ureter is exposed outside the chamber, which risks damage, infection and contamination.

We will address these problems by designing and producing a novel organ perfusion chamber using 3D printing technology (Figure 2). Our long-term aim is to use the new organ chamber to safely introduce prolonged NMP. This, in turn, will allow the delivery of novel pre-transplant therapies that improve allograft function.This will be low cost as the main hardware components will retain the use of the readily available cardiac bypass technology. The development funding will be invested in the design of a 3D printed chamber to house the kidney for short and long-term perfusion.

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Figure 1

Normothermic Machine Perfusion Circuit

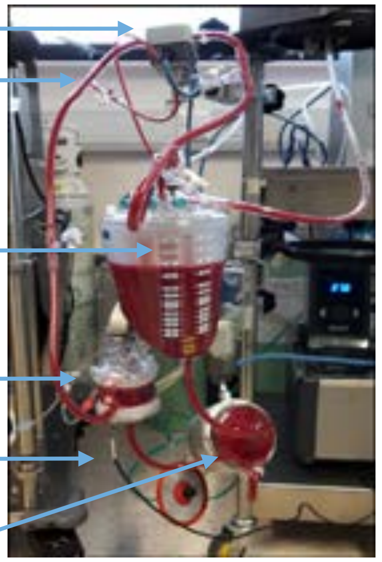

Figure 1A: Picture of the consumable components of the normothermic perfusion system. The system hardware is based on paediatric cardiopulmonary bypass technology (Medtronic). The perfusate is pumped from the venous reservoir via the centrifugal pump into the membrane oxygenator and heat exchanger before it enters the arterial arm of the circuit. The oxygenated and warmed blood enters the kidney via the renal artery and is then allowed to drain from the vein back into the reservoir where it is re-circulated. The arterial pressure is fixed allowing the kidney to autoregulate its own blood flow.

Figure 1B: Perfusion set- up with organ perfusion chamber placed on a sterile drape. Nutrients and fluids are infused to maintain homeostasis and fluid balance.

Organ perfusion chamber

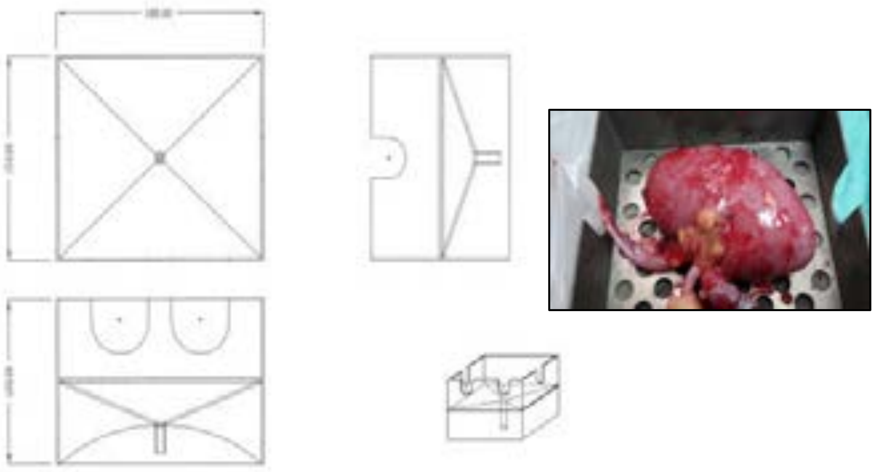

Figure 1C: Current design of kidney stage. Stainless steel unit with stainless steel perforated mesh. The base is sloped to allow drainage back into the venous reservoir.

Figure 2

Design of prototype 3D printed benchtop organ perfusion chamber

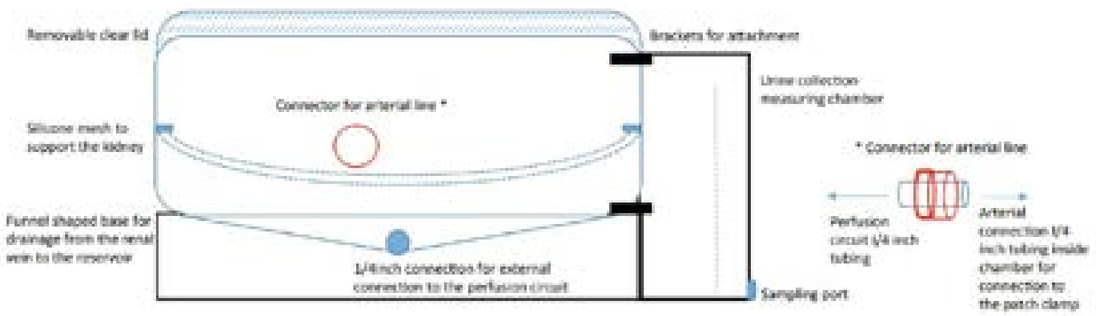

Figure 2. Schematic diagram of the 3D printed organ perfusion chamber. The kidney rests on a silicone mesh and the renal artery is connected via the patch clamp to the arterial connector inside the chamber. Flow from the renal vein drains back into the venous reservoir for re-circulation in the system. An external 3D printed chamber is attached to the main organ perfusion chamber for the collection and measurement of urine. A sampling port allows the collection and analysis of urine.

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Adhesion Prevention: Does Laparoscopic Surgery Really Prevent Readmission with Adhesion Complications?

James M Halle-Smith, Ewen A Griffiths

University Hospitals Birmingham NHS Foundation Trust

Background

Adhesions are pathological fibrous connections between surfaces within body cavities. Most peritoneal adhesions develop after surgery but other risk factors include infection, for example after diverticulitis or pelvic inflammatory disease, and radiotherapy[1,2]. There are multiple long-term sequelae of peritoneal adhesions which include small bowel obstruction (SBO), reduction in female fertility and chronic pain[1,2]. Furthermore, adhesions complicate any further surgery leading to increased risk of complications and operating times [1,2]. Combined, it is clear that adhesions are responsible for considerable long-term clinical and economic burden, and thus strategies to reduce their incidence are desirable.

Previous Surgical and Clinical Adhesions Research (SCAR) Group Studies

Given that most adhesions in open surgery occur deep to the laparotomy incision, it has been suspected that laparoscopic surgery would reduce the incidence of adhesions. That said it was difficult to prove this concept due to the fact that existing evidence consisted of small case series with poor follow-up. Large population-based studies were therefore desirable and in 1999 the first Surgical and Clinical Adhesions Research (SCAR) group study was published in the Lancet using Scottish administrative data similar to hospital episode statistics. This landmark study showed that over a period of ten year one third of patients were readmitted at least twice with adhesion related complications (Table 1)[3]. This was followed by the SCAR-2 study, which showed that colectomy and ileal pouch surgery increased the risk of adhesion complications[4], and the SCAR-3 study, which reported a higher rate of adhesion related readmission amongst those with peritonitis [5]. An important limitation of these studies was that laparoscopic surgery rates were still relatively low, so it remained difficult to draw any strong conclusions regarding laparoscopic surgery and adhesions (Table 1). However, it has been long thought that laparoscopic surgery is associated with reduced adhesion formation due to the smaller incisions and differences in dissection techniques performed.

Table 1 - Summary of SCAR studies

Study	Author and Year	Study Period	Number of Patients	Surgery Type	Laparoscopic Surgery %	Main Findings
SCAR-1	Ellis et al. 1999	January – December 1986	29,790	Open abdominal or pelvic surgery	0%	- 22.1% readmissions due to adhesions in first 12 months after surgery. - Steady increase over 10 years after surgery. - One third of patients - 4.8% had six or more readmissions.
SCAR-2	Parker et al. 2001	January – December 1986	12,584	Open lower abdominal surgery	0%	- Total colectomy and ileal pouch surgery had highest risk of adhesion complications
SCAR-3	Parker et al. 2005	April 1996- March 1997	12,756	Open lower abdominal surgery	0%	- Peritonitis increased risk of adhesions. - No change in adhesion morbidity despite modern surgical techniques
SCAR update	Krielen et al. 2020	June 2009- June 2011	72,270	Upper GI, gynaecological, liver, colorectal	30%	- 30% of patients readmitted for adhesion related causes. - Significant reduction in adhesion related readmissions and reoperations potentially complicated by adhesions. - Independent risk factors: age, female sex, absence of malignancy.

Evidence for Laparoscopic Surgery Preventing Development of Adhesions

As laparoscopic surgery became more commonplace, two studies from Denmark and the USA, with 8,583 and 69,303 patients respectively, reported reduced rates of surgery for small bowel obstruction after laparoscopic surgery (Table 2)[6,7].

This has been followed by the SCAR update study, published in the Lancet in 2020, which reported outcomes for 72, 270 patients with 30% of procedures performed laparoscopically. This showed vast differences in adhesions readmission rates and reoperations potentially complicated by adhesions (Tables 1 and 2).

In addition, this study also showed that laparoscopic surgery reduced readmission rates for all types of procedures, from rectal surgery to cholecystectomy. Independent risk factors for adhesion development were also reported and included female sex, advanced age and absence of malignancy.

Significantly, these findings have been mirrored in a large American study, involving 1.6 million patients, which reported a reduction in incidence of adhesions for five different abdominal procedures (Table 2)[9].

Table 2 - Summary of studies reporting lower adhesion rates with laparoscopic surgery

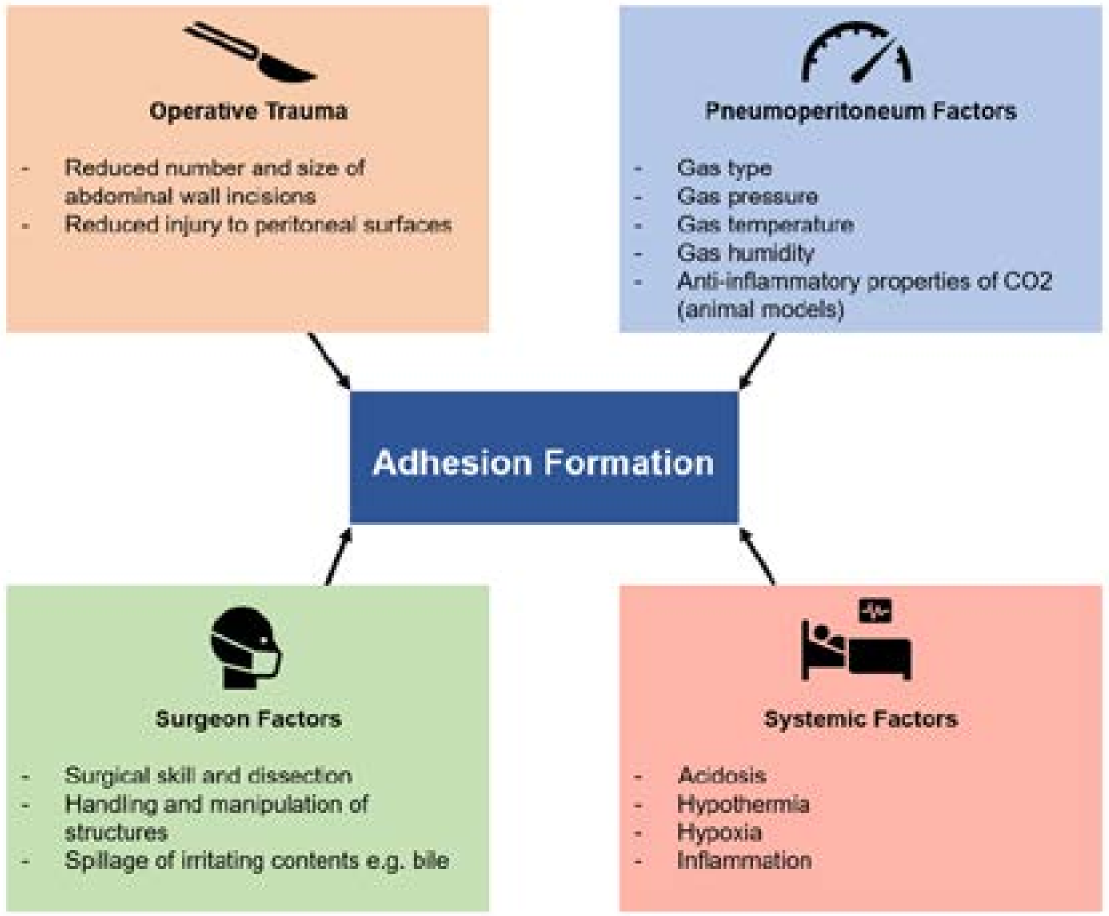
Country	Author and Year	Number of Patients	Surgery Type	Laparoscopic Surgery %	Main Findings
Denmark	Jensen et al. 2016	8,583	Elective colon cancer resection with primary anastomosis	19%	- Incidence of SBO was 1.2% after laparoscopic and 1.6% after open surgery - Laparoscopic surgery was associated with reduced risk of subsequent SBO surgery compared to open surgery
USA	Aquina et al. 2016	69,303	Elective colorectal resections	26%	- Open resection was associated with a higher risk of SBO (HR 1.14, 95%CI 1.03-1.26) and having operation for SBO (HR 1.12, 95%CI 0.94-1.32)
Scotland	Krielen et al. 2020	72,270	Upper GI, gynaecological, liver, colorectal	30%	- 30% of patients readmitted for adhesion related causes. - Significant reduction in adhesion related readmissions and reoperations potentially complicated by adhesions - Independent risk factors: age, female sex, absence of malignancy.
USA	Udelsman et al. 2020	1,612,629	RYGB, cholecystectomy, partial colectomy, appendicectomy, hysterectomy	45%	- High risk patients (IBD/PID) excluded. - Significant reduction in incidence of adhesive SBO after all operation types with laparoscopic surgery

Legend: SBO = small bowel obstruction; RYGB = Roux-en-Y gastric bypass; IBD = inflammatory bowel disease; PID = pelvic inflammatory disease

Future Directions

Given that there is now high-quality evidence that laparoscopic surgery reduces the risk of readmission due to adhesions, it is natural to hypothesise why this is the case. Some suggestions include reduced injury to peritoneal surfaces, fewer incisions through the abdominal wall and the anti-inflammatory properties of carbon dioxide insufflation, shown in animal models (Figure 1)[10]. Further work is required to greater understand these mechanisms and work to translate them into future therapeutic options.

Figure 1 – possible mechanisms of adhesion formation and areas for future research



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Can patients cure surgeons?

Michael Sugrue

Working within ASGBI over the last 6 months, we have given some thought to the development of a patient advocacy group for emergency general surgery (EGS) patients and their families. The title of this talk delivered by Mr Michael Sugrue at the recent ASGBI was more tongue in cheek and designed to be probative.

So the question is do we need to change and if so will increased patient feedback help the transformation? In EGS care patients, surgeons and the health service are the pillars by which we achieve an optimal outcome. Currently to our knowledge there are no active EGS patient support or advocacy platforms. This is unlike other areas in surgery, particularly breast cancer and colorectal care, where patient and family power have been most helpful in improving awareness of treatment and outcomes.

Patient advocacy groups have strengthened other areas of surgery. Breast Surgeons are only too aware of the Pink Power and not only its ability to change some of the ways we think but also generate valuable resources and funding.

Over the last 12 months COVID-19 has led to further challenges highlighting the difficulty our patients and their families have with deficits in communication. This has resulting in less than satisfactory experiences. ASGBI and Surgeons globally need more feedback on issues that patients want not just in terms of their outcome but also their experience.

Generally PROMS and PREMS identifying in that surgical treatments and processes are excellent. Communications, Interpersonal skills and system organisation are the aspects most likely to upset the patients and their families.

As Emergency Surgery, by its very nature, has an element of surprise for families it has travelled below the radar, remaining a poorer cousin to the more dramatic trauma and injury systems.

ASBGI and our working group are keen to change this and we look forward to you support, so that not only can surgeons cure EGS patients but EGS patients can cure sub-optimal aspects of surgical EGS care.

Human factors - improving patient safety and our own performance

Peter Brennan MD PhD FRCS, Consultant Maxillofacial Surgeon & Honorary Professor of Surgery
Portsmouth Hospitals University Trust

Error is 'normal' and inevitable

Human error is as old as humanity. We all make mistakes and therefore error is a 'normal' part of everyday life. The Roman philosopher Cicero (106-43BC) quoted 'anyone can err, but only a fool persists in error. In healthcare, 1 in 20 hospital admissions has some form of error and 1 in 20 of these (1 in 400) are serious[1]. Many mistakes could be reduced or prevented by understanding and applying human factors (HF) principles. Healthcare is still years behind other high reliability organisations (HROs) in embedding HF training.

Individual and team factors

Individual

A good way to address HF is to consider individual and team factors. All too often we do not look after ourselves, leading to reduced performance, potentially compromising patient safety and increasing risk of error. Even a 1-3% reduction in body mass due to water loss can reduce cognitive function by up to 20%[2]. Staying awake for more than 18 hours has the same effect as being twice over the UK alcohol limit. Anger or stress also significantly raises the risk of error and conflict in the team.

If Hungry, Angry, Late or Lonely, Tired, think HALT (Figure 1) and if safe to do so, stop and take a break to regain optimal performance. If you are feeling any of these effects, the team is also likely to be feeling the same. Remember to look after yourself - the briefing on every commercial flight 'put your own mask on before helping others'.

Figure 1 – If possible STOP if Hungry, Angry, Late or Lonely, Tired

Team

We all work as part of a team. There are so many factors involved in team dynamics but a few need particular consideration. There has to be some hierarchy but lowered authority gradients are vital: empower the whole team to speak up with any concerns and without fear of retribution. This can be actioned at the team brief in a warm, friendly and non-confrontational way. It is also good practice to ask trainees, scrub nurses and others to lead the brief.

At the team brief, think about any 'what if?' scenarios so if there is a complication during surgery, there is less chance of a 'startle reaction' and snap decisions made which can lead to further problems.

Good Communication is so important. 90% is non verbal so be aware of the effect of PPE. We recommend using open questions and body language and use repeat back if there are safety specific steps that you want to ensure your message is both heard and understood by the receiver[3]. Distractions can be a major cause of error so if there are steps that need intense concentration, alert the team at the briefing and consider turning off music at that time.

Finally maintain situational awareness (SA) for you and the team can reduce the risk of error. SA is a dynamic process (Figure 2). By thinking ahead (remember the what ifs?) it is possible to actively avoid error (Figure 3)[4].

Figure 2 Situational awareness is a dynamic process and dependent on many factors.

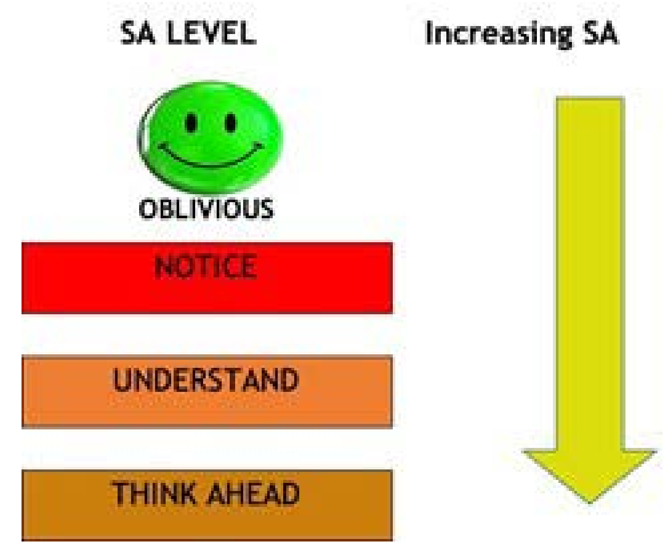

Figure 3 Situational awareness can be enhanced by actively thinking ahead.

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COVIDSurg: Data-driven decision making to improve surgical safety during COVID-19

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COVIDSurg platform

COVIDSurg Collaborative was formed in March 2020 from the NIHR Global Health Research Unit on Global Surgery at the Universities of Birmingham and Edinburgh in response to a global requirement for data to improve surgical safety during the pandemic.

The group aimed to unite surgeons and anaesthetists around the world to better understand the impact of the COVID-19 pandemic on surgical patients and surgical services. Over the past 18 months, data from the collaborative has provided an evidence-base to shape clinical practice and guide safe care in pandemic conditions. Our results have been disseminated to surgeons around the world and to surgical patients in information booklets co-produced with these key stakeholders.

Study portfolio

The CovidSurg Collaborative has designed, coordinated and published the results from three main international observational studies:

1. CovidSurg Cohort - assessing the outcomes of operated patients with perioperative SARS-CoV-2.
2. CovidSurg Cancer - assessing the impact of the COVID-19 pandemic on patients planned for elective cancer surgery, including the outcomes for patients who ultimately did not undergo an operation.
3. GlobalSurg-CovidSurg Week - understanding the optimal timing of surgery for patients previously infected with SARS-CoV-2.

Key findings from these studies have already shaped global surgical practice in the pandemic, being incorporated into dozens of international guidelines, gaining hundreds of citations in 2020/21, and embedded into an online CPD platform (https://modules.surgery2025.com/).

The earliest data from the CovidSurg Cohort study showed that patients with perioperative SARS-CoV-2 infection have significant excess mortality and risk of postoperative pulmonary complications[1]. Male patients, those older than 70 years, with an ASA grade of 3-5 or requiring emergency surgery were at highest risk. Using the data from this study we developed the CovidSurg Risk Score (https://covidsurgrisk.app/) to estimate the mortality risk for patients with SARS-CoV-2 infection perioperatively[2].

Data from the CovidSurg-Cancer study showed that COVID-19 free (also called 'lite' or 'green') surgical pathways, with inpatient wards, operating rooms, and intensive care units segregated away from patients being treated for COVID-19, reduced rates of SARS-CoV-2 infection and pulmonary complications postoperatively[3]. Study data also demonstrated that a single preoperative swab should be performed for patients with no clinical suspicion of COVID-19 before major surgery in both high and low risk areas and before minor surgery in high risk population areas to prevent serious complications of COVID-19 in patients undergoing surgery with pre- or asymptomatic infection[4].

The GlobalSurg-CovidSurg week study enrolled over 140,000 patients in 116 countries, representing one of the world's largest scientific collaborations. It demonstrated that surgery after SARS-CoV-2 diagnosis should be delayed at least 7 weeks, where possible, to reduce the known risks of serious breathing complications and death to the same rates of patients never infected[5]. For patients with ongoing symptoms, a delay beyond 7 weeks until symptoms resolve may be beneficial, as breathing complications and death in this group remains elevated.

Future perspectives

This pandemic highlighted the fragility of surgical systems worldwide, with 1 in 7 patients not receiving their curative cancer surgery during COVID-19 lockdowns (COVIDSurg-Cancer study). The major global agenda for surgical policy over the next decade must be strengthening the resilience of surgical systems to support post-pandemic recovery and address overwhelming waiting lists in the wake of high volumes of cancellation of elective surgery.

To support this global effort, CovidSurg has launched a new project allowing investigators to assess the resilience of their local elective surgery system.

The aim of this project is to to validate and calibrate a consensus index created by an international steering group.

Join this CovidSurg project by completing the elective surgery resilience index assessment here: https://redcap.link/surgeryresilience.

More details can be found at https://vimeo.com/564705704.

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Overview of COVID Research

Peter Hutchinson, Murat Akkulak
University of Cambridge

The start of 2020 was very encouraging with strong recruitment to trials and the prospect of expanding the surgical trials initiative, both in terms of current and new projects. Then the COVID-19 pandemic struck, and it rapidly became apparent that as a result of the virus this would be a very different year presenting challenges but also opportunities.

The challenges have been to continue recruitment to surgical trials, many of which have been affected due to the impact on both patients and staff. On a background of the 2019–2020 epoch with an incredible 52,088 patients being entered into surgical trials, it rapidly became apparent that we would need to adapt. Although recruitment did cease during the first lockdown it is encouraging that trials have been able to recommence recruitment, or recruit elsewhere, for example the SUNRRISE trial, as part of our joint RCS England-Australian New Zealand Clinical Trials Initiative. It is also encouraging that during the pandemic we have been able to expand the RCS England clinical trials initiative with new Surgical Specialty Lead appointment in bariatric surgery and three new Surgical Specialty Leads appointed in Vascular Surgery. We have also appointed Prof Michael Jenkinson as the Chair in Surgical Research at the University of Liverpool, with generous support from the Sir John Fisher Foundation.

The pandemic has had a major impact on patients with or without suspected SARS-CoV-2 infection, and patients with other conditions in terms of access to surgical care. There has also been a major effect on staff in terms risk of transmission and wellbeing with operating in very difficult environments. With this in mind in March 2020 we launched the RCS England COVID Research Group, a weekly and now monthly meeting of surgical researchers who have built up a portfolio of 50 projects providing data to assist in the management of surgical patients during the pandemic. Work from members of the group has provided data on the outcome of patients infected with SARS-CoV-2 during the peri-operative period, data to support alternative, including non-operative ways of managing patients, and data demonstrating that certain procedures can be performed under local anaesthesia. Other projects are looking at the well-being of staff, novel PPE and aerosol science in terms of virus transmission. We have also started a clinical informatics subgroup to interrogate HES data. Our aims include using data to assist in the management of the recovery phase, given the exponential growth in waiting lists.

2020 has also seen growth in our other projects, both in the UK and globally. In terms of international collaborations, the five RCS England NIHR global health unit/groups presented an update of their activities at a virtual Surgical Global Health meeting in the autumn and it is encouraging that there are new surgical groups being created and applying for the current NIHR global round. There is no doubt that the surgical global initiatives have provided important data on the management of surgical conditions in low and the middle income countries, but we recognise that we now need to take this to the next stage, that of policy implementation, with an exciting collaboration with the London School of Economics to be launched in 2021.

It also been a successful year for our robotics initiative with the launch of RADAR, part of the Commission on the Future of Surgery initiative. We acknowledge the amazing growth in robotic technology and the challenges this brings in terms of implementation, demonstration of both efficacy and safety and training. During 2021 we plan to appoint the first RCS England-Robotics fellow.

2020 was also a year that heightened our concerns in relation to the safety and monitoring of surgical implants. The Cumberledge report highlighted this in relation to vaginal mesh implants. We recognise that there are many questions to be addressed and are therefore starting a RCS England device science and registries group. This has a number of aims: to collate the current portfolio of surgical registries, to define the core criteria for a successful registry, and explore ways that we can combine registries with research, by embedding trials within registries.

In conclusion, while 2020 has been a turbulent year for surgical research, specifically recruitment to trials, it has provided other opportunities to increase our understanding of surgical conditions and improve the management of patients through research, both in the UK and internationally.

The role of the perioperative physician geriatrician in emergency general surgery: how it evolved, what do physicians do and what do surgeons want?

Dimitrios Damaskos, FRCSEd, FEBSEmSurg
Consultant Surgeon, Royal Infirmary of Edinburgh

The ageing of the population is a fact, and with it, our surgical patients are increasingly older and have more comorbidities, as a result of that. It is a well-known aspect of our day-to-day work today but it was not recognised until fairly recently.

The article by Pearse et al (Critical Care 2006) showed us that mortality in major abdominal/colonic procedures in patients over 69 years of age is significantly high, perhaps more than we wanted to believe. The issues around need for better care for elderly patients undergoing emergency surgery were then identified in the Peri-operative Care: Knowing the Risk NCEPOD document (2011). In that report, the role of frailty has been identified and particular attention was paid to multiple comorbidities/polypharmacy/cognitive and sensory impairment compromising the outcomes of these patients. The subsequent (2015) National Emergency Laparotomy Audit from England and Wales issued specific recommendations that patients over 70 undergoing an emergency laparotomy "should have Input from specialist Care of the Elderly teams". As a matter of fact, the latest NELA report showed that only 28.8% of these patients receive this care currently in England and Wales.

The "High-Risk General Surgical Patient: Raising the Standard" 2018 report from the Royal College of Surgeons of England (endorsed by multiple specialist societies) recommends that "patients aged over 65 years and other patients who appear frail for their age should have their level of frailty assessed and recorded within four hours of admission or transfer, using a recognised assessment tool. In addition, these patients should be screened preoperatively for risk of perioperative neurocognitive disorders.". They also emphasize on the fact that "commissioners and hospital service managers should incentivise delivery of care for high-risk general surgical patients that complies with these key pathway components". This year's British Geriatrics Society position paper states clearly that all elderly and frail patients undergoing emergency surgery should be seen by a consultant geriatrician within 72 hrs from admission and that medicine of the elderly should be an integral part of the pathway (Age and Ageing, 2021).

Results From the UK observational Emergency Laparotomy and Frailty (ELF) Study conclude that "The presence of frailty is associated with greater risks of postoperative mortality and morbidity and is independent of age". They propose that frailty scoring should be integrated into acute surgical assessment practice to aid decision-making . Multiple international societies agree and endorse similar practices, with the most recent ERAS in emergency surgery guidelines having been published earlier this year (Peden et al. World J Surg. 2021).

What can geriatricians do for emergency surgery patients? The role is evolving but the example of the Guy's and St Thomas POPS group shows the way. They provide Comprehensive Geriatric Assessment (CGA) with a multi-disciplinary team, ensuring early identification of frailty / high risk patients. That leads to the prevention and / or treatment of medical complications proactively, which results in less morbidity and readmissions. They are also vital in other "softer" interventions such as advising and participating in the management of chronic conditions, intervening on polypharmacy, initiating and substantiating discussions on anticipatory care pathways. Overall, this will help optimise the functional recovery of the patient through an MDT approach, coordinating discharge planning along with the allied health professionals/therapists. On some occasions, they can even work in partnership with the surgeons and anaesthetists for joint decision making and collaborative person-centred care.

What do surgeons want? A complete answer to that question cannot be given, and answers may vary from surgeon to surgeon and from institution to institution. It would be fair to say though, that, in principle, surgeons want good overall outcomes, high patient satisfaction, low mortality and morbidity and a low readmission rate. Responsibility of the medical teams for acting on and following up on investigations requested by them is also a common theme. Other potential answers could include combined surgeon/geriatrician ward rounds and shared care, takeover of frail/unfit for surgery patients directly by medical teams at the front door with surgical consultations on demand, or takeover of patients by geriatricians once the surgical problem is confidently resolved but the patients have ongoing medical or rehabilitations issues.

How can this be accomplished? There are many potential models of care and none has been identified as a gold standard so far (Vilches-Moraga et al. Aging Clin Exp Res. 2018). As repeatedly stated on almost all subjects, one size doesn't fit all and there will be local variations and different approaches. The impact of having perioperative physicians as part of the emergency surgical pathways is a reality and is considered a target to aspire to by the Surgical, Anaesthetic and Geriatric Medicine societies of the United Kingdom. As such, its implementation should not only be viewed as a cost-efficient solution but also as an alignment with what is considered to be standard modern-day practice.

coress

Applications sought for the post of CORESS (Confidential Reporting System for Surgery) Programme Director-Elect

CORESS (Confidential Reporting System for Surgery) invites applications for the post of Programme Director-Elect.

The role of Programme Director-Elect will be to work with as deputy, and to assimilate and take on the role of the current Programme Director, with anticipated appointment of the successful applicant to the post of Programme Director within 6-12 months. The term of appointment of the new appointee will be 4 years, to include the period spent as Programme Director Elect.

Key responsibilities of the post are to liaise with the 10 surgical specialty associations to solicit reports of adverse incidents and near misses in surgical practice, which are published and disseminated to the surgical workforce as anonymised educational vignettes and presentations.
The role of Programme Director involves chairing the pan-specialty Advisory Board, liaising with other organisations involved in patient safety including the surgical Royal Colleges, NHS England Patient Safety, HSIB, the MRHA, and MDU. The successful applicant will be involved in and will eventually direct the strategic development of the charity and its educational programmes and aspirations. The Programme Director reports to the Board of Trustees chaired by the Lord Ribeiro CBE FRCS.

It is expected that the applicant will be in good standing as a medical practitioner with experience as a committee chair, interests in surgical education, a proven track record of organisational skills and published outputs. Presentation skills and familiarity with charitable governance will be an advantage.

This post represents an excellent opportunity for an individual with interests in surgical education, patient safety and quality improvement. This post is an honorary appointment, but all reasonable expenses will be refunded with oversight by the Hon. Treasurer and Board of Trustees.

The formal application pack is available from: admin@coress.org.uk

The closing date for applications will be 10th December 2021.

Applicants interested in the role can contact the current Programme Director for further information.

Surgical Life: The Journal of the Association of Surgeons of Great Britain and Ireland, Number 60
FEATURES

Improving management for acute cholecystitis and biliary pancreatitis – the 'hot gall bladder pathway'

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Mr Abdelsaid contributed to the conception, reviewing of the final manuscript, data collection and editing.
Dr Kam contributed to the design of the work and drafting of manuscript.
Mr Jayasankar contributed to the data collection.
Mr Balasubramaniam contributed to the conception, reviewing of the final manuscript and editing.

Mr Abdulaal contributed to the conception, reviewing of the final manuscript and editing.

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Background

Cholelithiasis is a common condition in the UK, accounting for 15% of the population with 20% being symptomatic, including acute cholecystitis and pancreatitis. In 90% of patient's acute cholecystitis is caused by cholelithiasis and 50% of patients with biliary pancreatitis. 20-33% of patients will make repeat visits to hospital with gallstone-related symptoms before any surgical intervention performed.[1-3]

Surgical intervention in the form of a laparoscopic cholecystectomy has been recommended for acute calculous cholecystitis and biliary pancreatitis. The timing of the surgery plays a crucial role in the outcome and management in patients diagnosed with either of the conditions. NICE guidelines recommend distinct time intervals for carrying out the procedure. An early intervention (hot gall bladder) should be performed within 1 week for acute cholecystitis and 2 weeks for biliary pancreatitis.[4] Despite this, there is a wide variation between NHS hospitals in the management of these patients. Patients are more likely to be readmitted with gallstone-related problems while waiting longer for surgery.

In 2018, the Royal College of Surgeons England published a quality improvement project collaborative aimed to reduce the time to emergency cholecystectomy for patients with acute cholecystitis or biliary pancreatitis. The results showed a national average of 16% complying with the NICE guidelines by performing the procedure within the time frame, as compared to 33 - 67% internationally.[5] As an acute NHS Trust, we established a 'Hot Gall Bladder Pathway' with the aim for improving outcome and decreasing complications of these patients. This allows a clear pathway to be followed to avoid unnecessary delay in performing the intervention. Quality improvement methods were used to integrate the 'hot gall bladder pathway' to manage patients with acute calculous cholecystitis and biliary pancreatitis, and to compare the current standard practice to existing guidelines and make appropriate changes. The primary aim of this study was to ascertain the effectiveness of a clear 'hot gall bladder' pathway in a DGH.

Methods

This was a retrospective 13-month study of the management of patients with acute cholecystitis and biliary pancreatitis presenting to a DGH in Kent from 1st February 2019 to 1st March 2020, following implementation of the pathway and approval from the local ethical committee.

The study was protocol-driven with strict inclusion and exclusion criteria for triaging patients with gall-stone related acute cholecystitis and pancreatitis appropriate for the 'hot gall bladder service', incorporating the procedure within the suggested time frame as regards to NICE guidelines.

Inclusion criteria included: Patients aged 18 or above with acute cholecystitis with no associated organ dysfunction (mild or moderate; Tokyo guideline grade I or II).6 Mild acute biliary pancreatitis. Exclusion criteria included: Patients aged below 18. Patients with acute cholecystitis and previous intervention with either endoscopic retrograde cholangiogram (ERCP) for common bile duct (CBD) stone or percutaneous cholecystostomy before Laparoscopic Cholecystectomy (LC). Acute severe biliary pancreatitis patients with suspected Complication or Cancer. Surgery performed for reasons other than acute cholecystitis/ biliary pancreatitis – gall bladder polyps, biliary colic, elective patients on list.

The 'hot gall bladder' pathway (Figure 1 and 2)

Figure 1: The 'hot gall bladder pathway' for acute calculous cholecystitis

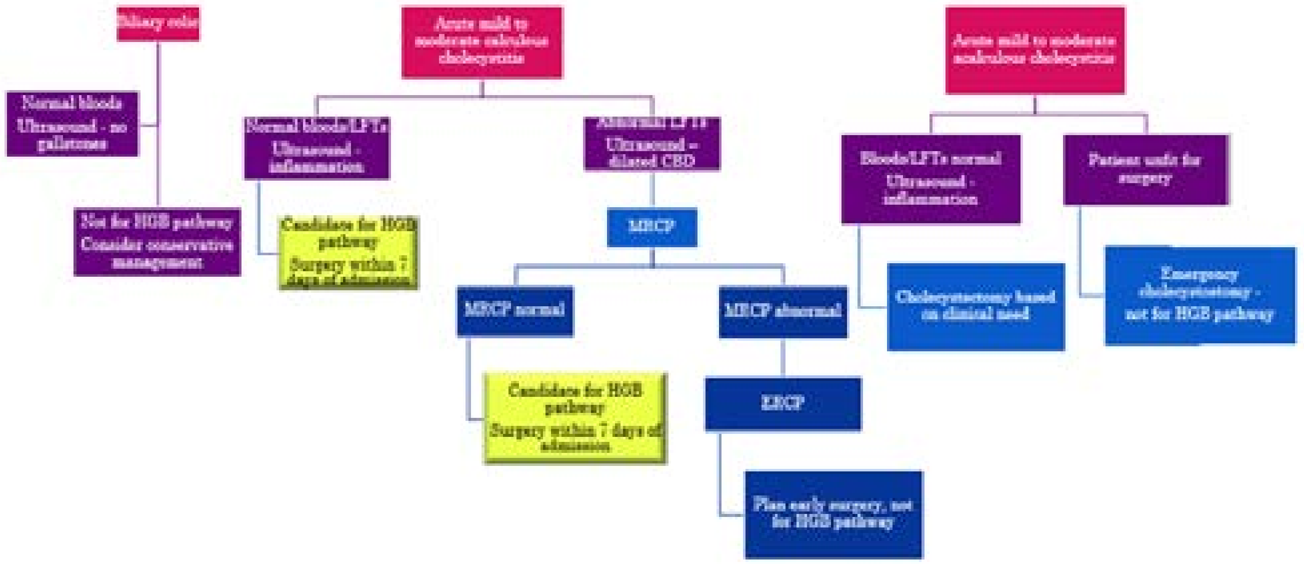
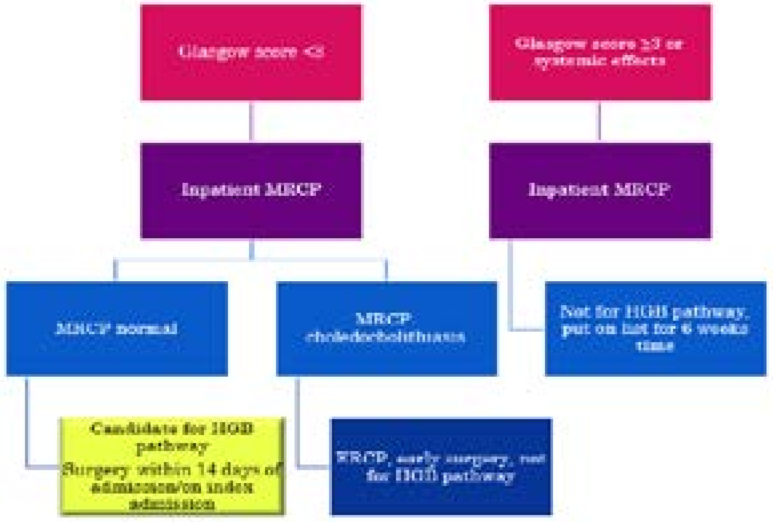


Figure 2: The 'hot gall bladder pathway' for mild biliary pancreatitis



Surgical Life: The Journal of the Association of Surgeons of Great Britain and Ireland, Number 60
FEATURES

Patients presenting to the hospital with deranged and obstructive liver function tests (LFTs) and dilated common bile duct shown on ultrasound scan (USS) will be booked for magnetic resonance cholangiogram (MRCP). If the slot is not available, patients will undergo intraoperative cholangiogram. Our general surgical division was also successful in acquiring 3 afternoon lists weekly supported by 3 upper gastrointestinal (GI) surgeons for providing the emergency LC. A dedicated online referral form (Figure 3) was designed for the study which needed to be completed and submitted by the admitting team. The form will be reviewed by the registrar and then the operating consultant (Hepato-pancreato-biliary/ GI consultant) if the patient is deemed appropriate for emergency LC. The patient will be booked onto the next available slot to have the procedure done within the recommended time frame.

The data including demographics and clinical details were collected and assessed from admission records, electronic discharge summary, blood investigations and radiological findings. They were then entered into a secure database and analysed using standard statistical methods.

Figure 3: The online hot gall bladder pathway referral form

Results

Between 1st February 2019 and 1st March 2020, a total of 134 patients were booked under the 'hot gall bladder pathway' for LC. 98 patients (73%) were considered suitable and the remaining 36 (27%) were deemed inappropriate for the hot gall bladder list. 98 included 68 (64%) and 35 (37%) patients presenting acute calculous cholecystitis with no associated organ dysfunction and mild biliary pancreatitis respectively (Table 1).

Table 1: Eligible cases for the 'hot gall bladder pathway'

Criteria met	*N (%)*
Acute calculous cholecystitis with no associated organ dysfunction (mild or moderate; Tokyo guideline grade I or II)	*68 (64)*
Mild biliary pancreatitis	*35 (37)*
Total	*98*

100% (98/98) underwent successful LC with no intraoperative complications.

21 of the 36 rejected cases (58%) was due to patients presenting with previous intervention either ERCP for CBD stone or percutaneous cholecystostomy before LC. 6 (17%) and 9 (25%) patients were excluded due to acute severe biliary pancreatitis with suspected complication or cancer and surgery done for others reasons such as gall bladder polyps, biliary colic and elective list respectively (Table 2).

Table 2: Rejected cases for the 'hot gall bladder pathway'

Causes of rejection	*N (%)*
presenting with previous intervention either endoscopic retrograde cholangiogram (ERCP) for common bile duct (CBD) stone or percutaneous cholecystostomy before LC	*21 (58)*
Acute severe biliary pancreatitis with suspected complication or cancer	*6 (17)*
Surgery done for other reasons such as gall bladder polyps, biliary colic and elective list respectively.	*9 (25)*
Total	*36*

68% (43/63) patients with acute calculous cholecystitis who were fit for the criteria underwent successful LC within the recommended 1-week time frame and 69% (24/35) with mild biliary pancreatitis achieved the recommended the '2 weeks' window (Table 3).

Table 3: Compliance rate against NICE guideline

Criteria met	*Proportion (%)*
Acute cholecystitis with no associated organ dysfunction (mild or moderate ;Tokyo guideline grade_ I or II) who underwent Laparoscopic Cholecystectomy within 1 week of diagnosis.	*43/63 (69)*
Mild Acute Biliary Pancreatitis who underwent Laparoscopic Cholecystectomy within index admission or within 2 weeks of diagnosis.	*24/35 (68)*

Histology confirmed 45 patients with acute on chronic cholecystitis and chronic cholecystitis in the remaining 54 patients.

Discussion

At the Trust, we perform 600-750 LC per year. Initially the rate of hot gall bladder was less than 5% of the acute admissions. We reached 23% with initial trials on Confidential Enquiry into Perioperative Deaths (CEPOD) list and no dedicated lists. After the implementation of the pathway we achieved the current compliance level. High conversion to open surgery and increased mortality were the major concerns in the past for acute gallstone disease with early LC.

However, early intervention is supported with recent evidence with reduced risk of recurrent attacks, representation and readmission and most importantly severe complications.7 There is a wide variation between NHS hospitals in the management of patients with acute gallstone-related cholecystitis and pancreatitis. Factors in human and capital resources including appropriate consultant availability and theatre space, organisational and operational issues have been suggested to be responsible for poor compliance rate to the NICE guideline.

Injury to bile duct can be fatal and is the most serious complication during cholecystectomy. The main reason to convert from emergency LC to an open surgery is the difficulty of appreciating the anatomy of Calot's triangle due to surrounding inflammation, whereas the fibrotic adhesion in the Calot's triangle makes it difficult for performing a delayed surgery.

Experience of the operating surgeon is vital. LC performed by upper GI surgeons have resulted in a lower conversion rate as well as shorter hospital stay as compared to non-upper GI surgeons due to their experience in handling a more complex and technical demanding procedure in emergency cases.8 The ready availability of appropriate surgical expertise and adequate laparoscopic experience are essential for establishing 'hot gall bladder' pathway.

100% of patients had successful LC with no record of intra-operative or post-operative complications with low 30-day re-admission rates. Support from senior upper GI surgeons, dedicated theatre lists and online referral form are invaluable for making better patient safety and care. This helps learning, improve technical skills and confidence of providing the 'hot gall bladder pathway'. Around 30% of patients in both groups underwent the procedure beyond the recommended time frame by NICE. Limited theatre access, imaging slots, poor documentation and lack of awareness of the criteria are contributing to the non-compliance. Better theatre availability with senior upper GI surgeons support, easy access to dedicated MRCP slots, and better training and education were recommended to improve the compliance level and support its wider implementation in the Trust.

Conclusion

This prospective observational study highlighted a clear 'hot gall bladder pathway' is effective at improving care for patients requiring emergency laparoscopic cholecystectomy and potentially useful for other acute Trusts which their standard is below the national NICE guideline, despite its limitation of small sample size and not being randomised. Improvements such as dedicated MRCP slots, posters and presentation promoting awareness are made to improve the 'hot gall bladder pathway' as a safe, efficient and cost-effective service.

Acknowledgments

The authors acknowledge the contributions from other members of the team including General Surgery department, Radiology department and Information Technology department for implementation of the 'hot gall bladder pathway'.

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MRCS: Who recruits the best candidates?

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CONTRIBUTORSHIP
The authors collectively identified the idea for this research. AJL provided guidance on statistical analysis. RE carried out the analysis. RE wrote the first draft of the manuscript. All authors contributed to, edited and reviewed the manuscript.

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BACKGROUND

The Intercollegiate Membership of the Royal College of Surgeons (MRCS) examination is highly valued as a "gatekeeper" for progression into surgical higher specialty training (HST) in the United Kingdom (UK). Success at MRCS is known to predict later success at HST national selection, annual appraisals, and the Fellowship of the Royal College of Surgeons (FRCS) examination.[1–3]

These studies confirm that prior academic performance is known to be the best predictor of later success in surgical training and high performers continue to perform well throughout their training.[4] However, little is known about the relationship between performance and where trainees choose to continue their higher surgical training (HST) after completion of Core Surgical training (CT). This is important to know as the number of applications to HST programmes has fallen in recent years but, while some deaneries (the regional organisations responsible for postgraduate medical training in the UK) remain competitive, others have low competition ratios and unfilled training positions.5 More understanding of the relationship between performance and place of HST may provide insight into why some training locations are more popular than others. To address this gap in the literature, we undertook a retrospective cohort study, comparing MRCS performance across all UK HST deaneries.

METHODS

All UK medical graduates who had attempted either MRCS Part A (written assessment) or MRCS Part B (clinical assessment) between September 2007 to January 2020 with matched HST data (ST3 and beyond) were included in this study. MRCS performance data were linked by administrators at the Royal College of Surgeons of England (RCSEng) to the General Medical Council's (GMC) list of registered medical practitioners database.

Data were anonymised by the RCSEng and MRCS performance data and HST deanery were extracted. Candidate first-attempt results were used as these are known to be the best predictor of future performance in post-graduate examinations.[2] For this study, training deanery refers to the geographical location where a candidate undertook or is currently undertaking their HST as declared in their last GMC National Training Survey. The geographical area and hospitals that each deanery includes can differ between specialties, but in general, the key training sites within each deanery remain relatively stable.

All analyses were conducted on anonymised data using SPSS® v26.0 (IBM, Armonk, New York, USA). The highest standards of security, governance and confidentiality were ensured when storing, handling and analysing identifiable data.

RESULTS

Surgical training data were matched for 2910 MRCS Part A candidates and 2847 MRCS Part B candidates. The mean Part A pass rate for the entire study cohort was 65.1% (1893/2910) (Standard Deviation (SD) 47.7), the mean percentage score relative to pass mark was 4.25% (SD 13.00) and the mean number of attempts taken to pass Part A was 1.6 (SD 1.0). The mean Part B pass rate for the entire study cohort was 76.3% (2173/2847) (SD 42.5), the mean percentage score relative to pass mark was 17.19% (SD 10.50) and the mean number of attempts taken to pass was 1.3 (SD 0.6).

There was a statistically significant association between MRCS Part A (P=0.010) and MRCS Part B (P=0.036) first attempt pass rates and HST deanery. Mean Part A pass rates ranged from 59.9% to 77.7% and mean Part B pass rates ranged from 70.1% to 85.0% between HST deaneries as shown in Figure 1.

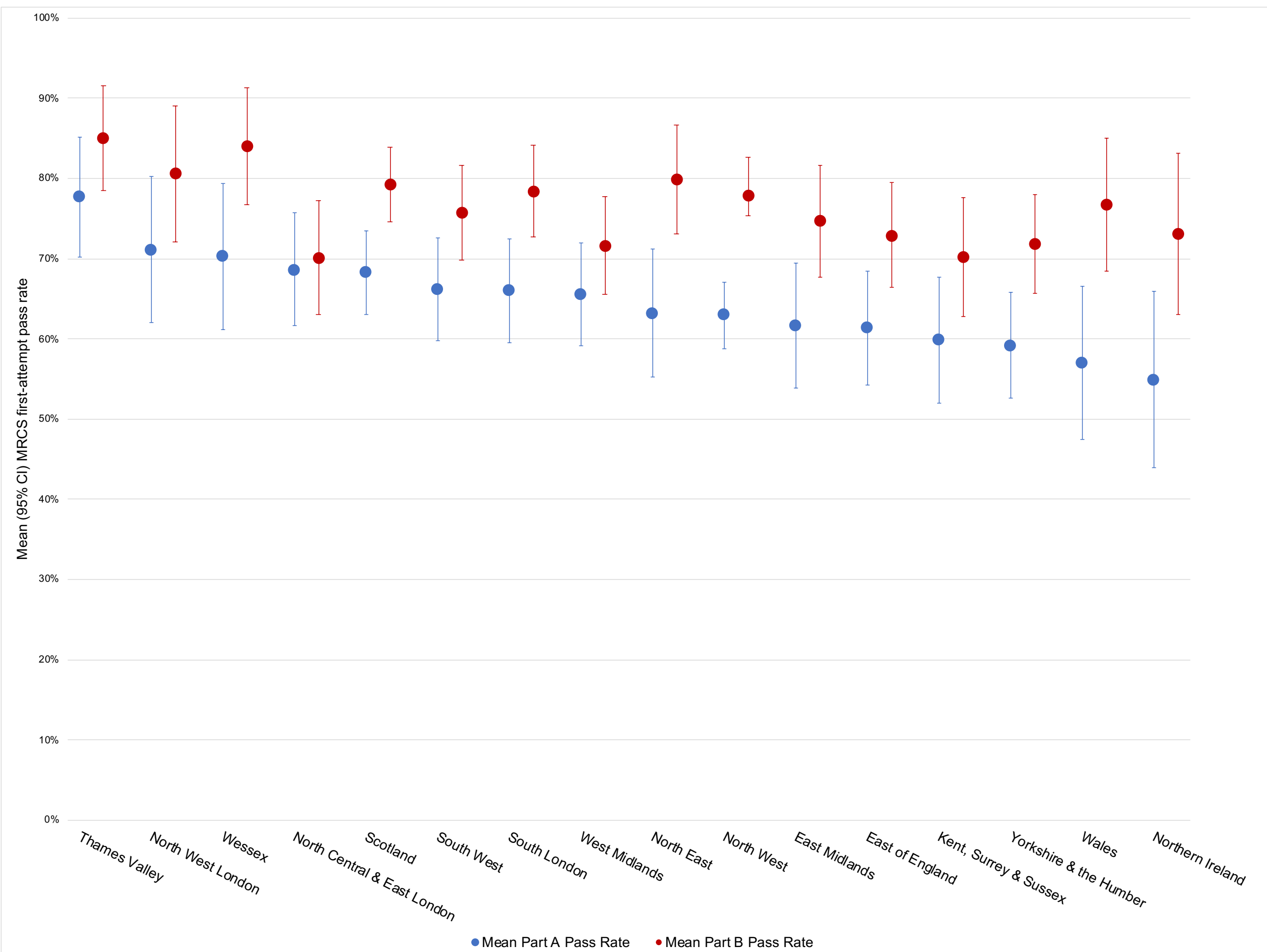

Figure 1. Mean (95% Confidence Intervals) MRCS pass rates by HST deanery. Specialties organised in descending order by MRCS Part A performance.

Mean Part A score relative to pass mark ranged from 2.0% to 9.4% and average number of attempts to pass ranged from 1.4 to 1.7 between HST deaneries. Mean Part B score relative to pass mark ranged from 13.9% to 20.7% and average number of attempts to pass ranged from 1.2 to 1.4 between deaneries. Table 1 shows the variation in MRCS performance between different HST deaneries.

Table 1. MRCS performance by training deanery. Deaneries organised by MRCS Part A performance.

		MRCS Part A			MRCS Part B		
Training Deanery	Part A Performance Ranking	First Attempt Pass Rate	Mean Percentage Score relative to pass mark (SD)	Mean Number of attempts (SD)	First Attempt Pass Rate	Mean Percentage Score relative to pass mark (SD)	Mean Number of attempts (SD)
Thames Valley	1	77.7% (94/121)	9.4% (13.8)	1.4 (0.9)	85.0% (102/120)	19.8% (9.5)	1.2 (0.5)
North West London	2	71.1% (143/201)	6.9% (12.9)	1.5 (0.9)	80.6% (162/201)	18.4% (10.4)	1.2 (0.5)
Wessex	3	70.3% (71/101)	6.6% (12.8)	1.5 (0.9)	84.0% (84/100)	18.0% (8.9)	1.2 (0.5)
North Central and East London	4	68.6% (116/169)	4.7% (12.0)	1.6 (1.0)	70.1% (115/164)	15.9% (11.4)	1.4 (0.6)
Scotland	5	68.3% (211/309)	4.5% (13.1)	1.6 (1.0)	79.3% (237/299)	20.7% (9.2)	1.3 (0.6)
South West	6	66.2% (141/213)	4.8% (11.8)	1.6 (0.9)	75.7% (156/206)	16.9% (11.2)	1.3 (0.7)
South London	7	66.0% (136/206)	5.1% (13.0)	1.6 (0.9)	78.4% (160/204)	17.5% (10.1)	1.3 (0.6)
West Midlands	8	65.6% (143/218)	4.1% (13.5)	1.7 (1.1)	71.6% (154/215)	16.2% (10.7)	1.4 (0.7)
North East	9	63.2% (91/144)	3.4% (13.7)	1.7 (1.0)	79.9% (111/139)	18.6% (9.8)	1.3 (0.6)
North West	10	63.0% (187/297)	4.0% (12.7)	1.7 (1.1)	77.8% (228/293)	17.6% (10.1)	1.3 (0.6)
East Midlands	11	61.7% (95/154)	3.1% (13.3)	1.7 (1.1)	74.7% (115/154)	15.0% (11.6)	1.4 (0.7)
East of England	12	61.4% (113/184)	3.3% (11.6)	1.7 (1.0)	72.9% (132/181)	14.0% (11.7)	1.4 (0.7)
Kent, Surrey and Sussex	13	59.9% (91/152)	2.0% (13.1)	1.7 (1.1)	70.2% (106/151)	13.9% (10.2)	1.4 (0.7)
Yorkshire and the Humber	14	59.2% (129/218)	2.4% (11.9)	1.7 (1.0)	71.8% (148/206)	14.5% (10.8)	1.4 (0.7)
Wales	15	57.0% (61/107)	0.9% (4.2)	1.8 (1.1)	76.7% (79/103)	18.4% (8.3)	1.3 (0.6)
Northern Ireland	16	54.9% (45/82)	0.5% (14.1)	1.9 (1.1)	73.1% (57/78)	19.1% (8.8)	1.4 (0.8)

DISCUSSION

We found a statistically significant association between MRCS pass rates and place of HST training (deanery). HST trainees in more popular (and therefore more competitive) deaneries such as London and the surrounding home counties[5] tended to perform better at MRCS overall. This is important. Given early performance predicts later performance in surgical training,[1–3] deaneries that attract the highest achievers are therefore likely to train doctors who continue to achieve highly in assessments taken later in postgraduate training (e.g., FRCS).

However, while there was variation in trainee MRCS performance across deaneries, it was only those at each end of the spectrum which differed significantly. This is reassuring. Moreover, where one trains will be influenced by many more factors than MRCS performance. At an individual level, these include prior exposure and experience, mentorship, personality, and sociodemographic factors.[6–12] At an organizational level, these include reputation, perceived training opportunities, location, workplace culture, social and financial factors.[5,13–15] In order to prevent certain deaneries suffering from increasing workforce shortages, further work is required to characterize the reasons behind choice of HST deanery, enabling less popular deaneries to consider how best to attract applicants.

CONCLUSION

MRCS performance is associated with HST deanery choice. Further work is required to characterize the reasons behind trainee's choice of training location, to address potential workforce shortages in less popular deaneries.

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Social Media Editor ASGBI

Mr Jonathan Epstein
Regional Representative

I was intrigued to be asked to take on a stint as Social Media Editor running the ASGBI account on twitter (@ASGBI). I had had a twitter account since November 2016 after what must have been a painful process of explanation for Richard Brady (@researchactive). Richard had worked at Salford as one of our post-CCT fellows and had been an early twitter adopter and had built a successful profile and developed significant social media expertise. As my account name suggests (@2eyes1keyboard) I'd been more of a reader than a tweeter ever since despite the prodding of my colleague Lyndsay Pearce (@lyndsay_pearce1).

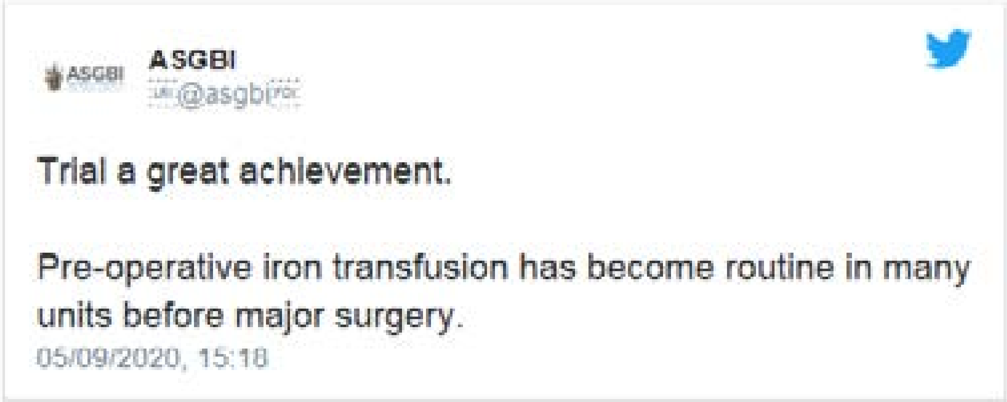
ASGBI had run a twitter account since January 2010 run by the brilliant office team and the account mainly acted to promote ASGBI events. From Summer 2020 access to the account was also given to an ASGBI regional representative and the first to take a turn was Cleo Kenington (@CleoKenington).

I took over from her to start my two months at the helm in September 2020. After a nervous start I settled in to a routine. I would spend 20-30 minutes each morning scrolling through the ASGBI feed and I would like and re-tweet a range of tweets that I thought would interest those following the ASGBI account. These would include research results across the breadth of general surgery and particularly emergency general surgery, forthcoming meetings and webinars, tweets about training and particularly tweets regarding equality and diversity in surgery. I would monitor responses during the day noting which re-tweets generated likes and followers. I'd been set a target to get the account up above 11,000 followers and it was pleasing to see that happen and I'm delighted that it now has over 12,000 followers.

I did feel a responsibility to handle the account professionally as the public face of ASGBI and I had a couple of near misses where I nearly re-tweeted jokes or Manchester City related matters when I thought I was logged in to my personal account but suffered no major mis-tweets. I didn't actually initiate many tweets directly focusing instead on curating the account through likes and re-tweets and it was great that the office team were still producing professional looking tweets promoting ASGBI events.

A selection of tweets follow below to show what I tried to do.

A response to the PREVENT trial.....



ASGBI
@asgbi

Important message.

"Rare/difficult operation" is an operation with steps - it's an opportunity for training....
06/09/2020, 06:38

A response to the PREVENT trial.....

And the most liked tweet of my 2 months celebrating the appointment of Gill Tierney....

ASGBI
@asgbi

We are delighted to announce that Miss Gill Tierney has been elected as ASGBI's Vice President for 2021 and 2022, and will thus become President for 2023 and 2024. Congratulations to Gill, we look forward to the next four years. #womeninsurgery pic.twitter.com/Yy7IAGg6Ti
10/09/2020, 14:37

All things come to an end and the tweets below marked the handover to Kamal Mahawar who took the account from strength to strength. I'd thoroughly enjoyed the experience and am very grateful for the opportunity.

ASGBI
@asgbi

Many thanks to @2eyes1keyboard for his stint as Social Media Editor for September and October. We now welcome @kmahawar as our social media editor for November and December.
05/11/2020, 13:11

Jonathan Epstein
@2eyes1keyboard

Thanks @asgbi - thoroughly enjoyable and interesting experience. Thanks to @researchactive for teaching me what Twitter was and @lyndsay_pearce1 for the advanced coaching. Thanks to everyone who engaged. Good luck @kmahawar - hope you enjoy it as much as I have...
05/11/2020, 21:09

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Challenges and Opportunities in Modern Surgical Practice: The Perspective of the Aristotle University School of Medicine

Introducing our Guest Editor Georgios Tsoulfas

Dr Georgios Tsoulfas received his medical degree from Brown University School of Medicine and completed his general surgery residency at the University of Iowa Hospitals and Clinics, as well as a transplant research fellowship at the Starzl Transplant Institute at the University of Pittsburgh. He then completed a two-year transplantation surgery fellowship at the Massachusetts General Hospital, Harvard Medical School and then joined the Division of Solid Organ Transplantation and Hepatobiliary Surgery at the University of Rochester Medical Center as an Associate Professor of Surgery. He has currently moved back to Greece, where he is an Associate Professor of Surgery and Chief at the Department of Transplantation Surgery at the Aristotle University of Thessaloniki School of Medicine. He has published over 100 papers in peer-reviewed Journals and in PubMed, as well as 35 book chapters. He has edited 6 books and is a reviewer for 30 International Journals and on the Editorial Board of several others.

Dr Tsoulfas is currently the World President of the International College of Surgeons and Chair of the International Relations Committee of the American College of Surgeons.

His clinical and research interests include hepatobiliary surgery, primary and secondary hepatic malignancies, ischemia/reperfusion injury, solid organ transplantation, as well as medical/surgical education and the use of technology.

Challenges and Opportunities in Modern Surgical Practice: The Perspective of the Aristotle University School of Medicine

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Receiving the invitation by Professor Papalois to be the Guest Editor for the September 2021 issue of the Association of Surgeons of Great Britain and Ireland (ASGBI) e-journal "ASGBI SURGICAL LIFE" was truly an honor, as well as a challenge and an opportunity. The challenge was to showcase some of the different ways that Technology and Artificial Intelligence are affecting current (and definitely to a greater extent future) surgical practice. The goal is to present the various forms that information technology, machine algorithms and machine learning are shaping the present and future of surgery in several specialties. This is done with the help of surgeons who are experts in their field, ranging from general to vascular surgery, neurosurgery, orthopedics, and transplantation surgery. What is critical and also apparent in all these papers, whether the authors are surgeons or not, is the absolute need for collaboration between surgeons and experts in the various technological fields (not surprisingly, they also have specialties!), so that we can realize the biggest possible benefits for our patients. We can learn from each other and the benefits will be additive. Another important aspect, as discussed in the ethics paper, is the need to acknowledge the fact that technical innovations in medicine may have significant implications on several different levels, including moral and ethical issues, in addition to the health and financial ones. It is my belief that as we are moving into a "brave, new future", we as surgeons need to make a conscious effort to learn the advantages and disadvantages of the various technical innovations, so that we can help decide what is best for our patients. The most effective way to do that is by starting the education process at the level of the medical students and residents, especially given the technological familiarity exhibited by them.

The second benefit of accepting this gracious invitation, was the opportunity to present to a greater audience some of the various changes at the Aristotle University School of Medicine in the last several years. It should come as no surprise that the challenges facing a public Medical School, especially in a country that was particularly hard-hit by the global financial crisis, are multiple and only seem to be increasing. However, there comes a time when we have to rise to the challenge and instead of problems, see opportunities to improve ourselves. This has been the mentality of not just the leadership, but also of all the medical students, faculty and personnel. The result has been essentially "opening a window to the world" through initiatives such as the Hellenic Diaspora Medical Forum and the Aristotle Medical Forum, but more importantly through the introduction of the first ever in Greece English speaking Medical School Curriculum to attract international students, the establishment of the Special Unit for Biomedical Research and Education (SUBRE), which will be a key in enhancing biomedical research, as well as an interdisciplinary approach to medical research. These initiatives have signaled a future where academic integrity and creativity is accompanied by an extroverted attitude, which will allow us to offer better health care to our patients and a great educational experience to our students.

Special Unit for Biomedical Research and Education (SUBRE) From the School of Medicine, Aristotle University of Thessaloniki (AUTh)

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Aristotle University of Thessaloniki

School of Medicine, Aristotle University of Thessaloniki:

The School of Medicine is one of the four Schools of the Faculty of Health Sciences, Aristotle University of Thessaloniki. It was founded as Medical Faculty of the Aristotle University of Thessaloniki in 1942.

The main goal of the School of Medicine of the Faculty of Health Sciences, Aristotle University is to educate the medical students as well as to provide Greece health professionals with the highest scientific standards. An additional aim is to make high quality research either by itself or in collaboration with other Greek and international research centers. During their undergraduate studies the students participate in various research programs of laboratories and departments. These outcomes are mainly presented in the annual Medical Congress of the School of Medicine.

The main educational goal of the School is the dissemination of ethical values that govern the medical practice to students as well as to ensure that the young medical doctors will acquire all scientific knowledge which will enable them to diagnose and effectively manage medical problems after obtaining their degree. Moreover, the faculty of the School of Medicine is the stuff of several hospitals as well as other units of the National Health System, and thus provides an important social work.

The organization of School of Medicine, Aristotle University of Thessaloniki has nine Sectors: Anatomy and Pathology, Physiology and Pharmacology, Biological Sciences and Preventive Medicine, Radiology - Medical Physics and Informatics, Sensory Organs, Child's Health, Neurosciences, Surgery, and Internal Medicine.

The School of Medicine of the Aristotle University of Thessaloniki is one of the most important and well-established Schools of Greece, both quantitatively and qualitatively, comprising the biggest School in the country regarding its enrollment, having more than 4.000 registered students, 58 departments, 26 laboratories and 331 Faculty Members (Academic Professors).

The decision to establish the Special Unit for Biomedical Research and Education (hereinafter referred to as 'SUBRE') has resulted from the Senate's conviction that the high quality of healthcare services is a fundamental societal demand and should be based on interdisciplinary scientific approaches that comprise mainly medicine, biology and technology. The ongoing advancements in molecular biology, genetics and pharmacology constitute essential factors for the effective provision of healthcare service while combined with biomedical informatics, they can contribute to effective diagnostic and therapeutic approach of patients. Also education and training for medical doctors and healthcare professionals, is one of the top priorities for every Academic Organization.

The School of Medicine is AUTh largest School and it was recently ranked in an international evaluation as top among the country's seven University Schools of Medicine. Its human resources are of high quality, with faculty members that spent many years of postgraduate education and professional training abroad and who continuously produce a high level of scientific and clinical workload. Therefore, SUBRE founding is considered necessary for it will facilitate the collaboration and interaction between the School of Medicine and scientific groups from other University Schools with relevant research interests, as well as institutions and/or companies dealing with biomedical research, medical education, Continuing Professional Development and the provision of quality healthcare services. Furthermore, establishing SUBRE will contribute substantially to the added value of the innovation zone of the School of Medicine and of the Aristotle University of Thessaloniki, as well as to the city of Thessaloniki and generally to Northern Greece.

SUBRE supports and promotes biomedical research and education based on interdisciplinary approaches. For meeting its scope SUBRE sets three units:

1 -Basic and Translational Research Unit, 2 - Clinical Trials Unit and 3 - Precision Medicine Unit. Education and Training is an horizontal activity and collaborative units support this goal (Figure 1 – Organizational chart, and Figure 2 – Collaborative units).

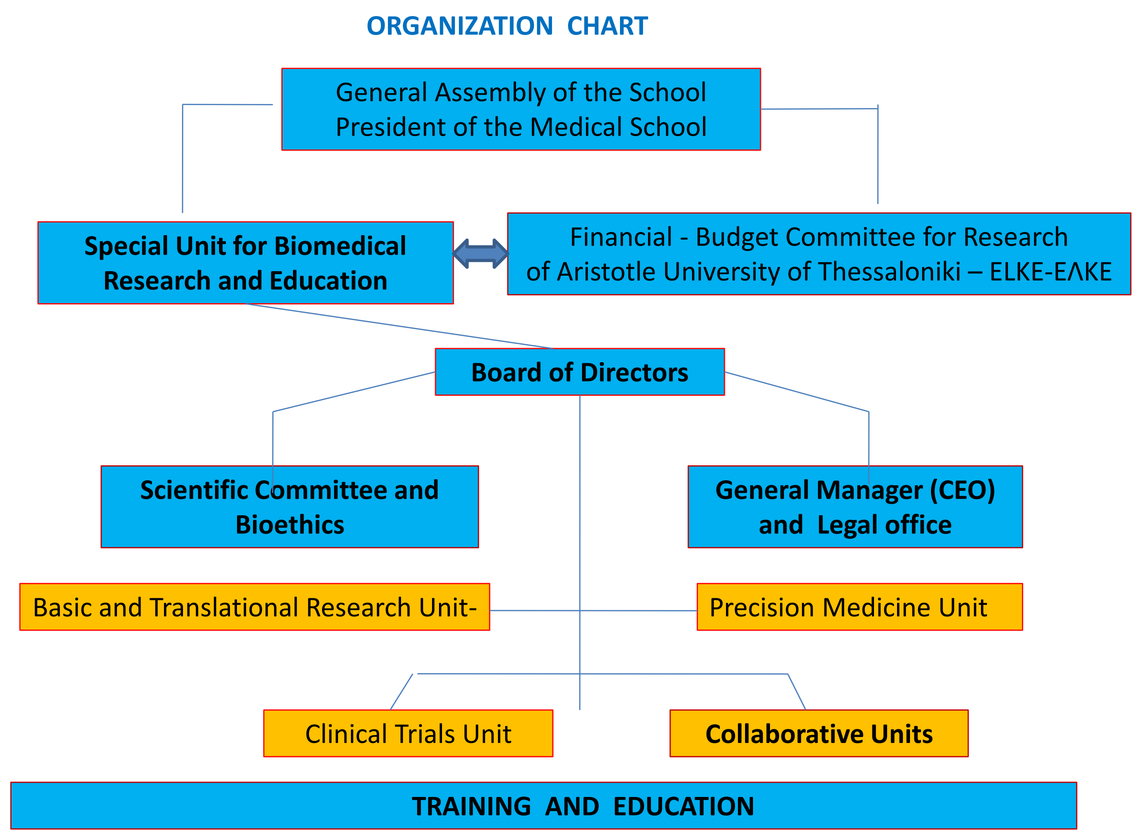

Figure 1 – Organizational chart

Collaborative Units

1 – Experimental – Research Lab
University Hospital "Papageorgiou"

2 - Veterinary Surgical Unit,
Department of Veterinary Medicine
School of Health Science

3 – Anatomy Lab, School of Medicine

4 - KEDEK – Center for Inter Scientific Research and Innovation

Figure 2 – Collaborative units

The aim of the SUBRE is to support and promote biomedical research and education based on interdisciplinary approaches :

- Facilitating two-way collaboration between various medical, dental and pharmaceutical specialties as well as other subject domains within the health sciences, biomedical engineering, molecular medicine, pharmacogenetics and biotechnology.
- Developing biomedical research in basic biosciences, in the area of translational research and applied biomedicine, in order to deliver quality, safe and continuing healthcare services to citizens, focusing on prevention and on -superior management of diseases.
- Creating, evaluating and standardizing innovative research and educational products, systems and services, as well as establishing spin-off and start-up companies in order to support and bring up to the market innovative applications / products for biomedical practice.
- Creating a meeting and working point for the academic community and biomedical research industry, aiming to come up with solutions to the interdisciplinary and complex problems in the field of biomedical research.

Facilities used from SUBRE for Education and Training:

1- Experimental – Research Center, University Hospital "Papageorgiou".

Three operating rooms for mammals (swines, rabbits, rats and mice) and and amphitheater of 300 seats.

2- Laboratory of Experimental Research and Training, Department of Veterinary Medicine, School of Health Science.

One large operating theater with 9 surgical tables, 1 seminar room (150 seats).

3- Department of Anatomy, School of Medicine, Aristotle University of Thessaloniki.

One large operating theater with 12 dissection tables (12 cadavers total capacity), 3 lecture rooms (40-80 seats each) and 1 amphitheater (250 seats).

4- KEDEK - Center for Inter Scientific Research and Innovation. Many seminar rooms and space for training as well as two amphitheaters (200 seats each). Also KEDEK serves as collaborative unit for the use of advanced simulators and new training methods.

Mission and Vision of SUBRE:

Continuing medical education and education for healthcare professionals is a lasting and growing need for all the counties around the world. Adaptation of new technology and methods, skills, essentials, technical and non - technical skills, as well as guidelines in pre- as well as in post-graduate level, is a process that dominates the present and the future of all healthcare systems.

At the same time, pre-clinical and translational research, is the only reliable and acceptable process internationally, for the development of new products with applications to humans.

Our mission is high quality healthcare services to patients and high quality education.

Our vision is the SUBRE, to become an international center research and to be the incubator and the bridge among continents, for the development of innovative medicines and therapies, and to educate and train medical doctors and health care professionals, under a common framework of values and principles.

SUBRE website:

https://www.subre.auth.gr/en/home/

School of Medicine, Main Building.

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AUTh and KEDEK

KEDEK – Center for Scientific Research and Innovation.

Papageorgiou Lab- Surgical Unit 1.

Amphitheater of Papageorgiou Hospital

Microsurgery Course

Anatomy Course

Robotic Surgery in Greece: Current Status and Future Perspectives

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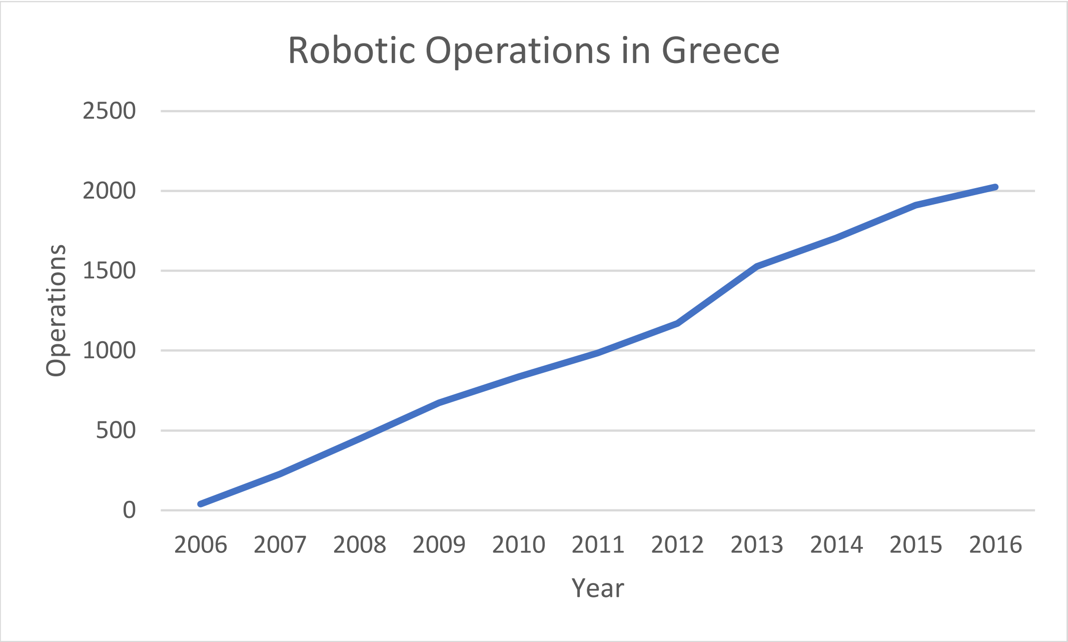
The upcoming September marks 15 years from the first robot-assisted operation realized in South-Eastern Europe. It was in Athens Medical Center where a patient with symptomatic cholelithiasis had undergone a robotic cholecystectomy with the da Vinci standard system.

One and a half decade later, most private hospitals operate a robotic system with many of them owning 2 or more platforms. On the other hand, only one public hospital recently acquired the technology while another teaching hospital no longer operates the system. Of note, the worldwide adoption of robotic technology in surgery coincided with a devastating financial crisis in Greece, which had direct impact on hospital spending, thus limiting investments in new technologies.[1]

Fortunately, the austerity measures implemented did not influence private hospitals investments and as soon as the technology became available to many surgical specialties – mostly general surgery and urology – Greece showed a remarkable interest in the new coming technology. As shown in our recent publication[2], robotic surgery has been received warmly in Greece by both surgeons and patients, although at the beginning direct costs were higher when compared to conventional laparoscopy or traditional open techniques. No matter the unwelcoming and uncertain financial environment, robotic surgical technology made its debut successfully and recorded a remarkable increase in the number of procedures performed throughout the first decade. [Figure 1]

Figure 1.



Besides increasing numbers of patients operated robotically, Greek surgeons also had great interest in publishing their results. [2] Of note, the world's first robotic single site cholecystectomies with excellent results and no reported complications were published by our team.[3]

Although not yet extensively used in the public healthcare sector, its steady adoption and reported encouraging results will embolden patients and surgeons to its wider use in the context of future economic regrowth. With more platforms soon to enter the market, the costs to acquire the technology, to perform maintenance and the price of intra-operative disposable instruments are believed to decrease in the future, making the technology more cost-efficient and affordable.

The future is bright and extraordinary in terms of surgical education too. We recently witnessed the never-ending potential of technology, as a surgeon using 5G network proctored a resident performing a minimally invasive colorectal operation from miles away.[4] As published before, using an ultra-high-speed communications network, allows for a proctor to guide a less-experienced surgeon throughout an operation in almost real time, with very low rates of data loss and minimal latency.[5]

In our opinion, the combination of robotic technology with 5G networks, could open endless possibilities in the future in terms of education of residents and fellows. Dual robotic consoles already allow for quality education. Telementoring could very well be the first step towards telesurgery if this technology could allow patients access to expert surgeons.

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3D printing and its role in surgery

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Introduction

3D printing is the latest of means and techniques that aim to visualize tissue damage and assist in therapeutic diagnosis and intervention through detailed localization of it. This method utilized 3D digital models derived from medical imaging data providing unprecedented immediacy for pre-surgical training, or diagnostic visualization[1].

The innovation began with the use of x-rays and the recognition of the internal structure of human organs and of course with the discovery of tomographs that enabled the creation of three-dimensional geometric recording (scanning) and the ability to reconstruct the complete 3D structure of tissues[2].

The evolution of modern CT scanners, the creation of specialized computer systems that accompany them and the integration of algorithms based on advanced digital image processing techniques and machine learning have made it possible to create 3D models of not only the bones that are easily separated from the neighboring tissues (fat, skin, muscles and other material) of the human body but also other structures in the patient's body such as the solid abdominal organs. These structures can be reconstructed to virtual 3d models. This process offers opportunities for versatile visualization and tangible exploration of these medical 3d models. Combining Virtual Reality (VR) projection and 3D printing techniques, very powerful, impactful interactions can be achieved in Surgery[3]. Pre-surgical preparation, training of residents and patient pre-surgical preparation, all become seamless, visually engaging processes instead of difficult time-consuming endeavors that can be presented both in computer screens and projected in Virtual and Augmented Reality[2]. Also, 3D printing can be used to create personalized or on demand surgical tools that a physician can order or even design himself (but mainly in collaboration with expert modelers) to optimize one or more of his surgeries. Such 3D printed surgical instruments have been used by the US military and navy for many years in remote missions where the supply of consumables was, if not impossible, at least difficult and time consuming[4].

Finally, in the field of general medical education, the 3D models of organs lesions that can be produced to normal size (1: 1 scale) provide optimal immersion and awareness of the disease for the treating physician but also enable the surgeon to apply many alternative treatment approaches through simulation pre and post surgery time[5].

3D printing technology

The demand for 3D printing in medicine began around the same year as the growing demand for customized 3D printing and occurred after 2009. In 2009, a US startup company “Makerbot industries” created the first 3D printer model based on the RepRap project[6] model that was the first open source (GPL 2) 3D printer. By March 2011, Makerbot industries had shipped 3,500 units of the first 3D printer to its customers[7]. The technology on which the operation of the first models of 3D printers that were created in mass production was based is Fused Deposition Modeling[8] (FDM) which has advantages that are mainly:

1) The low cost of raw material,

2) The low temperature development of the extrusion head (approx. 200°C) for melting the thermoplastic material and the table used for the integration of the “frozen” material with the fluid material. The high temperature parts are limited in a specific place inside 3D printer making it completely safe for the end user,

3) The extended maximum dimensions of the reproduced models,

4) The relatively high quality that has to do with the resolution and accuracy of creating 3D models by the printer,

5) The low cost of both the device and the raw material.

For more details on the above technical features of 3D printers the reader can find the appropriate information from the sources[9].

An important parameter that can play a very important role in the functionality of 3D prints that can be used in surgery is the possibility of colorful prints in a single model or even the creation of models with high durability or with properties that may differ from the usual ones.

3D printing, as was outlined, is taking front and center stage in surgical training and practice. This work presents 3 diverse use cases of 3d printing in surgery for pre-surgical planning, anatomy training using VR and tool manufacture. Demonstrating the simplicity, immediacy and clinical applicability of these use cases is the core rationale of this work.

Case study 1-3D printing to assist difficult surgeries

In the framework of research conducted in Greece, members of the research teams of the “Papageorgiou” General Hospital of Thessaloniki, the first University Surgery Clinic of the Aristotle University of Thessaloniki, the Department of Rural Surveying Engineering of the Aristotle University of Thessaloniki and two SMEs Vidavo and Conmet, 3D printing of patients’ liver models are used to assist difficult tumor removal operations. The aim of the research is originally the digitization and 3D modeling of the geometric characteristics (parenchyma, lesion, and vessels) of the liver of patients with solitary (benign or malignant) tumor in order to facilitate the process of its removal by the treating physicians.

A special protocol was created through which patients with a specific disease are first admitted to the First University Surgery Clinic located at the “Papageorgiou” General Hospital of Thessaloniki and undergo the necessary CT examinations at the radiology department of the Hospital. The digital files of the examinations (DICOM) are properly processed using the Nvidia’s Clara Artificial Intelligence - AI assisted annotation tool[10] for liver parenchyma and tumor extraction and custom thresholding algorithms for internal veins and arteries reconstruction. After the digital file of the 3D model is created, the parenchyma, the hepatic vein, the portal vein, and artery as well as the tumor all appear together as separate entities in a single digital model file (standard wavefront .OBJ format).

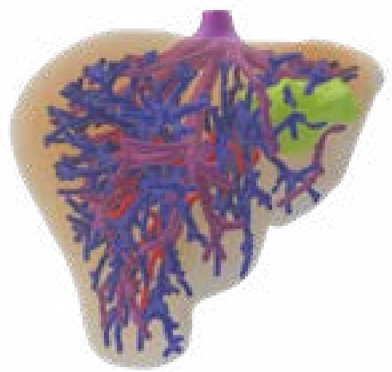

Figure 1. Digital image of the 3D model as it has been generated as a single 3D model file. With brown color, the Liver’s parenchyma, with blue color the portal vein, with purple color the hepatic vein, with red color the hepatic artery and with green color the liver’s tumor.

The digital file (Figure 1) is used by specialized slicing software that prepares the printhead driver files of a 3D printer to create the final model in normal size (1:1 scale).

Because most common 3D printers produce monochrome prints and there is a need to separate the different tissues into a single 3D printed liver model, a common 3D printer (Prusa i3 MK3s)[11] is combining a special filament synthesizing unit (Mosaic Palette 2s)[12] able to generate a multicolor filament which is feeding properly the printer's extruder to generate a multicolor model (up to four different colour filaments). A special processing unit (raspberry pi-octopi) and a driving software is also used to assist the complicated process to generate the final liver model with the vessels, parenchyma and tumor in a single structure (Figure 2).

Figure 2. The printed model of the above-mentioned case. The model has been used to assist the surgeon for his treatment approach. With red color, the liver's parenchyma and artery, with blue color, the portal vein and with purple color the hepatic vein and tumor. The liver's parenchyma is divided in two parts. The second part is displayed with transparent color.

The key to this research is both the creation of a single and accurate model of the liver and the use of a common 3D printer to create a colorful print. 3D polyjet printers that produce colorful prints with materials that have special plastic properties and opacity are also available in the market, but the cost of these printers is extremely high as well as of the consumables, while the maintenance cost of such an "industrial" printer is correspondingly high[13].

Our aim is to eliminate the cost of the printing system that will be used for a similar printing of a liver model in full size (scale 1:1) and should not exceed 1000-2000 euros while the consumables should also be at a low cost (e.g. 40-60 euros per kilo).

The final result confirms the success of the project of creating a low-cost system that can create after proper processing of DICOM images a 3D model of a patient liver at a cost of less than 100 euros/incident.

Case study 2-3D printing for educational purposes in surgery and neuroanatomy

In the framework of the ENTICE Knowledge Alliance project[14], we explore the novel educational approach of intertwining 3d printed models with augmented reality functionality on mobile devices, smart glasses (e.g. MS HoloLens) and VR.

The medical topics of the project focus on the surgical anatomy elements of the hepatobiliary system and basic/intermediate neuroanatomy. The first case concerns the printing in full size (scale 1:1) of the parenchyma, circulation and biliary system of one normal liver (without pathological findings). This printed model will be used to project on it, through an AR application pathology and specialized morphology of the circulatory biliary vessels. Since the AR camera is trained and recognizes the scale, position and orientation of the printed model the digital models pertaining to pathology and pathophysiology of the biliary system and the vessels will be projected as augmentation through the augmented reality system (Figure 3).

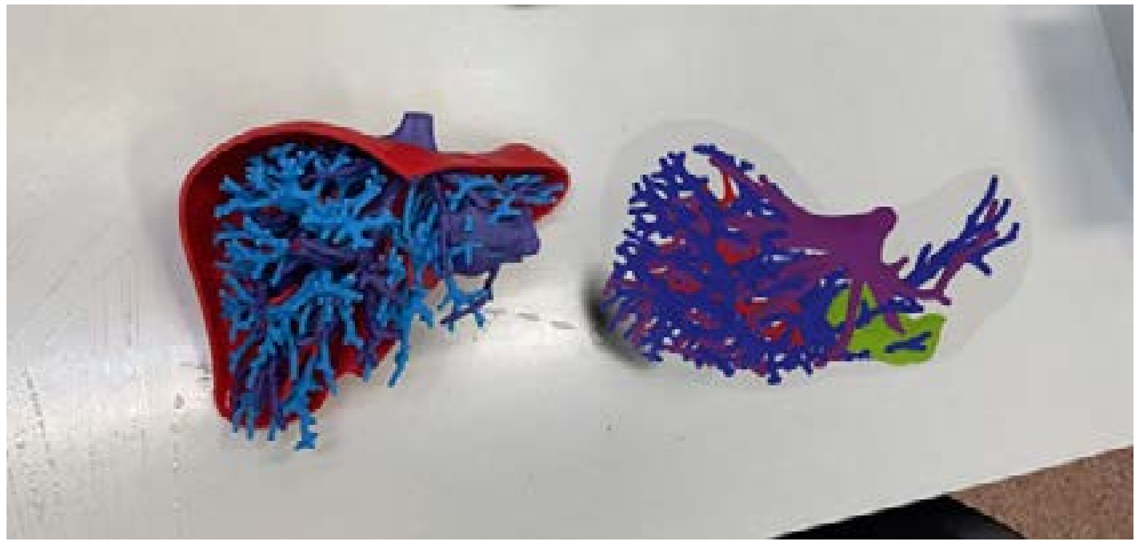

Figure 3. The 3D Printed model in contrast to the Augmented Reality (AR) model. On the left side the 3D Printed model and on the right side the AR Model.

Similar to the hepatobiliary case, the 3D model of the normal neuro anatomy human system has been obtained, which includes, among others, the complete nervous system starting from the brain and ending in the lower part of the spinal cord (figure 4).

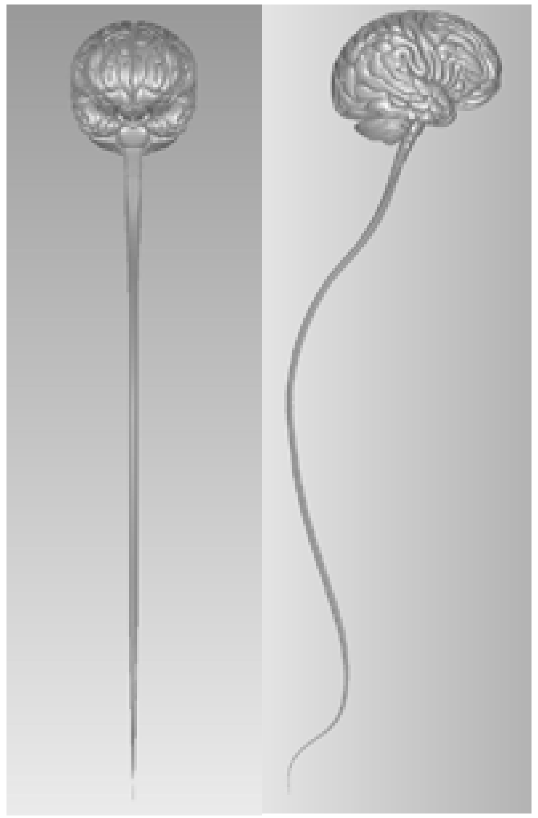

Figure 4. A 3D model of the human brain with the spinal cord.

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3D printing models of these scales has presented its own unique challenges. Vertebrae and intervertebral discs have been integrated in the print for practical reasons, in order to maintain structural integrity of such a large model. Additionally, this approach allows for better image recognition for AR algorithms, in order to identify specific parts of the Central Nervous System (CNS) (Figure 5) in the spinal cord (Figure 4) but also to tangibly demonstrate the relationship of the skeleton with the nervous system. Because the model is large enough to be printed in its entirety on our available printer, it has been printed in pieces (Figure 6,7) later to be joined using magnets.

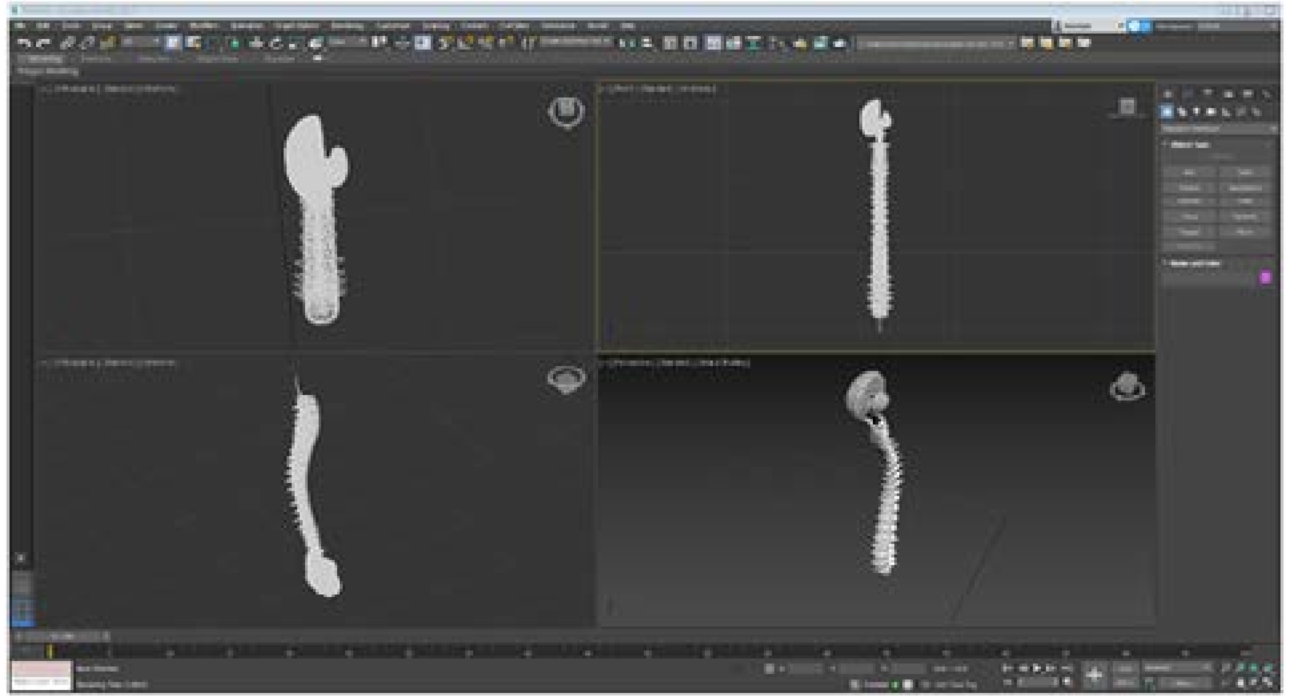

Figure 5. A 3D model of the Central Nervous System.

Figure 6. 3D Printed model of Lumbar spinal column using FDM technology. With magenta, the main model and with white color, the Polyvinyl alcohol - PVA water soluble support structure.

Figure 7. 3D printed model of right and left lobe of the human brain.

Case study 3-3D printing of surgical tools

Interplanetary travel does not belong to such a distant time in the future. Space agencies have already sent unmanned missions to Mars and the moon and are preparing manned missions. Extensive research is being conducted at the medical level to create 3D printed tools for remote missions and the goal is to produce custom (when and if needed) tools to treat diseases that will accidentally occur to crew members. Sure, a space mission is equipped with first aid kits to deal with any accident, but to deal with a special surgical case, the use of a 3D printer can help to print special tools or consumables in the context of surgical treatment of an incident. Moreover, there exist places worldwide where goods supply is difficult and sometimes 3D printed surgical tools would be the optimal solution (Figure 8).

However, in any of the above-mentioned cases there is an issue with the mechanical properties (durability) but also the antimicrobial properties of the 3D printed tools. Objects printed from common thermoplastic material used in most everyday prints (Polylactic acid -PLA) have limited mechanical strength properties but there are filaments that have better characteristics (Polyethylene Terephthalate Glycol - PETG and Acrylonitrile butadiene Styrene - ABS). Also, many companies that produce FDM 3D printers have experimented with printing consumables that have even better mechanical properties such as carbon fiber-enriched filaments or other metallic elements such as copper. In addition, research has been conducted by researchers to detect the antimicrobial properties of copper filaments prints[15, 16, 17].

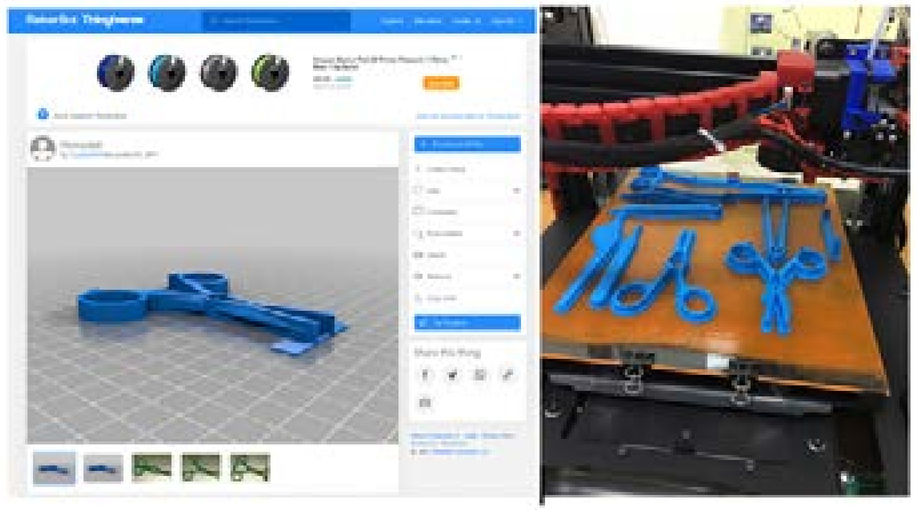

Figure 8. 3D models of surgical tools are easy to either purchase for low cost or download from thingiverse[18] or other 3D models online repositories. Their printing is also easy to achieve[19].

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An equally important discovery was the use of silver nanoparticles used as a coating for 3D printed tools to enhance their antimicrobial properties[20]. Finally, let us not forget that the thermoplastic material melts at 200°C and already acquires an initial surface free of germs. However, the overall printing system must operate in a sterile environment and have the appropriate specifications and certificates so that the produced printing model acquires antimicrobial properties at birth. For this reason, many researchers have applied the application of tools with silver nanoparticles to enhance their antimicrobial **properties.**

Conclusions

New technologies certainly contribute greatly to surgical practice, and we could say that 3D printing technologies will also play an important role in the future development of this particular field of medical science.

Before 3d modelling the surgeon had to prepare their preoperative plan by mental visualization based on medical imaging. CT and MRI scans, image fusion and radiology consultations were needed to identify a viable surgical pathway for lesion excision with minimal side-effects. Education on the same topics was also based on medical imaging data, memorization of characteristic images and previous experience. Surgical equipment was bespoke, expensive and externally provided through a complex logistics chain that identified and validated these tools for the surgical theater.

This work aimed to demonstrate how, with a very low cost, non medically dedicated 3d printer, several proof of application use cases can be realized. From the creation of patient specific 3d prints for direct pre-surgical planning, to surgical anatomy training for residents, to emergency surgical tools replacement, a holistic, self-sufficient approach emerges.

Through 3D printing technologies, surgical units can become more effective, more resilient and can tangibly improve the level of healthcare provided.

In that road there are, still, several limitations. Validating the quality of the 3d printing for surgery is essential, given the severity of possible failure. An integrative, patient specific, education-centric approach for both pre-operative planning and resident training is required, to avoid an ever encroaching "technological gimmick" viewport for these impressive new technologies.

Concluding, 3d printing, along with other experiential technologies can be an effective capacity multiplier for the modern surgical department. Initially be to Its advent could facilitate a new level of interdisciplinary collaboration, creating a new branch of professionals with rich knowledge both at the level of anatomy and radiology but also of image processing and 3D modeling in specialized software. That way, compact effective, highly resilient, and cost-efficient surgical units can be evolved.

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Expanding role of technology in liver surgery

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The introduction of technology, and particularly minimally invasive technology, has dramatically changed the landscape of liver surgery over the past decades. Since its initial implementation in the 1990s, laparoscopic liver surgery has been increasingly used for minor and major resections.[1–3] Laparoscopy has been associated with no higher mortality and has demonstrated several benefits for the patients when compared with open liver surgery.[1] More specifically, for minor-only liver resections – resection of two or less segments – laparoscopy has been associated with fewer overall complications, less blood loss, lower transfusion requirements, and decreased length of hospital stay, while operative time and resection margin rate were not found to be different when compared to open liver resection.1 The results reported for major-only liver resections – resection of three or more segments – have been similar with the exception of transfusion requirements, which have been equivalent between the laparoscopic and open approaches.[1] According to the second international consensus on laparoscopic liver surgery held in Morioka in 2014, laparoscopic minor liver resection had been established as a standard practice, while laparoscopic major liver resections were described as "still innovative procedures in the exploration phase".[4] Starting in the early 2000s, the implementation of robotic technology in liver surgery has allowed for improved three-dimensional vision intraoperatively, elimination of hand tremor, and more comfortable operating circumstances for the liver surgeon.[3] Although robotic liver surgery has been associated with similar patient outcomes when compared with laparoscopy for both minor and major resections[3,5–7], recent evidence suggests it may not be as cost-effective as laparoscopy, particularly in low-volume liver centers.[5,6,8] A recent systematic review and meta-analysis utilized the cumulative summative methodology and demonstrated that the learning curve for laparoscopic liver resection was 50 cases (range 25-58) and for robotic liver resection was 25 cases (range 16-50).[9] The authors concluded that the overall learning curve for minimally invasive liver resection has steadily decreased over time, and it appeared less steep for robotic compared with laparoscopic liver resection.[9] Recent data from an expert high-volume liver center have demonstrated the gradual improvement in performance and outcomes of minimally invasive liver surgery as experience grows and also emphasized the importance of shortening the learning curve.[10]

The major concerns limiting broader adoption are related to the technical challenges, anatomic complexity, and oncologic adequacy of minimally invasive approaches to liver surgery.[1] Emerging technology in imaging techniques in the recent era might be of value in overcoming such impediments. Intraoperative ultrasonography (IOUS) in liver surgery, particularly in laparoscopic liver surgery, has been very useful in better understanding the complex anatomy and improving the accuracy of staging for liver malignancies as assessed by preoperative computed tomography (CT) and magnetic resonance imaging (MRI) scans. For instance, the use of IOUS has been reported to affect or change the clinical management in approximately 50% of patients with liver cancer undergoing resection.[11] Depending on the indication for which IOUS is utilized, all segments of the liver can be evaluated, including the difficult posterior portions of segment 7, and the paracaval portion of the caudate lobe. Additionally, IOUS can be particularly useful for the evaluation of aberrant anatomy that is often encountered. These might include a replaced right hepatic artery arising from the superior mesenteric artery and coursing posterior to the portal vein or a replaced or accessory left hepatic artery arising from the left gastric artery and coursing through the ligamentum venosum. Evaluation of the venous system can also be performed depending on the type of liver operation since accessory hepatic veins are not uncommon.[11]

Another advent that has notably improved the accuracy of preoperative evaluation and planning for patients requiring liver surgery is the preoperative three-dimensional visualization of CT or MRI imaging studies, a process known as virtual reality. With the use of liver planning computer software and within 5 to 75 minutes[12], two-dimensional images from CT or MRI scans can be assessed in three dimensions to allow for enhanced oncologic evaluation of liver lesions, as well as to ensure that the post-hepatectomy liver remnant can adequately regenerate to its pre-hepatectomy volume.[13] Currently available software tools allow for preoperative assessment of liver volumetry and careful planning of the liver resection margins based on virtual anatomic images. Data from three centers in the United States highlighted the ability to accurately predict postoperative liver volume using preoperative planning software and underlined the importance of such a tool given the limitations of the relevant current calculation-based methods[13] These calculation-based methods represent an easy approach to predict standardized hepatic volumes but appear to be inadequate when capturing volumes at the extremes of the size range. Information generated from such computer software tools is very helpful in the armamentarium of the liver surgeon to better evaluate tumor resectability by assessing tumor location relative to the surrounding major vascular and biliary structures, which in a number of cases has changed the management plan.[12,13] Virtual reality has found application not only in open but also in laparoscopic liver surgery.[12]

Similar to virtual reality, augmented reality (AR) has also been applied in liver surgery. AR allows for a composite view by superimposing a computer-generated enhanced image on the operating field. It has found application in the resection of several liver malignancies and has proved its usefulness in assessing tumor disappearance after neoadjuvant chemotherapy.[12] A major challenge of the broader implementation of AR is the accuracy of its registration to the specific anatomy of each individual patient, which is usually confirmed by IOUS. This poses a significant issue, especially in minimally invasive liver surgery, as the intraoperative pneumoperitoneum can lead to surface deformation and inaccurate registration.[12] The registration process in most reports has been manual, however, semiautomatic registration approaches are being developed and tested. Although the accuracy achieved by AR navigation lies within a reported mean error of 5.4 mm (0.9-10.6 mm), several methods have been proposed to improve accuracy. For open liver surgery, this might include respiratory gating or registration only during the expiratory phase, while other reported approaches, particularly in robotic liver surgery, might include using surface and intraabdominal landmarks or even the tumor and a gating clip as registration landmarks[12] Overall, margin-negative liver resection has been successfully performed using AR guidance, while deformation caused by the surgeon when manipulating the operative field has also been a reported challenge. Intraoperative imaging modalities, such as a low-dose intraoperative CT scan with an optical tracking system trailing the endoscopic camera or a three-dimensional IOUS, have been used to achieve a continuous update of the three-dimensional reconstruction.[12] Interestingly, current research endeavors are also focusing on the development of a four-dimensional ultrasound probe, which enables the fusion of images from CT or MRI scans with real-time ultrasonography.[12]

Another technological achievement implemented in liver surgery over the past decade, which compared to AR is not affected by manipulation of the operative field by the surgeon, is the colorful visualization of structures using indocyanine green (ICG)-fluorescent imaging technique.[14] A group from Tokyo introduced this novel approach that allowed for precise identification of not only the vascular and biliary hepatic system but also of liver malignancies, such as hepatocellular carcinoma. This ICG-fluorescent imaging technique – previously mostly used in cardiac, breast, and gastric surgery – also found application in liver surgery in a way that the images of fluorescing structures are overlaid on the surrounding color images. Given the limited ability of ICG fluorescence to penetrate tissue up to 5 to 10 mm, it can be used to complement rather than replace conventional imaging studies, including IOUS, radiographic cholangiography, and angiography.[14] Notably, the ability of ICG fluorescence to localize structures, such as the hepatic arteries on the hepatoduodenal ligament surface, can be found useful not only in major liver resections but also in liver transplantation or pancreatic and biliary procedures.[14] A particular strength is use of ICG guidance for laparoscopic segmental anatomic liver resection with the negative staining technique where ICG is given intravenously systemically after laparoscopic ligation or clamping of the inflow portal segmental pedicle. Although color is a major advantage of this imaging method, one of the challenges with the current ICG fluorescence imaging technique is its white fluorescence color, which can make fluorescing structures difficult to visualize when the background tissue is also white or yellowish-white.[14] In such cases, monochromatic fluorescence can be employed to discern between the ICG-fluorescing structures and the non-fluorescing background.[14]

In conclusion, it is apparent that the role of technology has gradually emerged in several surgical fields, including liver surgery, over the past decades. The required technical expertise, understanding of complex anatomy, and need to achieve optimal oncologic outcomes represent areas where technological advances offer the potential to push the limits in laparoscopic liver resection. Minimally invasive approaches have been increasingly used for liver resections with proven patient benefits. Imaging technological advents, such as IOUS, ICG fluorescence, virtual reality, and AR, can be used to enhance understanding of the complex liver anatomy intraoperatively, increase tumor resectability, and improve patient outcomes, particularly as experience with these modalities grows.

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The role of Artificial Intelligence in Liver Surgery

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Introduction

The 1st Industrial revolution is dated in 1784 and was mainly based on mechanical production and the development of railroads and steam power. One century later, in 1870, the 2nd Industrial revolution happened thanks to the development of mass production, electrical power and the advent of the assembly line. The 3rd Industrial revolution is dated in 1969 with automated production, electronics, and computers. We are now living in the 4th Industrial revolution which has been premature but is very likely to speed up the progress of humanity and will be based on Artificial Intelligence (AI), big data and robotics.

Artificial Intelligence (AI) in health nowadays is a collection of different technologies that may enable machines to comprehend, sense, learn and act so they can perform a wide number of administrative and clinical healthcare functions. Previous technologies were just tools/algorithms complementing human beings. However, health AI today can truly augment human activity as is expected to become a real revolution and probably the highest change ever happened in Medicine.

In the beginning of this 21st Century, the convergence of data storage, connectivity, computational power, and AI is very likely to lead to a real precision medicine that could achieve customization of healthcare, leading to highly confident medical decisions, treatments, practices, or products being tailored to the individual patient. It is unknown whether the digital revolution will translate in the realm of surgery. However, the future in this field seems promising and is very likely to experience a tremendous revolution in the coming years. We will discuss the most recent advances in this field of AI with a main focus on liver surgery

Concepts On Artificial Intelligence And Big Data

There have been several definitions of AI over the last few decades. John McCarthy offered the following definition in 2004: "It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable." Probably all the definitions that can be found are correct, but what it really boils down to is "how close or how well a computer can imitate or go beyond, when compared to human being".

Deep learning and machine learning are sub-fields of artificial intelligence, and deep learning is a sub-field of machine learning. We live surrounded by a huge number of real-world applications of AI systems today as speech recognition, online virtual agents for Customer Service, computer vision or recommendation engines or automated stock trading. AI-driven high-frequency trading platforms make thousands or even millions of trades per day without human intervention.

Artificial Intelligence can be divided into Weak and Strong AI. Weak AI, also called Narrow AI or Artificial Narrow Intelligence (ANI), is AI trained and focused to perform specific tasks. Even though it is called as weak, it enables some very robust applications, such as Apple's Siri, Amazon's Alexa, IBM Watson, and autonomous vehicles. Strong AI is made up of Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI). Artificial general intelligence (AGI), or general AI, is a theoretical form of AI where a machine would have an intelligence equalled to humans. Artificial Super Intelligence (ASI)—also known as superintelligence—would surpass the intelligence and ability of the human brain. AI is still entirely theoretical with no practical examples in use today (Figure 1).

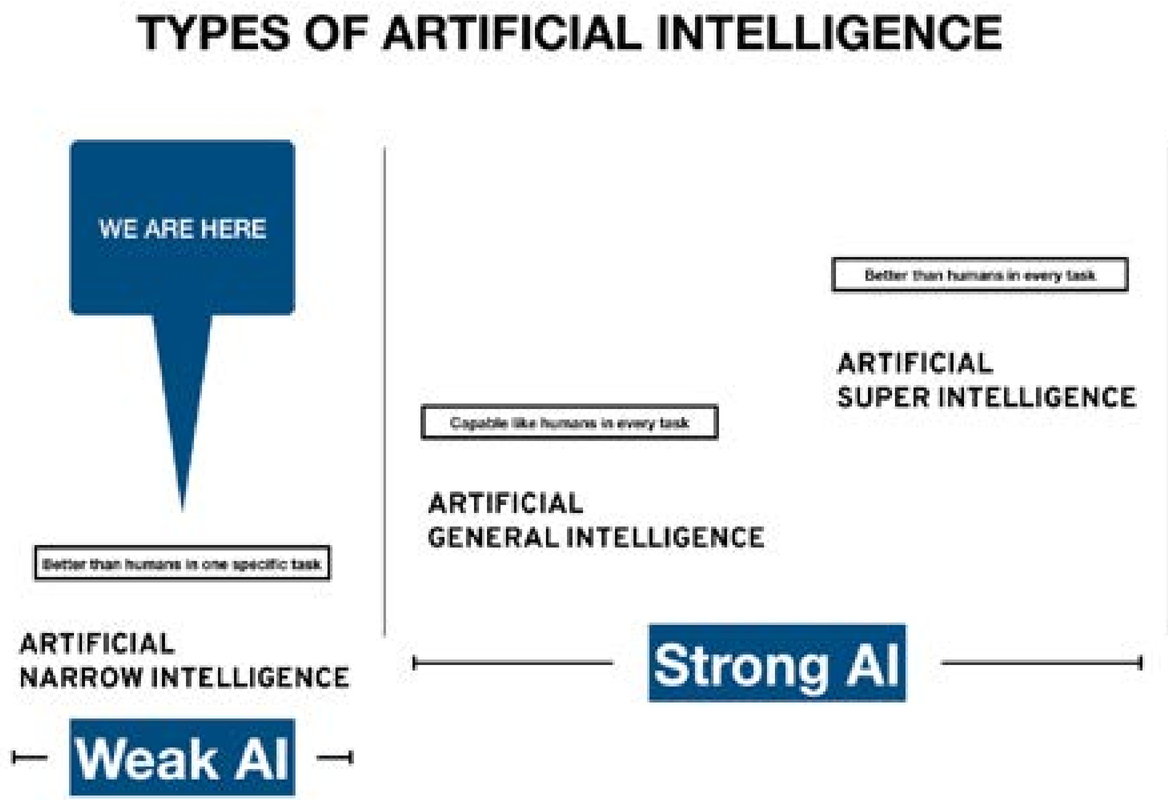

Figure 1. Types of artificial intelligence.

Healthcare transformation is going to be mainly focused on "digital health", "big data" and "precision health"[1]. These three main areas are interconnected and comprise most of the research areas in current healthcare revolution. Big data in healthcare consists of billions of entries about patients, treatments, drugs, surgical procedures, research results, and many more. Big data is enabled by the continuous acquisition of diverse datasets and aggregation of large amounts of in- formation. These acquisition processes allow for the application of newly developed and sophisticated data analyses that are providing robust and highly specific information for biomedical, clinical, and operational decision making[2].

The main area of development of AI in healthcare is Robot-Assisted Surgery. However, current applications include fraud detection, dosage error reduction or improvement and refinement in diagnosis (Figure 2) (Accessed 1st August 2021. https://www.accenture.com/_acnmedia/PDF-49/Accenture-Health-Artificial-Intelligence.pdf#zoom=50). However, even though these are the main areas of economic growth, the expansion in this field is huge and several applications are expected to be seen in the incoming years (Figure 3).

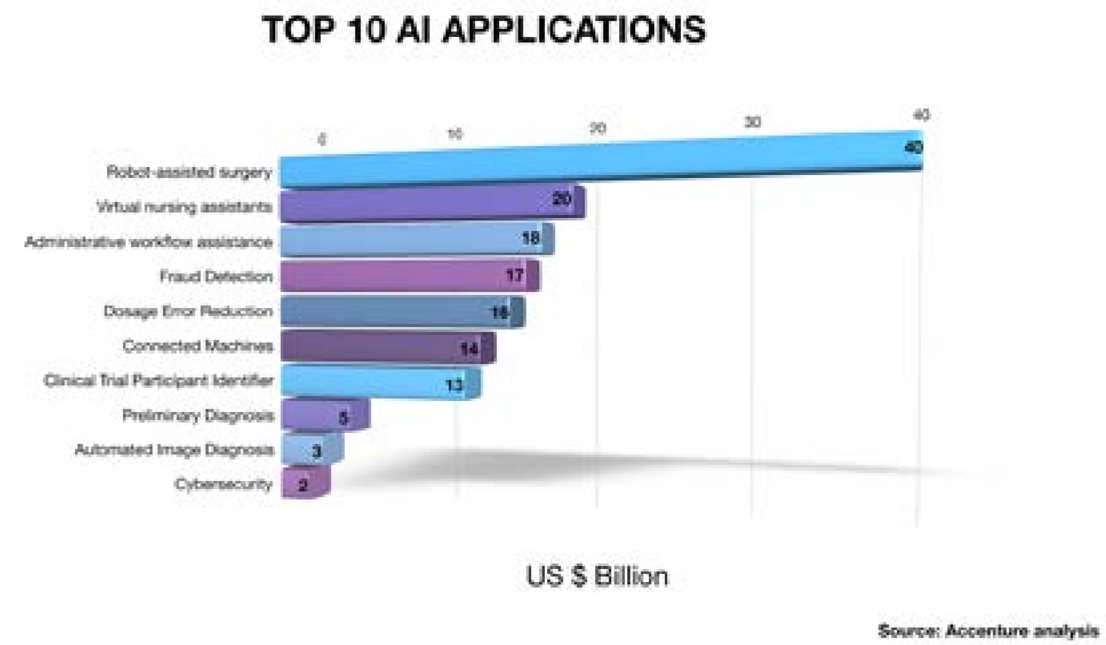

Figure 2. Top 10 Applications of Artificial Intelligence in Healthcare

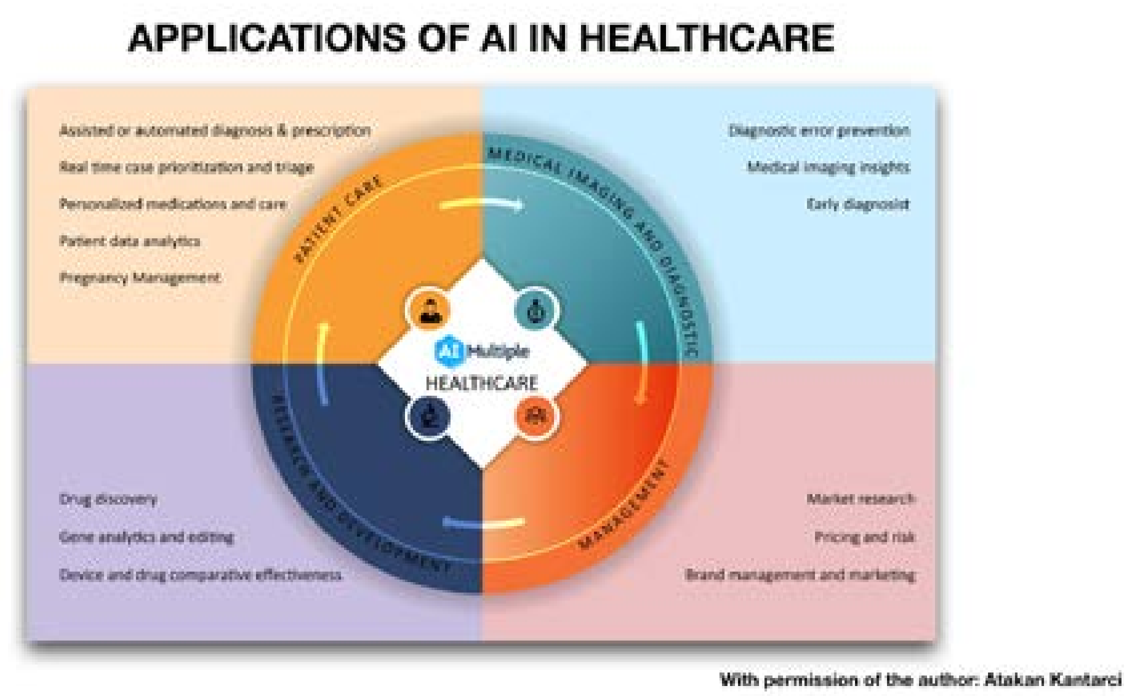

Figure 3. Current and potential applications of AI in Healthcare. With permission of the author Atakan Kantarci (https://research.aimultiple.com/healthcare-ai/ Accessed 1st August 2021).

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Artificial Intelligence In Liver Surgery

A recent review from Hashimoto defined four main subfields of AI in regards to its application in surgery:

(1) machine learning,

(2) artificial neural networks, (3) natural language processing, and

(4) computer vision[3].

One of its main applications is very likely to be a change in the way that traditional radiology must be considered. A deep learning-based AI system was trained using mammograms from 76,000 women in the UK and 15,000 in the USA, and was then retrospectively applied to UK and USA test sets comprising 25,856 and 3,097 women, respectively(4). The authors reported an absolute reduction of 5.7% and 1.2% (USA and UK respectively) in false positives and 9.4% and 2.7% in false negatives. Furthermore, in an independent study of six radiologists, the AI system outperformed all the human readers. When a simulation was run, in which the AI system participated in the double-reading process that is used in the UK, the AI system maintained non-inferior performance and reduced the workload of the second reader by 88%. "Radiomics" is a rapidly evolving field that quantifies imaging phenotypes using automated methods that, combined with high-throughput technologies, will improve the precision in future patient-directed medicine. This new field is mined with machine-learning algorithms to select concordant features and develop models that may improve outcome prediction. Very recently, a total of 470 patients who underwent contrast-enhanced CT and curative resection for solitary HCC were recruited from 3 independent institutions in China. In the training phase, a radiomics-derived signature was generated based on 3384 engineered features extracted from primary tumour and its periphery using aggregated machine-learning framework from 210 patients. This model was used for the rest of cases as testing datasets. The authors identified a three-feature signature that demonstrated favourable prediction of HCC recurrence across all datasets including alpha-feto-protein, albumin-bilirubin grade, liver cirrhosis, tumour margin, and radiomics signature. The two models showed superior prognostic performance, with C-index of 0.733-0.801[5].

Our team has explored the benefits of AI in predicting which donor may be the best option for a specific recipient for the allocation of a liver graft in the field of transplantation. When a donor liver graft is offered, a huge number of variables are considered by surgeons to decide: first, whether the graft is suitable for transplantation; and second, which recipient may be the most optimal one for this specific graft. We did a multicentric Spanish model which analysed more than 60 variables and did an external validation with King's College Hospital in London and found out that Artificial Neural Networks worked much better than all current reported scores to predict 3-months and 1-year graft survival for specific Donor-recipient pairs[6,7]. Standard biostatistics may be sufficient for many problems in hepatology. However, machine learning is clearly going to improve our potential of clinical prediction. Using these tools to decipher the complexity of liver disease may lead to the identification of more optimal biomarkers and therapeutic strategies that will lead to a more precision medicine approach in the field of hepatology[8].

Recent manuscripts from two different groups in Europe and USA have focused on the potential of augmented reality in defining security areas to prevent mistakes during surgery(9,10). Deep learning models were developed and trained to identify safe and dangerous zones of dissection during laparoscopic cholecystectomy. Both models reached accuracy values of almost 80% to safely identify critical view of safety.

Although still in its development phase, precise hepatectomy in the intelligent digital era is an objective to reach (Figure 4).

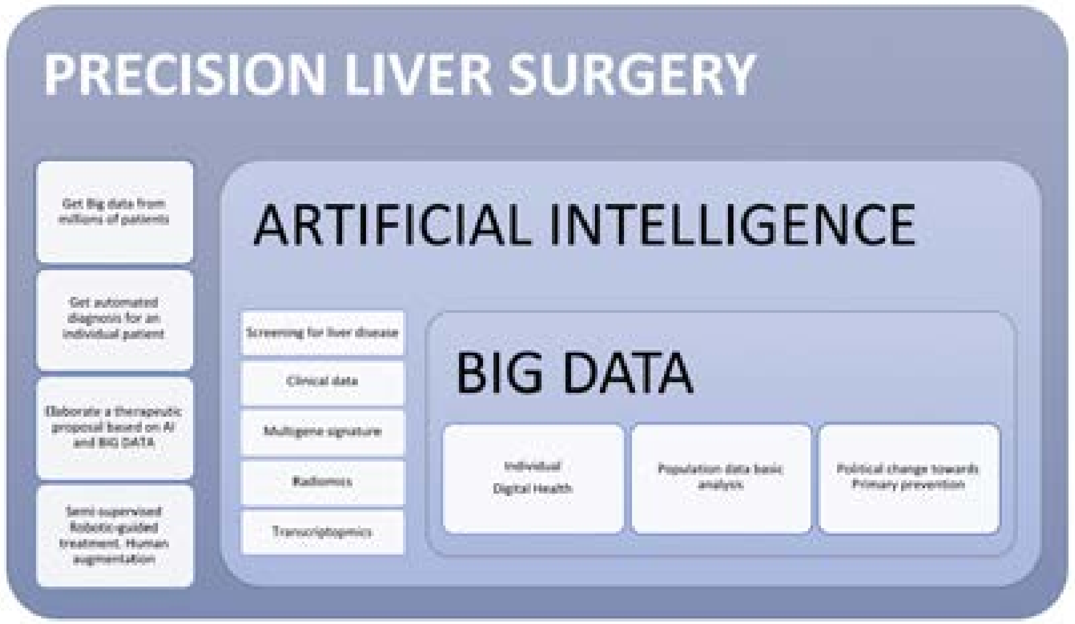

Figure 4. The steps and components of the future precision liver surgery.

This concept is very likely to be based on the following items which may encourage a full picture of a perfect future approach to a patient with liver disease[11]:

- A wide expansion of medical big data which may optimize the diagnosis and treatment strategy for liver tumours.
- Artificial intelligence assisted diagnosis and treatment planning
- 3D visualization and 3D modelling in liver surgery real-life applications
- Systematic application of indocyanine green molecular fluorescence in liver surgery
- Implementation of Virtual and Mixed Reality in hepatectomy
- Predictive model guided postoperative management and rehabilitation
- Wearable device guidance of rehabilitation after surgery

In the past, a 'physician for all purposes' with minimal equipment, handled patient treatment on the basis of traditional knowledge. Now, each patient has a wealth of information that is displayed within the numerous devices available within modern surgery rooms for performing and monitoring treatment. However, the management of all this information is left to the choice of the individual surgical team in order to make decisions in the supposed best optimal manner. The future of surgery will be based on automatic holistic processing of all the available data to ensure that care delivery is facilitated, optimized and adequately implemented by using techniques from surgical data science[12].

Artificial Intelligence In The Web And In Healthcare Market

AI in healthcare has experienced an exponential increase in the last decade. Considering its impact in web search strategies, it seems that since 2015 there is an increasing growth of interest, which is remarkable in Eastern countries (Figure 5).

Concerning the impact of AI in market, with immense power to unleash improvements in cost, quality and access, AI is exploding in popularity. Growth in the AI health market is expected to reach $6.6 billion by 2021—that's a compound annual growth rate of 40 percent and a total growth of more than 10x in 7 years- and to surpass $120 billion by 2028 (Figure 6).

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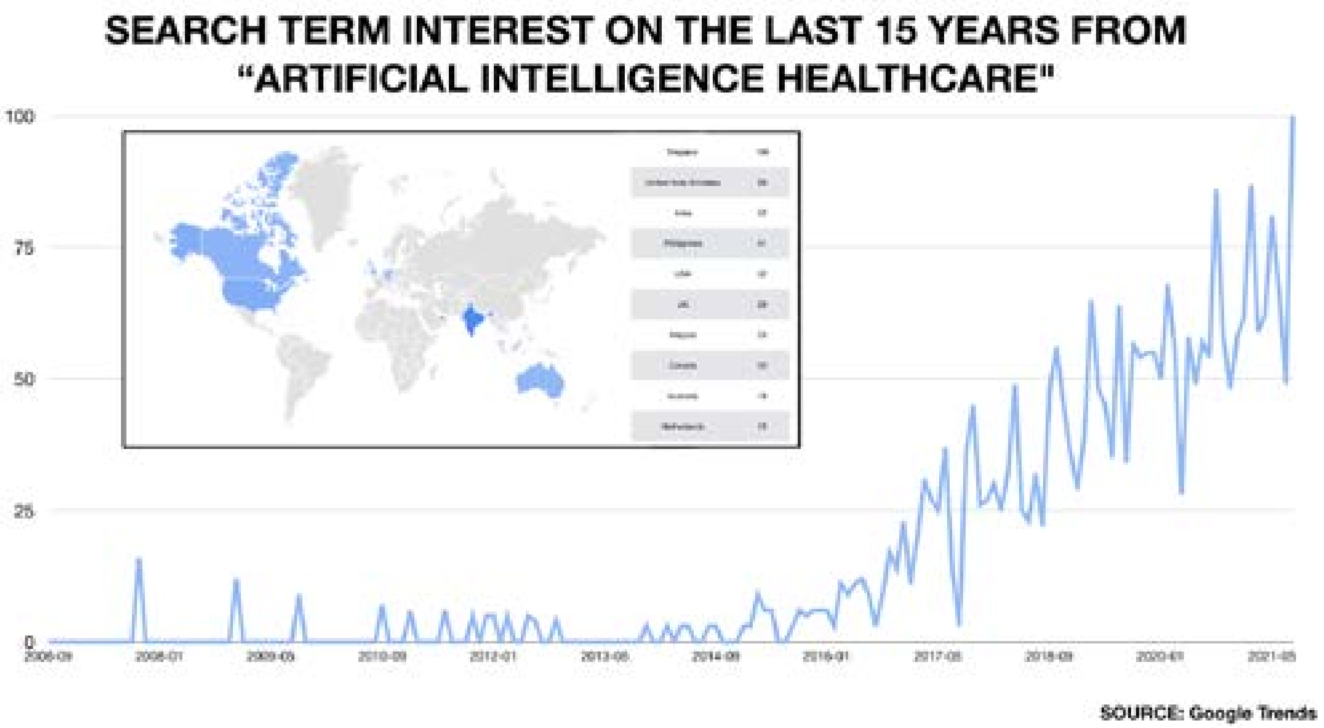

Figure 5. Search term interest on the term “Artificial Intelligence in Healthcare”. Source: Google Trends. Data obtained 15th August 2021.

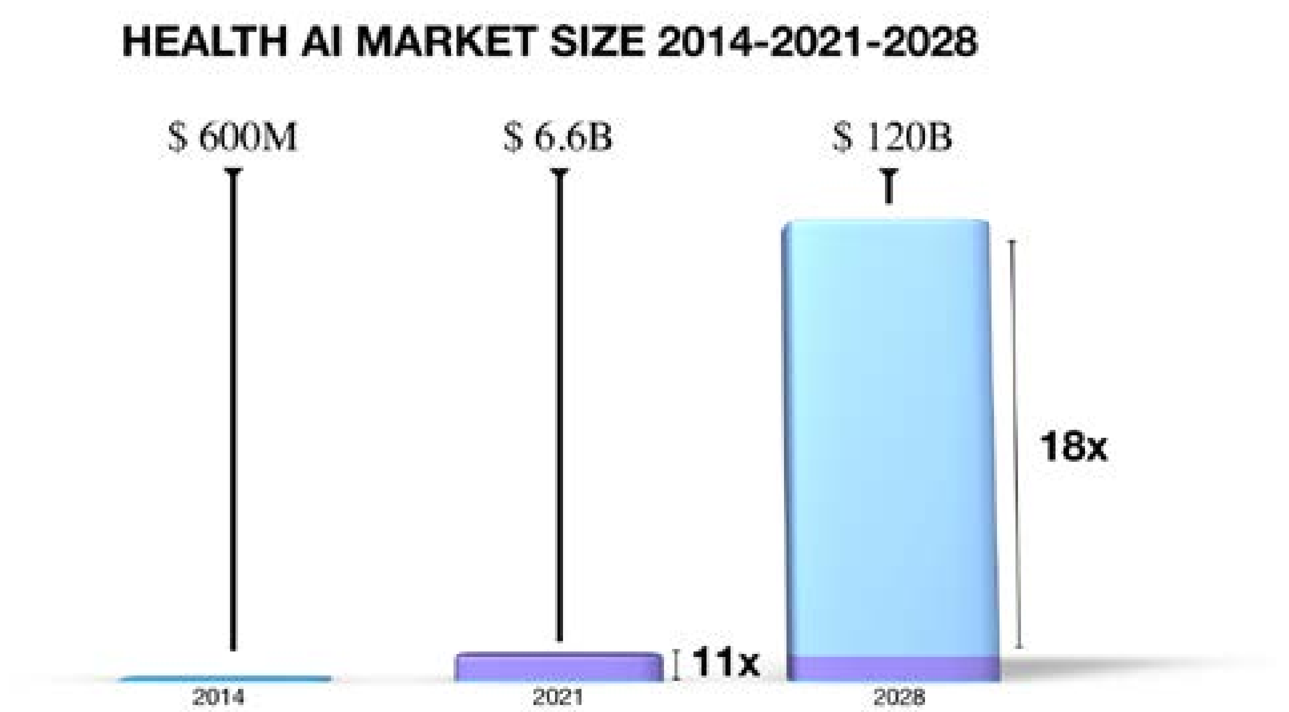

Figure 6. Health AI Market Size 2014-2021-2028. Source:
1) Accenture analysis and
2) Artificial Intelligence In Healthcare Market Size, Share & Trends Analysis Report By Component And Segment Forecasts, 2021 - 2028

Conclusions

The future of surgery is going to be mostly focused on AI, Big Data, robotics and semi-automated procedures. As Paul Reader, CEO of Mid Foundry stated, “Automation is not the future; human augmentation is”. Surgeons will keep on being the centre of a personalized precision medicine. However, their role will not be as a leading figure, but as a supervisor of a myriad of AI-guided processes that may surely get into an optimal, efficient and precise treatment for the patient.

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Three-dimensional (3D) printing and augmented reality in liver transplantation

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Since the first successful case of liver transplantation (LT) by Dr. Thomas E. Starzl in 1967[1], LT has become an common practice for the management of liver failure, cirrhosis and its complications, metabolic defects of the liver, and several liver malignancies.[2] In the United States, the vast majority of liver grafts are from deceased donors. However, the scarcity of organ donors cannot meet the increased demand for liver grafts. Therefore, several strategies have been employed to increase the available liver donor pool, including living donor liver transplantation (LDLT) and split liver transplantation (SLT). The medical and anatomical complexity of LT overall, as well as the ethical implications of LDLT, warrant careful pre-transplant evaluation and assessment of the donor and recipient, including pre-transplant imaging studies. The broad use of pre-transplant imaging improves accuracy and understanding of anatomical variations and is essential for staging purposes in case of LT for liver malignancies.[3–5] The emergence of several technological advancements has revolutionized several surgical fields by improving pre-operative assessment and planning, intra-operative guidance, as well as surgical training. Three-dimensional (3D) printing and augmented reality (AR) are two particularly important advances that have found application not only in the field of surgery in general but also in the field of LT. 3D printing utilizes several computer-based techniques to generate an actual solid 3D object from a computer image through printing consecutive thin layers of a specific type of material (Figure 1).[6] On the other hand, AR utilizes pre-operative imaging to generate 3D visualization of the anatomical structures, including blood vessels and tumors, and allows for a composite view by superimposing a computer-generated enhanced image on the operating field (Figure 2).

Figure 1. Example of a 3D printed liver model (Aristotle University School of Medicine, Thessaloniki, Greece).

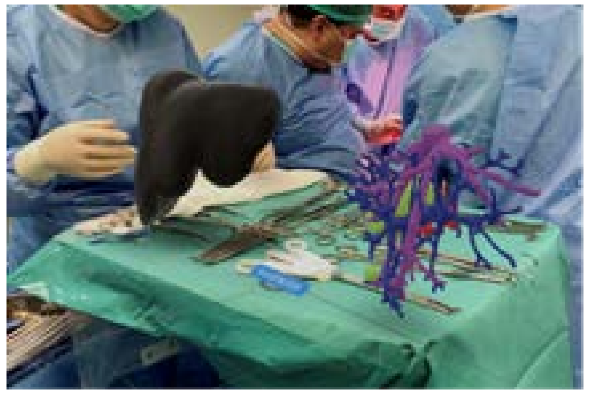

Figure 2. The use of augmented reality during liver surgery (Aristotle University School of Medicine, Thessaloniki, Greece).

3D imaging allows for better understanding of the relationships between the biliary and vascular structures and the hepatic parenchyma compared to conventional imaging studies, as well as allows for liver volumetry analysis, which are vital for pre-operative planning.[7–9] Despite the benefits of 3D imaging over two-dimensional (2D) imaging, still these 3D images are evaluated through a 2D computer monitor. Instead, 3D printed liver models can be used to improve pre-operative planning and safety of LT with several groups having described the application of 3D printing in LT around the world.

The Cleveland Clinic group was among the first to describe the use of 3D printing in the setting of LDLT in 2013.10 They reported 3 consecutive adult patient pairs (3 recipients and 3 donors) whose livers were synthetically reproduced using 3D printing and then these 3D printed liver models were validated against their actual native livers intra-operatively.[10] The authors stated that 3D liver printing can be helpful in facilitating LDLT and minimizing intra-operative adverse events by improving the surgeons' understanding of the spatial relationships between biliary and vascular anatomical structures.[10]

Moreover, Soejima et al. from Fukuoka, Japan reported their experience with preoperative simulation in LDLT for small infants in 2016[11] Large-for-size syndrome is one of the major reasons for poorer outcomes of LDLT in small infants either due to several vascular complications or due to the hemodynamic disturbance by compression of the large graft due to primary closure of the abdominal wall. Soejima et al. highlighted the superiority of 3D printing over 3D imaging in simulating the operation and having a real sense of the size, vascular anatomy, and thickness of the reduced graft, which can help prevent large-for-size syndrome.[11]

In 2019, Wang et al. published a report of 30 consecutive children who underwent LDLT with (n = 10) versus without (n = 20) the support of 3D printing in Shanghai, China.12 The authors stated that the use of 3D printed liver models facilitated operative planning, and particularly the management of hepatic veins and the prevention of large-for-size syndrome. In addition, donor inpatient costs were lower – however, the cost analysis did not factor in the actual cost of construction of the 3D models – and donor operative time was shorter in the 3D printing group compared with the control group, while recipient outcomes were similar between the two groups.[12]

3D printing has also found application in patients with complex anatomy undergoing LDLT. In 2020, a group from Kyoto, Japan described the use of 3D printed models of each part of the liver and then combination of the individual parts in a patient-specific liver model for a patient with situs inversus totalis undergoing LDLT for biliary atresia.[13] The 3D printed liver model allowed for accurate intra-operative navigation of the surgeons, who were able to totally remove the recipient's liver without injuring the aberrant right hepatic artery.[13]

Another group from Torino, Italy reported their experience with the implementation of 3D printing in pediatric LDLT planning in 2021.14 The authors were able to safely extend the donor left lateral segmentectomy to a restricted left hepatectomy, including part of segment 4, while preserving the graft segment 4 arterial flow.14 Overall, they also underlined the advantages of 3D printed liver models in precisely predicting the future liver remnant and the graft's weight, and accurately understanding the relationships between the vascular structures.[14] In 2021, a team from Bangalore, India was also able to demonstrate the applicability of 3D printing in predicting the actual size of the graft after donor hepatectomy in patients undergoing LDLT.[15]

An additional method to expand the liver donor pool is through SLT, which involves dividing a whole deceased donor liver into two parts which can be implanted into two recipients. In an attempt to make the most utility of a whole liver, the medial segment has been proposed for potential use as a mono-segmental graft in pediatric LT. Chen et al. from Taipei, Taiwan demonstrated the feasibility of medial segment graft procurement with the by 3D printing and ex vivo procedures performed on explanted deceased donor livers to overcome the gap between theory and clinical implementation.16 Despite the limited recent clinical experience, they also suggested designing the medial segment graft to be used in auxiliary partial LT or in an infant or small child as a partial liver graft.[16]

In addition to 3D printing, AR has also been introduced in the field of liver surgery.[17] In the process of AR, pre-operative imaging studies undergo segmentation in that they are divided into graphically homogeneous areas to represent distinct anatomical structures.[18] Then, the surgeon has a vital role in identifying crucial anatomical structures and overlaid graphic elements. For a complete application of AR in surgery, the pre-operative imaging datasets are incorporated into a coordinating system of segmented imaging studies and then this 3D reconstruction is applied intra-operatively into the patient's body and specific anatomy using fixed anatomical markers, a process called real-time registration.[19] One of the major challenges in implementing AR is the accuracy of registration to the specific anatomy of each individual patient. The registration process in most reports has been manual, however, semiautomatic registration approaches are being developed and tested. The accuracy achieved by AR navigation lies within a reported mean error of 5.4 mm (0.9-10.6 mm).[17] Although AR has already found application in liver operations, there are no known reports on the use of AR intra-operatively during LT. However, AR has been proven to be very useful around the setting of transplantation.

On March 11th, 2021 (World Kidney Day), the United Kingdom National Health Service (NHS) collaborated with the multimedia messaging application "Snapchat" to increase awareness around organ donation through a body-tracking AR lens.[20] This allowed users of the application to locate and educate themselves on key body organs, as well as to encourage them to discuss organ donation with their family and peers. When activated, the application users were instructed to flip the camera and point their phones at someone to access the body scanning technology. Then, the application identified organs that can be donated, such as the heart, lungs, eyes, kidneys, liver, pancreas, and small intestine. The user was able to select specific organs to learn more about them or swipe-up to be directed to the organ donation website. This AR application can be applied more broadly on other calendar days too (e.g., February 14th – National Donor Day, etc.) or launch campaigns to increase awareness on the importance of organ donation, which will contribute to expanding the donor pool.

Moreover, when obtaining consent from the family of a brain-dead person who can be a potential deceased organ donor, the transplant coordinators often show the findings of the brain angiogram to the potential deceased donor's family. Since AR has been previously used to teach about the human blood flow and to diagnose reduced blood circulation[21,22], the transplant coordinator could show to the family of the potential brain-dead donor that the blood does not flow to the potential donor's brain using AR glasses. Such visualization can be solid proof to help the family with no medical background better understand the irreversibility of the situation and can be a strong argument to consent for organ donation.

Last but not least, with the gradual introduction of robotics in living donor hepatectomy in certain expert LT centers[23–25] and with the advent of precision surgery, melding AR with real time viewing such as through the robotic screen may better utilize AR and 3D technologies during surgery[26,27] and may significant impact the field of LT in the future.

In conclusion, recent and pioneering technological advances, such as 3D printing and AR, have been introduced in the field of liver surgery and transplantation, and particularly LDLT and SLT. These advances can be proven helpful in increasing awareness on the importance of organ donation, in pre-operative planning, in surgical training, in minimizing complications in both the recipient and the donor – which is vital for the broader implementation of LDLT –, and as a result can contribute to the expansion of the liver donor pool.

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The Future of Liver Surgery: TPD, MIS, CA, AI, AR, AAV, AE

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Introduction

The progress in the field of liver surgery in the last three decades has been remarkable. Once an area of brave pioneers, it is now routine surgery at most major hospitals worldwide. The landmark work in segmental anatomy, low-CVP anesthesia, physiology of hypertrophy and regeneration, and engineering of surgical tools now allows cancer surgeons, transplant surgeons, pediatric surgeons, and general surgeons to deliver safe surgery in this organ that was so foreboding into the late 1970s. Writing from the perspective of someone fortunate enough to work with some of the great pioneers of this area, following are my observations of the present state of liver surgery and prospects as it heads into an era of advanced technology.

Current Status

Liver resections can now be done at most major centers with an operative mortality of less than 3% and with most patients returning rapidly to normal lives. In open operative approaches, the essentials of anesthetic, surgical, and peri-operative support for major hepatectomy are well-known and standard worldwide[1]. Hepatectomy is now safely used to treat congenital anatomic defects, severe liver infections, cancer, trauma, and transplantation.

TPD (Transparent Public Data)

It is long known that expertise of the center and the surgeon are an essential parameter in determining outcomes from major HBP surgery[2]. This is the reason that the regionalization of HBP surgery is a public health policy in many nations that have a robust regulatory component to their health care. Health systems in the U.K., Sweden, the Netherlands[3], and Canada[4], amongst others, have regionalized HPB surgery with favorable results. In the United States, even though many papers are written about disparate outcomes depending on surgery volumes and the disparity of delivery of care for our citizens, few policies have been instituted[5]. Operative mortality can vary tenfold amongst hospitals and practitioners in the same city. If patients knew about the disparity in the outcome, they could improve their survival by 4-10% by employing “neoadjuvant Uber therapy”: taking a taxi service to a much safer hospital across town.

Since this article is for a special issue on information technologies, I suggest transparent, public reporting of outcome as a crucial informatic advancein liver surgery. Operative outcomes and long-term survival of patients under the care of specific surgeons, hospitals, health plans should be made publicly available for all major surgery. We should hold surgeons and hospitals to high standards. We should also make clear when health plans restrict patients from access to good health[6].

MIS (Minimally Invasive Surgery):

There is no doubt one of the significant technical advances in surgery in the last four decades has been the evolution of laparoscopic surgery. Major operations in many disciplines are now performed laparoscopically to improve patient recovery. Liver surgery is no different. In 2009 Nguyen et al. reviewed the rapidly growing experience in laparoscopic liver resection for benign and malignant indications[7]. Much laparoscopic surgery was being employed. Laparoscopic liver surgery is no longer an experimental procedure.

Writing from the perspective of someone who operates on patients with open incisions, laparoscopic incisions, and robotic incisions, we need patient benefit to be the priority consideration in the choice of approach. I choose the laparoscopic or robotic approach just as I choose whether someone should have a midline incision or a thoracoabdominal incision.

The most common time I choose a laparoscopic or robotic approach is when I believe the patient has an “incision-dominant” procedure. Those are surgeries where an MIS approach can be used to perform liver resection safely and rapidly and where recovery from open surgery is dominated by the large incision. By performing such surgeries using an MIS approach, patients can have very short hospital stays and rapid recovery. This approach is easily achievable laparoscopically for lower segments and anterior segments. This approach is favored robotically in posterior and superior segments[8,9]. This is why cyst fenestrations, wedge resections, segmentectomies, and bisegmentectomies should generally have a laparoscopic or robotic approach. Using an MIS approach for minor liver resections results in outpatient and extended-stay surgeries[8] valuable to patients, hospitals, and payers.

Major liver resection will always be dominated by the physiology of liver regeneration recovery. These are operations that technically can be performed by surgeons with the highest level of expertise but should not be advocated for general use. An expert team should choose to use laparoscopy or a robotics approach to major liver resection, taking into account patient co-morbidities and technical aspects of the surgery.

The outcome of intricate operations such as for hilar cholangiocarcinoma will always be dominated by how well we resect the tumor and whether we leave any cancer behind. In a report on robotic resection for hilar cholangiocarcinomas, Professor Dong wrote very honestly about the early recurrences that were seen[10]. It was concluded that this type of surgery could technically be performed by experts, but it was dubious that a robotic approach would be beneficial.

Most discussions of whether an operation should be done by the MIS approach currently center on conversion and cost. I think we should evolve this discussion to patient outcomes. In particular, I believe the long-term outcome is most important.

CA (Computer-aided Surgery and Education)

Robotics: Many debates in MIS surgery involve comparative discussions of laparoscopic surgery versus robotic surgery. Enunciating the value of robotics is essential (Table 1). For most operations, investigators have not shown a benefit of robotics over laparoscopy by the usual surgical outcome parameters of operative mortality, complication, and length of hospital stay. This would make sense because robotics is nothing but computer-aided laparoscopy. Therefore, in expert hands, the outcomes of both should be the same. Therefore, the discussion should center on when the computer-aid helps the surgeon and, therefore, the patient. Discussion should also center around non-traditional measures of surgical success.

For the patient, there are certain values of robotics that are clear. It is a technology that allows MIS instruments to reach anatomic locations that are hard to reach. Good examples of these include the transluminal approach to 5th and 6th order bronchi, trans-ventricular approach to parts of the brain, and posterior segments of the liver. Thus, there are operations performed robotically that would not be routinely performed by an MIS approach otherwise.

Robotic surgery is also a technology that is easier to adopt. Thus, it is much more likely for a surgeon to adopt MIS through robotics[11]. Most surgeries worldwide are still performed through an open operative approach. Converting surgeons to MIS surgeons through robotics will give many more patients the option of MIS surgery. It is also clear that conversion rates are lower. This is likely because sewing is a competency in robotics, while in laparoscopy, it is an expertise. When there are injuries to adjacent organs or vascular structures, it is easier for the surgeon to fix it robotically than laparoscopically. Thus, patients are also more likely to benefit from an MIS approach when performed robotically because of the lower likelihood of conversion to open surgery.

Table 1. Value proposition for robotic surgery

- Cases that transform patient outcome if done robotically
    - Adoption, Feasibility
        - More patients will benefit from MIS surgery
    - Individual patient outcome: robotically accessible; cases needing a lot of sewing
        - Each patient has improved outcome
- Cases that are more comfortably done robotically
    - Value is for the surgeon: prevents injury, prolongs career
- Cases that can easily be done laparoscopically
    - Value is teaching
    - Resident and fellow console time
    - Graduated responsibility
        - Gallbladder, ovary, uterus, intestine, lung, pancreas, liver

The value of robotics to the surgeon, however, should not be overlooked. Robotics, in general, is ergonomically easier for the surgeon than laparoscopy[12-14]. Occupational injury during laparoscopy is not unusual. Maintaining the health and career longevity of the surgeon should be a goal of our field.

There is value in doing simple procedures robotically. The value lies in training young surgeons to become experts. A rational training program involves increasingly complex surgeries that start with cholecystectomies and oophorectomies, then hysterectomies, then luminal surgery such as gastrectomy or colectomies, and finally HBP surgery. Such programs allow young surgeons to be well trained in the medical and technical aspects of robotic surgery. Even though there are many surgeons going straight from robotic cholecystectomy to robotic hepatectomy, this is not the optimal path. Our traditions and philosophy of Western surgical training are based on gradated clinical responsibility, increasing complexity of cases, and a volume of surgical case experience to satisfy a learning curve. Robotic surgical training should be no different.

Education: Computer-aided education has already become a significant part of Western medical education. 3-D reconstructions of medical imaging, living anatomy computer modules, and virtual reality anatomic programs serve as important teaching tools for anatomy[15]. Many simulation programs, including virtual reality programs, are now available for use in the training of the robotic surgeon[16]. These are intended to shorten the learning curve and decrease the risk for patients during the training period. It is likely that in the near future, a patient's scans will be imported into available simulation programs to allow the surgeon to train on the specific case they are about to perform to further provide for surgeon learning and clinical patient benefit.

AI (Artificial Intelligence and Automation)

A significant difference between laparoscopy and robotics is the possibility of employing artificial intelligence (AI) and achieving automation in robotics. By definition, these are not possible for laparoscopy.

AI and display: Computer-aided display is already widely used in robotics. Images from two different cameras on the laparoscope with different perspectives are now merged and displayed to the robotic surgeon as a high-definition 3-D image to increase the accuracy and efficiency of the operation.

The next evolution of display is likely to involve 3-D reconstructions of CT or magnetic resonance scans with computer-aided deformation-registration and overlay onto the white light visible anatomic structures[17,18]. This would help in seeing vessels and vital structures deep into the visible area. Many dyes are also being developed to aid in the visualization of vessels, nerves[19], anatomic structures such as ureters, and tumors[19,20]. Overlay of such structures onto the visible surgical field will likely improve the safety and likelihood of R0 resections in cancer cases. These data will also allow the computer to set "no-go" zones to further improve the safety of the operations.

AR (Augmented Reality): Augmented reality display will not only be limited to the surgeon's console. There is already work being done to employ an augmented reality display designed for the bedside assistant and other assistance in the room[21]. Ergonomically, the bedside assistant has the most difficult tasks in the room. The bedside assistant performs skilled moves, including placement and firing of staplers, operate ultrasonic dissectors such as the CUSA, suction, apply clips, and introduce/retrieve needles. The bedside assistant also has to avoid the moving robotic arms. Many skilled moves are guided by monitors obstructed by the robotic arms or placed in poor ergonomic positions. Having augmented reality (AR) goggles for the bedside assistant can significantly improve efficiency and accuracy while improving ergonomics[21].

Transmitted multi-panel and augmented display images can also be used for mentoring. There is work being done to allow facile transmission of multi-panel images for clinical mentoring for the care of stroke patients[22]. Transmitted images in surgery can include a laparoscope view of the surgical field, the bedside view of ports and arm actions, and room view of personnel-orchestration in the room. Such a multi-view display of surgical setup is necessary to document the advanced technological space that is the modern operating room. Seeing these would greatly enhance multicenter live-surgery master classes. Seeing these views would also allow mentoring from afar, particularly if ghosted instruments can be applied to the pictures of the surgical field, or annotation can be made on any view to clearly illustrate suggestions.

Automation is already being investigated for tasks, scenes, and entire operations. The value for each of these is debated. I personally do not see a great value in automating very simple operations such as oophorectomies and cholecystectomies. However, for tedious, repetitive, and intricate tasks such as liver parenchymal transection or abdominal wall flap dissection, the tirelessly computer-aided robot could be a safe and efficient automated surgeon. The robotic auto-surgeon can further be aided by an advanced display of blood vessels, essential structures such as bile ducts and tumors, each dye-enhanced with a different wavelength.

AI in Post-op Care (Sensors, Data Monitoring Centers, Algorithmic Workpaths)

Choosing appropriate liver operations for robotics has resulted in a very short length of hospital stay[8]. When a small tumor is operated upon robotically, the result can be a conversion of open operations necessitating 4-7 days of hospital stay to outpatient surgery. Many liver operations performed robotically are now outpatient procedures or extended-stay procedures. This has brought in a new challenge of monitoring the patient's first days after surgery when they are no longer routinely in the hospital. The patient who was once in the ICU is now an outpatient. This has pushed for innovations in telemedicine and sensor-based monitoring.

Some are pushing for continuous home monitoring of the patients using vital signs delivered by traditional sensors. I believe this will bring much useless data that will distract from the core task of taking care of these outpatients. I also think this will bring many episodes of false-positive tachycardia, bradycardia, and hypotension, for which the monitoring institution would be legally responsible. Therefore, we and others have embarked upon using intermittently acquired data in three forms:

1) patient-reported symptoms,

2) activities tracker, and

3) essential physiologic data.

In monitoring for patient-reported symptoms, a simple assessment of anxiety, pain, and wellbeing provides probably essential data on symptomatology. Activities tracking is objective data integrating patient wellbeing and caregiver support[23]. The activity steps are highly predictive for significant complications[24]. Our colleagues in agriculture have long known that step tracker data are highly correlated to livestock wellbeing[25].

Much progress is being made in the field of microsensors and wearable's that operate on low power for home monitoring. At present, many of our studies are performed using a very inexpensive step monitor (Vivofit; Garmin, Kansas City, Missouri). We favor this apparatus because of its low cost, its ability to function for months without recharging, and that it is waterproof, allowing our patients to bathe. Any wearable that requires charging more than once a week is unlikely to be a true health device. Mini-sensors that are size in millimeters and performed operations using power in the microwatt range are now being designed and tested. Such sensors are being piloted for the measurement of glucose and oxygenation. Subcutaneous implantation of these with relaying of data by cell phones will likely be implemented in the future monitoring of post-operative patients.

Patient monitoring through large call and data centers has already been implemented in many parts of the world for chronic monitoring of patients with diabetes, pulmonary disease, and heart disease. For post-operative patients, it is likely that the physiologic, metabolic, patient-reported data will also be monitored at a similar data center (Figure 1). The arriving data will likely be analyzed by computers configured through AI[26]. Readings will then be triaged for human intervention when out of the acceptable normal range. This may result in a call to the family to see an anxious patient when metabolic and physiologic data are intact. Alternatively, this may result in a call to the primary care team if one or more derangements are of medical concern. Finally, severe derangements may result in a call for an ambulance if deemed urgent. In order for these AI algorithms to be established and implemented, there will be a need for multicenter, multinational collaborative studies of recovery and monitoring of post-operative out-patients.

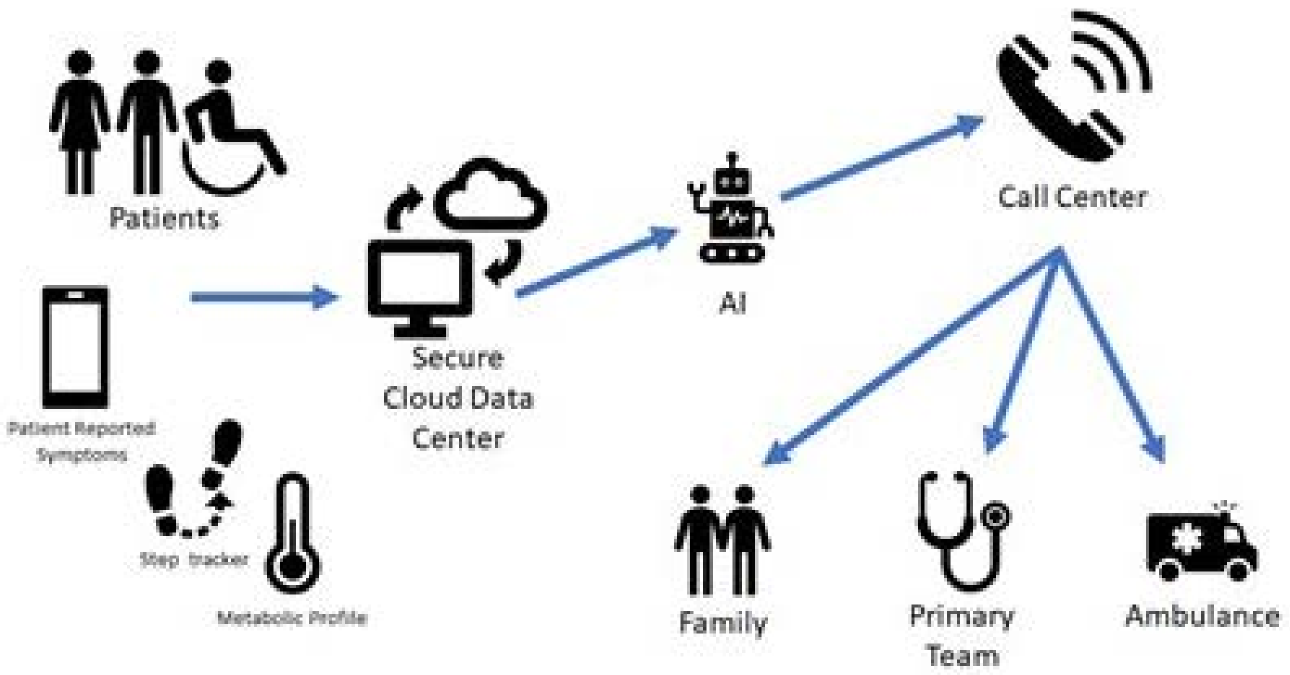

Figure 1. Monitored home recovery program. A model of post-operative home monitoring being tested is illustrated. Patients with wearable sensors and phone APPs will send intermittent data (symptoms, activity, and metabolic profile) to a remote monitoring team through a secure cloud data center. The monitoring team assisted by AI-driven algorithms can triage the course of action:
1) no action,
2) call family,
3) call primary care team to intervene,
4) call an ambulance.

The arriving data will likely be analyzed by computers configured through AI[26]. Readings will then be triaged for human intervention when out of the acceptable normal range. This may result in a call to the family to see an anxious patient when metabolic and physiologic data are intact. Alternatively, this may result in a call to the primary care team if one or more derangements are of medical concern. Finally, severe derangements may result in a call for an ambulance if deemed urgent. In order for these AI algorithms to be established and implemented, there will be a need for multicenter, multinational collaborative studies of recovery and monitoring of post-operative out-patients.

AAV (Adeno-Associated Viruses: Gene Surgery)

Medicine has entered a genomic and genetic age. Our understanding of diseases at the molecular level is increasing by leaps and bounds. Such knowledge has already changed our evaluation of the surgical patient from a prognostic and therapeutic standpoint. Many metabolic and hematologic diseases occur because of genetic derangements within the liver (Table 2). As our understanding of genomics and epigenetics improves, we can now manipulate the human genome to try to remedy many of these genetic disorders.

Many of the gene-editing strategies aimed at curing genetic diseases are targeted towards the liver[27] (Table 2). Many gene-editing modalities for genetic disorders such as hemophilia A, hemophilia B, PKU, lipoprotein lipase deficiency, and many others are in clinical testing. In essence, the goal is to perform gene surgery on either the hepatocyte or the endothelial cells within the liver to remedy the underlying genetic disorder to correct the phenotype.

Table 2. Diseases where gene surgeries targeting the liver are currently in human trials

Hemophilia A
Hemophilia B
Phenylketonuria
Acute intermittent porphyria
Familial hypercholesterolemia
Fabry's disease
Mucopolysaccharidosis (MPS)
Wilson's Disease

As liver surgeons, we need to be involved in such gene surgery technology. One of the most successful gene scalpels for genetic manipulation is the adeno-associated virus (AAV)[28]. This virus has already shown the ability to cure certain genetic syndromes of blindness and deficiencies of lipoprotein lipase[29]. There are also approved AAV-based medicines for the treatment of inborn immunodeficiencies.

Liver surgeons can help in harvesting liver pieces for ex vivo gene transduction trials. We can aid in biopsies of the liver and assessment of off-target gene expression and toxicities. AAVs also elicit a high-level immunologic response that does not allow a second dose to be given at present. Whether we can overcome this immune response by a washout of the liver and isolated perfusion to allow second and third doses to be delivered for better effect and long-lasting effect remains to be investigated. Much of this could only be done with the help of a liver surgeon. I would predict that the forward-thinking surgeon will be the gene surgeon of the future. Future directions in many fields will include the prevention of disease through genetic manipulation.

AE (Advanced Education)

One of the most critical aspects of the evolution of technology in liver surgery involves teaching and credentialing. Liver surgery will always be a big operation, no matter how small the incision. Making sure those who practice in the field are well trained to operate and rescue from any major surgical misadventure is essential. Surgeon with no liver surgery training should not be allowed to do major laparoscopic or robotic liver resections. Hospital leaders and leaders of major surgical organizations must protect our patients and our field by instituting the appropriate guidelines and enforcing them to ensure patient safety. We must define the training pathways and the criteria for credentialing to be sufficiently rigorous for patient safety but not so stringent as to obstruct the delivery of care or advancement of the

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field[30]. Most of all, we must ensure that our best trainees get an opportunity to do research and training in innovations and be our next-generation leaders by pioneering new technologies.

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European and National Legislation for Experimentation with the use Laboratory Animals. "The Letter and the Spirit" of EU Directive. The Value of Collaboration and the Implementation of Modern Technologies.

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Introduction:

It is impressive the perception we had about mobile phones or internet about 20 years ago, which are the developments of the last 10 years and what is provided for the future. It is a geometric progression.

The Nobel Prizes for Medicine and Physiology, such as other relative Nobel, for example Chemistry, is an important indicator, which shows as the importance of the use of laboratory animals, in medical research and its applications. Over 70% of the above mentioned Nobel Prizes, have used immediately or indirectly, animal models for the announcement of their significant discoveries. But it is not only about that. These Prizes are furthermore the most significant prove for the importance of cooperation of the scientific specialties not only in Medicine, which is a huge scientific family, but also in many other scientific fields. For example, the Nobel Price for the CT scan. CT scan is a technique which composes a routine in a hospital's everyday life in the whole world. The discovery was made by A. Cormack and G. Hounsfield (award in 1979), Electrical Engineers (experiments in pigs). Additionally the discovery of the use of radiolabel molecules in diagnostic approaches (RIA). The experiments were performed on rabbits by Rosalyn Sussman Yalow, a physicist (award in 1977). This technique is a widespread need in hospitals all over the world and in large diagnostic laboratories (Private and Public). Furthermore the Nobel Prize in Chemistry is not only given to chemists. This is also given to scientists with a very important contribution in the scientific field. For example, Dr. Aaron Ciechanover in 2004, for his research on proteins and applications in hematological diseases. So it is not only given to chemists but also to other scientists such as doctors.

All the above give us three significant messages:

- The interdisciplinary approach and cooperation of scientists and their specialties is the key to significant results.

- Experimental research using laboratory animals touches almost all scientific fields.

- Even in our time of great technological explosion and evolution, the use of animal models remains a necessity for research and the development of new products and therapies.

Experimental and Translational Research: Past, Present, Future.

For these reasons, this research, in our days is called translational research. It is not a mistake to mention it as experimental or biomedical research. Not at all. But the definition of translational research, shows the route for the research procedure and how an idea could be translated in something which has clinical importance and application.

The definition of translational research gives us another important message. The dilemma, which existed a few years ago and concerned whether basic or translational research is the most important, is non-existent. It is a false dilemma. The only real question is what do we like most about ourselves, on a personal level, practicing and serving. The question of which of the two is more important does not exist. Both are equally important and one feeds the other with ideas and information. In the age of molecular biology and molecular technology, this question does not exist.

The above messages and the basic principles presented were the basis of the discussion on which the European legislation was drafted for the use of laboratory animals for scientific purposes. Specifically, in research and education[1,2]. The purpose of this contribution is more to present the bioethical dimension of the legislation and even more how to implement it. It is simply what we call in legal and administrative science, " the letter and spirit" of the law.

The ultimate goal of all research efforts is the application of new therapies in humans and animals. These treatments, in order to be applied, must go through the phase of clinical trials, before their final approval, which last for several years. This research is expensive and special mention will be made of it in the next section of the text. However, what should be mentioned here is that the cost of clinical research is mainly covered by the private sector and industry. Specifically the pharmaceutical industry and medical equipment companies. Every new treatment as an idea comes from an international base of biomedical knowledge. This knowledge is from official scientific publications and patents (international copyright protection). In turn, publications and patents come from public and private research institutes (Universities, public and private research institutes, pharmaceutical industry, etc.).

This is the flow from the idea to the test (experimental and clinical) and at the end, as far as everything goes well, it can be applied to human and animals (veterinary medicines).

This flow concerns all bodies (public and private) and in addition to the legal framework, other bodies have an official role, setting the precise conditions for the development and testing of new products. That is, the legal framework gives us the way of operation of the experimental laboratories, the principles that govern them and at the same time gives us several technical details, for the exact way of their administration as well as the welfare of the animals and the best possible way of hosting and handling them. Guidelines from official bodies for the precise design of preclinical research and its implementation, such as the European Medicines Agency (European Union), the Food and Drug Administration (USA) and some others of minor importance (eg World Trade Organization) is another case, which has the purpose just described.

The legislation concerns the licensing and operation of the laboratories and the international guidelines, the exact way of planning and implementing of the research.

Of the 10,000 molecules (future drugs) that enter the initial stages of evaluation, only 1 or 2 reach the stage of the final clinical evaluation and initial approval. Of the 100 patents for medical devices or biomaterials, only 1 will be evaluated clinically and finally will be used. The pre-clinical evaluation period (efficacy, toxicity, etc.) can last up to 10 years and costs at least 1 billion. Euros. Clinical research costs about the same.

We all know that in recent years we are experiencing a deep global financial crisis, which was perfectly reasonable to affect both pre-clinical and clinical research. U.S.A. is a large country, the forerunner and pioneer of global research, in which for many decades, preclinical research has been funded, mainly by the government and even more specifically by the National Institute of Health (N.I.H.). However, gradually due to the crisis, this funding is constantly and to a large extent reduced, while the funding of the private sector (Industry) is increasing. Nowadays this funding is mainly from the private sector. In Europe, throughout the period from the middle of 1990s until the outbreak of the crisis, we had almost 15 years in which Member States and scientific bodies were consulted and debated (eg FELASA - Federation of European Laboratory Animal Science Associations, of EFPIA - European Federation of Pharmaceutical Industries and Associations) for the new text (directive) that will be implemented in all Member States and will be integrated into their national legal system.

Precisely because of the crisis and the high cost of preclinical research, U.S.A. and the E.U. came close enough, recognizing each other the opportunity to share and conduct pre-clinical research together. Such an option has some strategic and practical advantages:

- Reducing the cost of research (joint programs).

- The exchange of human resources and know-how.

- The faster completion of studies.

Therefore, the European legislation for the use of laboratory animals for research purposes, as a final text, came quite close to what is already applied in the U.S.A. for several years. In other words, the legislation functioned, in a way, as an "ISO system" of mutual recognition between the two sides of the Atlantic Ocean. Similar systems and laws (certainly, not exactly the same) apply in many Member States of the so-called Western world (Canada, Australia, Japan, South Korea, etc.).

Another important parameter, with bioethical dimensions, is the global market for preclinical and clinical research, which is conducted by the so-called CRO companies (Contract Research Operators). There are dozens of CRO companies around the world, many of them based in Asian countries[3]. It concerns a market of about 13 - 15 billion Euro (in preclinical stage) which is developing rapidly. In the paper entitled: "The Perspective of Modern Experimental Research" I describe all the possibilities for collaborations between different parts of the world[4].

So the bioethical perspective of pre-clinical experimental or translational research has scientific (best possible design), managerial / administrative (record keeping and protocols for ongoing or future review) and of course financial (huge amounts that can and can benefit but also harm or corrupt) dimensions.

In our country, we have a total of 73 licensed experimental laboratories based on European legislation (Directive 63/2010 - PD 56 / April 2013). Of these, 48 are University Laboratories and Laboratories of public or private law (eg Pasteur, Academy of Athens, Fleming, etc.) and 21 are Laboratories that are subject to special tests and controls at the Ministry of Rural Development. Only 4 are private.

In-product development has the following 4 basic stages:

- The stage of the idea or the seed of the idea (seed stage). It is the stage at which all the ideas for a new treatment will come to the table, some prototypes will be examined as well as what are the proposed treatments.

- The initial or preliminary stage (early stage). At this stage the first pilot experiments using animals will be done and the usefulness of the research proposal will be proved.

- The pre-clinical stage. Here's the actual stage of experimental experiments using animal models. If the experiments of many years give really encouraging results which are confirmed by their statistical test, we proceed to phase I clinical study.

- The following are the phases of the clinical studies II and III (pre-launch stage). These are the major phases of clinical trials in hundreds (II) and thousands of patients (III) in collaboration with multiple centers (multicenter study).

It is therefore obvious that 3 of the 4 developmental stages are not clinical but pre-clinical. That means, stages which will primarily be pre-clinical trials using animal models. At these stages, within the laboratory or laboratories where the experiments are performed, the main focus is on the Protocol Evaluation Committee and the Animal Welfare Monitoring and Opinion Committee.

In order for an establishment to be officially licensed, it must submit to the Competent Authority of the country it belongs to (for Greece it is the Veterinary Directorate of the respective Region) the complete data concerning it:

- Staff, staffing, CV, appropriate training and experience.

-Laboratories, spaces, dimensions, materials and method of construction, how modern or not, equipment, suitability of equipment for respective animal species, location of equipment within the laboratory and compliance with specifications described in the legislation (noise, method of construction, humidity, lighting regulation, areas and cage heights etc.)

-Organization schedule, flows, tasks and areas of responsibility.

The licensing is valid for five years (after their expiration there is a re-examination) and together with the licensing application is submitted the Composition of the Protocol Evaluation Committee and the Animal Welfare Monitoring and Opinion Committee.

The first has the following composition:

1. Biomedical Research Scientist, as President, with his/her deputy.

If required, his vote counts double. This is a scientist who comes from the Life Sciences (eg Medicine, Pharmacy, Biology, Veterinary Medicine, Nursing, etc.).

2. The Designated Veterinarian of the establishment, with his/her deputy.

3. Biostatistician, with his/her deputy. A scientist with proven knowledge and experience in biomedical research statistics.

4. A representative of the Regional Authority who also participates in the meetings, with the right to vote. Also a Veterinarian.

The Protocol Evaluation Committee signs a report to the researchers, for the confidentiality of the information which they submitted and the protection of their intellectual data (confidentiality) as well as that they have no conflict of interest in the proposed project (non conflict of interest) such as financial or other (e.g. publication). The Protocol Evaluation Committee has the right to accept the protocol, to reject it or to ask for some changes or modifications as well as intermediate or final retrospective evaluations with submission of all data and measurements (row data).

The second committee has the following composition:

1. Head of the Committee, the Director of the Laboratory.

2. Designated Veterinarian.

3. Personnel responsible for the daily care of animals.

4. An independent Member from the scientific community (only for the facilities where animals will be used for experiments).

The Animal Welfare Monitoring and Opinion Committee has the following responsibilities:

- To monitor that the implementation of the protocols is fully in line with what was exactly licensed.

- To inform the researchers timely and in a written manner about anything related to the implementation of their protocols. Programming, experimental conditions, approval of participants, etc.

- To inform the Protocol Evaluation Committee on a regular basis or exceptionally if required, for any issue related to the smooth and proper operation of the laboratory and the implementation of the protocols.

In this context, let us examine the "letter and the spirit" of the law and let us see the scientific-bioethical dimension of the legislation.

The Protocol Evaluation Committee has a balanced and functional composition. First of all, it should be noted that in the older legislation there was not even a scientific committee that evaluated the protocols. With the implementation of the new legislation this has changed dramatically. Its composition enables each laboratory, depending on the research projects it can undertake, to have the flexibility of choosing the right people. For example, a laboratory with a purely surgical orientation or a laboratory of basic neurological research, have a different work philosophy. They are not bound by law in the selection of persons. On the contrary, it promotes the participation of almost all scientists or experts. The participation of the Veterinarian is very important. The first and main reason is the obvious. It is his scientific field. But the law sends the clear message that there must be a permanent and not an ephemeral relationship of scientific and professional cooperation with the laboratory. He must be the scientist with a personal and professional view of the laboratory and not for the formal coverage of some needs. At the same time, he promotes his/her education since the law clearly requires the adequacy of his qualifications.

The Biostatistician is the scientist who provides two main directions in the whole philosophy of experimental research. First, that the statistical design has been done before the experimentation and the use of animals (key points of the final outcomes and evaluation of the study) so it agrees with the principle of Reduction, means the minimum possible use of animals.

Secondly, whether we are referring to the retrospective evaluations or the final evaluation of the protocol, in order to draw clear conclusions, they must be statistically justified. He/She is the scientist who provides the mathematical - biostatistical documentation (or not) of working hypotheses and measurements.

The representative of the Region, the Veterinarian of the Competent Regional Authority, acts both as a representative of the legality of the procedure followed and for which he can give an opinion during the meeting, as well as a scientist, who actively participates and can see from experience through his/her participation in committees and other laboratories, what is experimentally correct.

Therefore the composition of Protocol Evaluation Committee operates in such a way that it balances between the scientific examination of the protocol and its legal adequacy during implementation.

Each Protocol Evaluation Committee begins the examination of the protocol with its ethical evaluation[5]. That is the first R (Replacement). In other words, it examines whether the research or educational proposal can be implemented without the use of animals and whether there are official published works or proposals. For this purpose, there is the European Center for Alternative Methods, where the Protocol Evaluation Committee but also the research team, can get ideas for replacement or to submit ideas for replacement. But if it is decided that an animal should be used, we proceed to the second R. Refinement. In the improvement. In the best possible design of the protocol and in its implementation with the best possible conditions. Initially, the type of animal model will be selected, which depending on the needs and goals of the program, will be selected, but always trying to be from the smallest species (eg mice or rats) to the largest (e.g. pig). Part of the refinement is pre-experimentation training. Are researchers experienced and trained in the use of this standard? Which anesthesia protocols will be used? Both to reduce stress and any pain and not to affect the results from it. E.g. the use of gas anesthesia in myocardial infarction experiments, where gas anesthesia are known to have a cardioprotective effect. Therefore the goal of this phase is the best possible design. The third R follows. Reduction. It is primarily the role of the Biostatistician. But not only that. Every scientist of the Protocol Evaluation Committee can express his opinion with his knowledge and experience. It is a collective effort. But especially for the biostatistician is the formalization of the validity of the statistical design before the experiment. As well as the validity of the results when the experiment is completed. It is natural and completely logical, a Protocol Evaluation Committee not to have experience in any cognitive / scientific subject. But " the letter and spirit" of the law is clear. If the laboratory has a clear orientation to specific objects, respectively the Protocol Evaluation Committee may include scientists of the same orientation. If again there is multi-collection in the examination of protocols and cognitive objects, the Protocol Evaluation Committee has the right to formally request the assistance of other scientists and experts, if accepted by the scientific officer of the protocol to be examined and they (the experts) also sign the document of confidentiality and non-conflict of interest[6].

In addition, retrospective evaluations are another important work tool for any Protocol Evaluation Committee. Both to objectively evaluate the progress of each project and to determine whether its objectives have been achieved, even before the completion of the project. It is something that experience has shown could happen. It should be mentioned at this point that if the Protocol Evaluation Committee asks the researcher(s) to submit in writing the study data (row data) the researchers are obliged to do so. Otherwise a serious fine is provided. Where is the philosophy and "the letter and spirit" of the law?

The Researcher or research team has the right to judge and evaluate according to their own opinion the final results of their study. However, the presentation of the data requested by the Protocol Evaluation Committee (even of all data - row data) is mandatory and also has as a competent body, the right to judge the scientific data officially submitted (eg statistical test and

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final conclusions). In other words, they can have their own opinion[7].

Given the fact that one of the main objectives of the implementation of the E.U. Directive on the use of animals for research purposes was, is and will be the highest quality and most valid scientific research published in international journals or conferences, for any project that the Protocol Evaluation Committee will consider it necessary, request in writing all the data and the results of the study in a final retrospective evaluation, so that the researchers take the final responsibility of the data provided and those that will be officially published to the scientific community[8]

The Committee for the Welfare and Monitoring of Experimental Procedures has a composition in which the following basic characteristics are served:

- Makes the Facility Manager, a real manager who has to deal with the laboratory on a daily basis and not have any duties.

- Presses him for the constant redefinition and updating of knowledge and skills of employees.

- Takes care of the operation of the laboratory based on rules of morality and ethics and scientific monitoring of all procedures.

- In addition, the committee must include employees who come into daily contact with animal care. Therefore it gives them the voice to speak up and report any problems or possible improvements.

- The Animal Welfare Monitoring and Opinion Committee is with its attitude and behavior, is the spirit of the laboratory. Seriousness, professionalism, documentation of procedures and responsibility.

Big Data and Artificial Intelligence.

Access to big data and the use of artificial intelligence technologies, are the key tools for the implementation of 3Rs in our era. Simulation and advanced technologies offers to scientific community an ocean of information and possible applications in a variety of issues. Some examples :

-Replacement of laboratory animals with modern simulation, in training.

-Advanced training courses with hybrid programs (use of animals and simulation).

-Detection of biochemical mechanisms and pathways in several search engines in order to offer better design of a scientific protocol with less use of animals.

- Reveal of possible targets for more effective design and trial of new molecules.

-Exchange of experience and knowhow among research teams and educators.

Conclusion:

A basic philosophy through "the letter and spirit" of European Directive (9,10), for the use of laboratory animals for scientific purposes, is the ethical and scientific documentation of any research or scientific proposal. For this purpose, it gives the working tools to the competent committees, so that both the principles of 3Rs and the basic scientific principles of planning and evaluation are followed with the most adequate and complete process possible. At the same time, it addresses with a spirit of respect but also responsibility not only to the committees but also to the researchers. It calls for their collaboration to be basically in a spirit of mutual assistance and common values and principles. New technologies and artificial intelligence offers to us a new way of thinking, test and evaluate new therapies and design of new training programs.

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Artificial Intelligence and Ethical Challenges in Surgery

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The phrase “artificial intelligence” evokes a strongly negative mental image for many. Numerous movies have presented eerie pictures of dystopian societies filled with humanoid creations. Although built by humans, these beings become self-aware and plot to overthrow their masters by manipulating their knowledge of human behavior in concert with their advanced technology. Depictions such as these have made the “Turing Test,” proposed by famous mathematician and cryptanalyst Alan Turing in 1950, common knowledge. The Turing Test seeks to determine whether a machine can successfully mimic human responses based on certain inputs. The Turing Test asks the question, “Can machines play the imitation game?” Certainly, many current machines can. Outside of film and television, we see numerous instances of artificial intelligence (AI) at work in our daily lives. We use Siri on our iPhones, cars can drive and park themselves, and social media provides directed posts and ads based on our daily conversations and interactions. These are all examples of machine learning: algorithms that synthesize large amounts of data, and predict outcomes without explicit programming. Though every facet of our society is driven towards further developing these systems in one way or another, the diminishing divide between humans and machines gives many pause.

Modern medicine is no stranger to the use of artificial intelligence. Within medicine, surgery is a unique field. From the patient’s perspective, it is invasive, involving an inherent vulnerability and trust in their provider that differs from other specialties. From the surgeon’s perspective, there is both great power and responsibility knowing that they hold their patients’ lives in their hands. However, new surgical technology is developed every day, with the goal of aiding the surgeon in the operating room, in order to improve patient care with algorithmic precision. As the use of artificial intelligence and machine learning in the care of surgical patients grows, we must consider how the central relationship between surgeon and patient may be affected in the process.

There are many promising benefits in utilizing AI in surgery. Through machine learning, it has been possible to identify subtle patterns within large datasets. Such AI systems often outperform the manual analysis performed by humans and have been shown to be useful in predicting surgical complications, including surgical site infections and anastomotic leak after resection.ii, , Image- and video-recognition based on mathematical algorithms that analyze visual cues, in combination with laparoscopic surgery, allow for anatomic identification that may be difficult for less-experienced surgeons, or in patients with difficult native anatomy. Such systems can be utilized both intra-operatively, as an aid to the surgeon, and as an educational tool for trainees. Increasing the amount of data input that these systems see only improves their pattern-recognition abilities; therefore, operative videos provided from surgeons globally will thoroughly enhance machine learning in its capability to define anatomy, improving diagnostic accuracy while controlling for center-based, regional, gender, and racial biases. Current systems are—like their human creators—flawed (facial recognition software being a prime example), but the future portends an avenue to improve upon these flaws and remove such biases from clinical care by using pure qualitative input to make decisions.

As for physically performing procedures, commercially-available technology remains human-controlled. The DaVinci robot, used increasingly in abdominal, gynecologic, urologic, and cardiac surgery, is controlled completely by the surgeon operating it. It allows for a minimally-invasive approach with improved hand and wrist flexibility, 3-D visualization, and ergonomic benefits when compared to laparoscopy. However, the technology for autonomous surgery is in development. Created at Johns Hopkins University, the Smart Tissue Autonomous Robot (STAR) is controlled by AI algorithms and receives input from both visual and haptic sensors. It was found to outperform humans in both ex-vivo and in-vivo robotic anastomoses of porcine intestine, though has not yet been used in humans. Its creators hope that it will one day provide surgical procedures to remote areas of the world, where access to care is lacking.

Therefore, the underlying value of continuing to encourage and develop surgical AI systems lies completely in optimizing patient care. In theory, we can utilize these systems to maximize diagnostic and procedural accuracy, using large amounts of objective data input to drive decisional algorithms. In turn, this should control for the inherent subjectivity and bias involved in human decision making, as well as for the expected margin of human error. The trade-off is the art of surgery: can a machine come to the same diagnostic conclusion as a surgeon who spends time talking to the patient, examining them, and using years of clinical surgical experience to make a diagnosis and operative plan? Apart from knowledge of surgical anatomy and technique, instinct and feel in the operating room are critical skills in a surgeon's toolbox, which are likely not transmissible to an AI system. However, if the AI's algorithmic process is indeed based on learning from and synthesizing vast amounts of such experience, theoretically this is even better for patient care. It would be as if each patient had a large team of experienced surgeons from across the globe personally collaborating on their case. By taking the best aspects from each of these surgeons, and eliminating the undesirable aspects of human error, an AI surgical system holds the prospect of being safer and more efficient for patient care than an individual human surgeon. However, it will be years before we can safely ensure that such systems can act independently without human oversight.

That AI could improve the quality of, as well as access to, surgical care is a wonderful possibility. However the positives of AI in surgery should be balanced by the recognition of several potential ethical issues that will arise. Though we are likely many years away from autonomous surgery as an option for humans, several questions remain and will need to be addressed as we approach this goal. To what extent should surgeons depend on the technology if it goes against their intuition? What is the threshold to determine if and when this technology safe to deploy? Self-driving cars underwent years of testing before being released for public use, and still led to fatal injury when its human drivers' attention faltered. Surgeons have an ethical responsibility not only to benefit their patients (beneficence) but also to avoid injury to their patients (non-maleficence). Will these responsibilities be able to be upheld as AI becomes more autonomous? Additionally, the process of obtaining informed consent will be challenged if surgeons cannot necessarily predict the results that the system will produce. Another ethical issue that AI systems will challenge is providing equity in surgical care. As mentioned above, technology is being developed in order to reduce care disparities and provide remote care to those who may not otherwise have access. However, is it consistent with the principle of justice to provide such technology to a vulnerable patient group who cannot access better care, if we cannot ensure the AI-based care is equivalent to a human performing the procedure? Ultimately, surgical care revolves around the surgeon-patient relationship. It remains to be seen how the trust and personal responsibility involved in this bond will change with the continued development of AI systems in augmenting surgical decision making.

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Artificial intelligence, virtual reality simulation and neurosurgical training: friend or foe?

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John was very excited. He is an ST4 neurosurgical trainee at Evergreen hospital. Having assisted his consultant on several lumbar laminectomies for stenosis and having learned the steps of the procedure, he was so excited when his consultant told him he would lead the case today. John eagerly started the case. As expected, the lumbar spine was very degenerative with thick ligaments and, clearly, very stenotic. Not having much experience himself in using surgical instruments simultaneously and not having a good sense of how much pressure to exert, he struggles with the decompression. Suddenly, following a generous bite with his kerrison rongeur, his surgical field fills up with clear fluid. John got very upset and was not quite sure how to best proceed. His consultant, smiled and calmly took over. He temporarily covered the dural defect, removed more bone to gain better exposure and then proceeded with a primary repair and seal. He performed a Valsalva manoeuvr. No further CSF leak. The patient had to stay in hospital 3 days longer than what was originally planned but made an excellent recovery. John learned his lesson and next time, he will try to avoid the same mistake.

Introduction

Neurosurgical training has traditionally been based on an apprenticeship approach, summarised in the old adage of "See One, Do One, Teach One". However, several reasons exist why this traditional method might be inadequate. The working hours reduction, the emphasis on service provision and the ever-growing threat of medico-legal action has led to a more defensive surgical practice and teaching culture (Faustinella and Jacobs, 2018).

As a result of this, alternative surgical teaching methods have been sought. One of those, includes the use of artificial intelligence (AI) in surgical education (Feizi et al., 2021)

Artificial intelligence and Machine Learning

AI is an interdisciplinary scientific field that derives from philosophy, psychology, neuroscience and computer science. Machine Learning (ML), a subdivision of AI, is the process by which a computer learns from data (Howard, 2019). ML learns, develops and evolves rather than just responds to rigidly defined rules. More sophisticated ML algorithms, using artificial neural networks have the potential to learn extremely complicated relationships. Such algorithms have been used in the classification of images (Rajkomar et al., 2019). AI and ML are able to process complex data and produce novel responses. The combination of AI & ML results in the development of virtual reality platforms (Figure 1) that serve not only for training but also offer the opportunity to provide individualised surgical teaching (Veneziano et al., 2020) and, autonomously, interact with participants and provide individualised objective feedback on performance (Mirchi et al., 2020, Sheikh and Fann, 2019).

Figure 1. Example of a VR platform setting involving pedicle probe insertion with haptic feedback (images kindly provided by FundamentalVR, https://www.fundamentalvr.com)

AI, ML and healthcare

Whether we realise it or not, AI has already been present in healthcare (Panesar et al., 2020). For example, AI has been applied in neuroimaging and an attempt to automate brain tumour classification, characterise low grade gliomas and stroke (Titano et al., 2018, Zhou et al., 2017, Bidiwala and Pittman, 2004). Interestingly, AI in many instances has performed better than the radiologists. This is because AI can handle simultaneously massive amount of data that a human brain could not do (Yamashita et al., 2008). Another use of AI is in decision making. For example, in preoperative planning, localisation of epileptogenic regions and stratification of vasospasm risk following subarachnoid haemorrhage (Kassahun et al., 2014, Dolz et al., 2016, Dumont et al., 2011).

Virtual reality simulation and Neurosurgery

Virtual reality (VR) uses technology to create simulated environment whereas AI provides the tools to interact within such an environment. In the context of surgery, VR simulator platforms provide a safe environment allowing quantification of the psychomotor performance of a simulated surgical procedure. The large data obtained during such a performance can be translated into specific metrics (for example, time, pressure applied etc) which can then be useful markers of performance, dexterity, skill, efficiency and performance. Machine learning allows the identification of patterns and the performance of tasks without specific programming (Mirchi et al., 2020, Sheikh and Fann, 2019).

There is a growing interest in VR use in medical education (Winkler-Schwartz et al., 2019). VR allows full immersion to a 3-D virtual world (Ahmed et al., 1997) involving both visual and physical experiences for the surgeon which would mimic a real operation as much as possible. This means that the surgeon would have sensory input and haptic feedback (Dakson et al., 2018, Clarke et al., 2013). This, technology has significantly evolved to allow the simulation platforms to better mimic the reality of surgery and the different tissue "feeling" between superficial and deeper structures (Swanson et al., 2003).

Figure 2 gives an example of a training environment mimicking as closely as possible a real operation. We can not emphasise enough the importance of haptic feedback technology as without it the VR learning experience is greatly reduced (Choudhury et al., 2013, Lemole et al., 2007, Sabbagh et al., 2020).

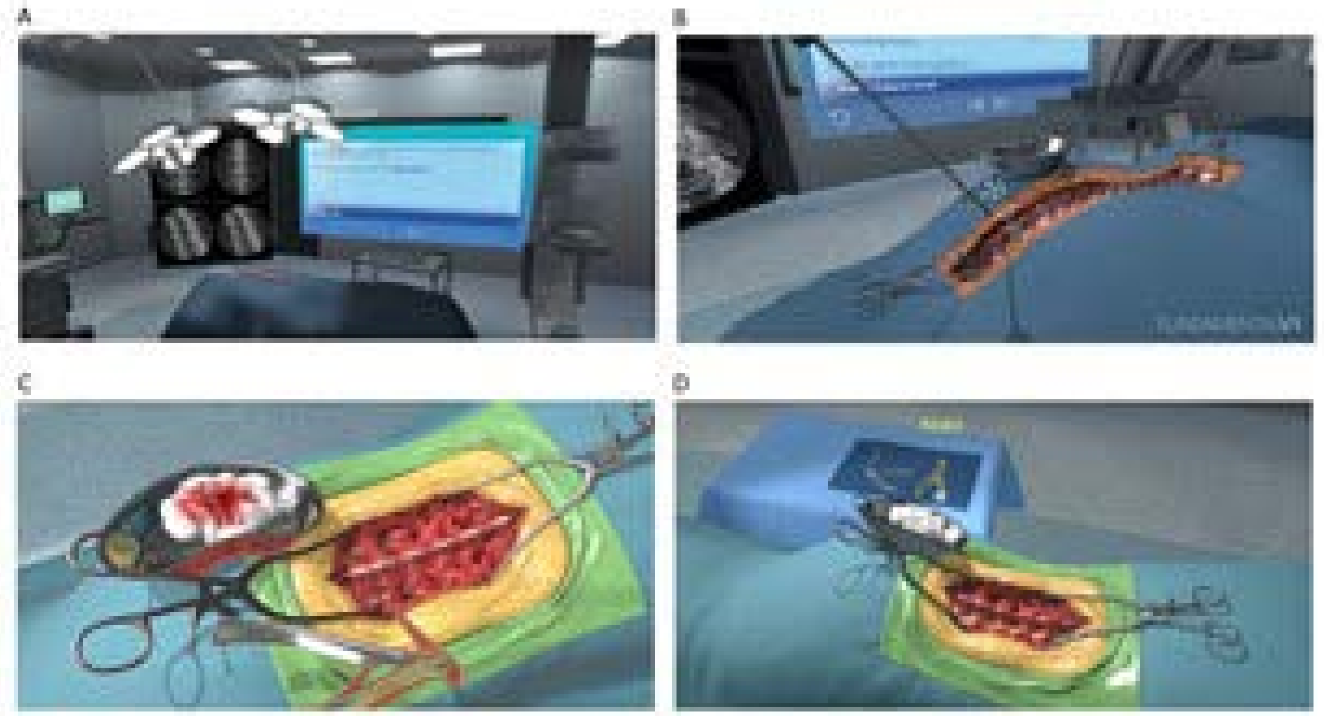

Figure 2. Examples of VR platform environments (FundamentalVR). The realism of the VR platforms is impressive. The surgical field detail is such that gives the impression and feeling of being in the operating room
A. The virtual operating room.
B. Virtual pedicle probe insertion
C. Facetectomy using Kerrison
D. Tool selection. (Images kindly provided by FundamentalVR, https://www.fundamentalvr.com)

Does VR improve neurosurgical performance?

In a review paper (Clark et al., 2017) the authors reviewed the literature in terms of VR simulators. They concluded that there is reasonable evidence that VR platforms enhance the ability of a trainee to perform ventriculostomy on a real patient (Yudkowsky et al., 2013). Interestingly, neuroendoscopic simulators, with haptic feedback, have been used with very encouraging results (Freudenstein et al., 2001, Rosseau et al., 2013).

In a systematic review (Mazur et al., 2018) the authors reviewed the literature on VR simulation for neurosurgical oncological procedures and concluded that the participants gained a better understanding of the relevant anatomy and surgical planning as a result of their VR experience. Of those studies, only one (Yang et al., 2009) was a prospective controlled study. In this, 84 patients were randomised.

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Imaging data were incorporated into the Dextroscope VR workstation for patients with skull base lesions. The test group practiced preoperative plans whereas the control group did not. Interestingly, as a result patients who were operated by surgeons in the test group had shorter operative time, shorter hospital stay, less blood loss and fewer complications. This, suggests a clear clinical advantage of VR simulation.

VR and stratification of experience level

In an interesting study (Gelinas-Phaneuf et al., 2014) the authors tested a VR platform with haptic feedback to perform a neurosurgical oncological procedure. The authors showed that the platform could differentiate the participants based on their level of neurosurgical seniority: simply put, the senior trainees were better in removing the tumour on the simulator. Similarly, Bissonnette et al (2019) examined the ability of AI as an assessment tool in virtual spine surgery simulation and assessed if it could differentiate the surgical skill level of the participants. The task involved performing a VR hemilaminectomy with haptic feedback. They concluded that senior participants restricted the use of pressure on the dura, used tools simultaneously, and displayed less angle variance with the burr when performing the laminectomy (Bissonnette et al., 2019). Siyar et al (2020) used a VR tumour resection platform and utilised 2 groups of participants: senior and junior neurosurgeons. Different VR scenarios were used with the same visual properties but different tactile properties. The authors showed that the VR platform used for tumour resection was able to differentiate between junior and senior participants (Siyar et al., 2020)

In a landmark prospective study involving VR brain tumour resection by Winkler-Schwartz et al (2019) the authors demonstrated the ability of ML to select performance parameters to classify participants of different skill and level to the correct category according to their level of expertise. They concluded that as few as 6 performance metrics were sufficient to successfully categorise 45 out of 50 participants into 4 groups of different level of experience. This study is unique because it established the minimum level of metrics required to classify participants in more than two categories (Winkler-Schwartz et al., 2019).

VR platforms have also been used successfully in spinal surgery. In a recent study, the authors investigated the validity of a VR platform for a C4-5 ACDF with haptic feedback. The procedure involved 4 steps: disc exposure & insertion of distractor pin, disc, osteophyte and ligament removal. Participants scored highly the realism of the platform. Additionally, the more experienced surgeons scored better compared to their more junior colleagues in each component of the procedure (Ledwos et al., 2020). Others have also reported encouraging results in the field of spinal surgery VR simulations (Gasco et al., 2014, Ray et al., 2013).

VR and operative feedback

As discussed earlier, AI systems that autonomously interact with participants and provide individualised objective feedback have been described (Mirchi et al., 2020, Sheikh and Fann, 2019). Mirchi et al. (2020) study involved participants to perform a VR simulation of subpial brain tumour resection using a simulated aspirator and bipolar. This was combined with the Virtual Operative Assistant providing feedback on metric performance. The Virtual Operative Assistant successfully classified senior and junior participants using only 4 metrics. This interesting study showed that the use of VR simulation is combined with feedback technology to provide surgical teaching and allow standardised surgical training.

Future directions

AI, ML and VR are evolving technologies that have attracted significant interest in neurosurgery as reflected by the rapidly increasing volume of publications (Buchlak et al., 2020) and increased market interest (https://bisresearch.com/industry-report/haptic-feedback-surgical-environment-market.html). With all the changes in surgical training, it seems that the use of simulation is going to be an important component of surgical training (Davids et al., 2020, Bohm and Arnold, 2015).

Interestingly, this technology can not only assist in enhancing skills but can also provide valuable assistance in live surgery. For example, the fascinating prospect of mixed reality (MR) allowing a neurosurgeon to visualise subcortical anatomical structures in 3D. The prospects of this technology is remarkable as elegantly presented in a recent paper by Cartucho et al 2020.

Friend or foe?

The use of this evolving technology is promising. ML is likely to play a major role in healthcare and training. However, over-reliance on automation may lead to clinical deskilling. Additionally, the increased accuracy of ML needs to be translated to increased interpretability and applicability to clinical practice as well.

It is vital that the effects of AI/ML/VR are measured against clinical-related criteria such as real surgery performance, timings, complications, hospital stay and patient satisfaction (Cabitza et al., 2017). We need to keep listening to the reserved voices, who consider surgery an apprenticeship (Ausman, 2012). AI, therefore, should serve as a complementary training tool. After all, the shaping of a good surgeon is based on common sense, experience and good judgement. Will AI-based learning provide those (Ausman, 2012)?

Final remark

John was very excited. He is an ST4 neurosurgical trainee at Evergreen hospital. Having assisted his consultant on several lumbar laminectomies for stenosis and having learned the steps of the procedure, he was so excited when his consultant told him he would lead the case today. John spent several hours last week practising the scenario of lumbar decompression at the virtual reality simulation lab of his hospital. He felt comfortable with the use of virtual instruments and the gentle handling of the virtual dura. On the day of the operation he confidently started the case. As expected, the lumbar spine was very degenerative with thick ligaments and, clearly, very stenotic. Confidently and timely he proceeded with the decompression while protecting the dura at every step. He achieved an excellent decompression. The grateful patient went home the following day.

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Technology as a major stakeholder in the management of surgical frailty

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The relationship between aging and the outcomes of a surgical operation has been assessed extensively for almost a century. According to Cutler, back in 1947, older patients are "peculiarly susceptible to pneumonia, wound disruptions and sepsis"[1]. However, it was quickly apparent that there was some inconsistency between the reported results of patients that underwent major operations and the occurrence of adverse outcomes, in correlation with their age[2]. It was established for some decades now, that the association of such events with age is highly variable and it is rooted in the broad heterogeneity that characterizes the procedure of aging per individual[3]. The interest for better patient care and improved surgical ward planning has pushed research forward to further develop the surgical treatment.

Frailty, on the other hand, has been proven as a much more consistent predictor of post-operative outcomes. It has been described as a state of decreased physiologic reserve. It is associated with a higher risk for worse health outcomes, that vary from any level of disability, dependency from other individuals or healthcare personnel, or increased susceptibility to death. While it indeed develops with age, it reflects the subclinical physiological decline, which in turn limits a patient's resistance to several stressors, such as a demanding surgical operation[4]. Initially described in the gerontology setting, frailty is now a rapidly emerging field of research in surgery, since it is a significantly stronger predictor of length of post-operative hospitalization, readmission rates and mortality[5].

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Practitioners across the world are trained early, on the recognition of the most vulnerable patient. However, when put to the test, studies have shown that they are no better than flipping a coin in correctly labeling the patients as frail and non-frail, being correct in approximately 40% of the cases presented6. Objective tools have been developed, to consistently identify frailty in the clinical setting. Physical frailty phenotypes, such as the Fried frailty phenotype, include the assessment of phenotypical characteristics, such as gait speed, exhaustion, weakness, weight loss and motor performance[4,7]. Frailty indexes evaluate the accumulation of health deficits, information collected via health records, surveys, questionnaires, and chart reviews[8,9].

The significance of adverse outcomes prediction has been well established in the surgical setting in the recent years. In colorectal surgery, frail patients had a 5-year survival of 24%, compared to an almost three times greater survival chance for non-frail patients (66%), a prognosis comparable with tumor and metastasis staging[10]. In the liver transplantation setting, frailty described by the Fried Frailty Index can describe quality of life better than Model for End stage Liver Disease scores[11]. Regarding 6-Minute Walking Test (6MWT), every 100-meter improvement in the distance walked, leads to a 52% decrease in mortality[12]. Furthermore, in vascular surgery, studies have described association between aspects of physical frailty, such as grip strength and body weight loss, with increased 30- and 90-day mortality[13,14], while worse outcomes are expected in the frail oncologic, uro-oncologic and gynecologic patient[15–17].

An important aspect of physical frailty, which has direct impact on the evolution of the syndrome, is physical activity. The level of physical activity in correlation with post-operation outcomes or susceptibility to adverse events has only been sufficiently described in literature during the last decade. In 2013, Najabi et al. used body worn sensors for continuous monitoring to evaluate the level of physical activity in diabetic patients, aiming to evaluate the risk of falling. With the use of three sensors, two accelerometers and one gyroscope, they instructed the patients to perform a Timed Up and Go test (TUG). Patients with a higher risk of falling had an average result of 62 seconds, in comparison with the 26 seconds in patient with low risk[18].

Wearable devices have quickly earned the attention of researchers worldwide, offering the ability to collect reliable data remotely, in an outpatient setting, using hardware that is already gaining popularity in the general population[19]. While the selection of the appropriate device requires an evaluation process, the incorporation of such devices have offered the possibility of remote management of frailty, as well as the collection of real-life data, free of possible influences and biases, unwillingly created in an inpatient setting examination[20].

Therefore, the use of wearable devices for the development of tests or the evaluation of patient frailty has gathered reasonable attention the past 5 years. In 2017, Joseph et al. evaluated Upper Extremity Function (UEF) in elderly hospitalized after ground-level falls, using two wearable sensors around the biceps muscle and the wrist. Patients with worse results were significantly more prone to discharge disposition, readmission, and further falls5. In 2018, Lee et al. successfully assessed physical frailty phenotypes, using a single wearable wrist-sensor, in bed-bound patients, unable to perform any walking tests; they were instructed to a repeated flexion-extension movement of the upper limb, while wearing the sensor around their wrists[21]. In a later study, Yanquez et al. used a two-sensor UEF test, where frail patients were credited with an average increase of 253% in post-operative length of stay. Mach et al. used activity-monitoring devices to classify transcatheter aortic valve replacement patients via a newly developed score, the FItness-tracker assisted Frailty-Assessment (FIFA)[22].

The potential of interventions supported by technology in surgical patients is truly impressive. Razjouyan et al. stressed the fact that even a single parameter, number of daily steps has already been correlated with frailty progression; a parameter that is nowadays widely monitored by even the simplest wearable devices[23]. The American College of Surgeons has already supported the idea of perioperative frailty score evaluation[24]. Especially in elective surgery, frailty evaluation and prehabilitation can have a substantially impact in our patients. Pre-frail patients, seem to be the group able to gain the most from a prehabilitation intervention regarding elective surgery, especially if we account for the fact that they have a 1.3-fold higher risk for major adverse events, compared to robust patients[25]. Richards et al. have recently published data correlating a less-than 2500 daily step count with 2-fold increase in post-operative length of hospitalization[26]. Meanwhile, Shahrokni et al. already described that the use of wearable trackers in elderly patients successfully improved step count in more than a quarter of the patient, as their social features independently offered motivation to the users[2]. Bolam et al. used wearable trackers in selected patients after knee arthroplasty surgery, offering remote rehabilitation guidance with positive results[27].

Moreover, an ongoing research protocol run by our Department in the Aristotle University of Thessaloniki has offered some preliminary results in liver transplant candidates. Patients following a relatively more active lifestyle, walk longer distances in the 6-Minute Walking Test, have higher VO2max values, while sedentary subjects are ranked as frail via the Liver Frailty Index[28], compared to significantly better scores for active subjects[29]. The use of wearable sensors for the remote guidance and evaluation of patients[30] in the transplantation field opens a brand-new area of practice, since most of transplant candidates, usually reside far away from the transplantation centre. The ability of remote, out-patient interventions reduces healthcare expenses, improves adherence to suggested protocols and is easier to implement. Published results by Lai et al. prove the safety of such interventions, they mention, however, that adherence was not satisfactory, leaving room for improvement[31].

Most importantly, Soangra et al. have stressed the fact that patients presenting greater risk for adverse effects after surgical intervention, could have their operation delayed, while they are enrolled in prehabilitation programmes aiming to improve their frailty status[32]. Even in the emergency setting, the use of wearable devices for a quick evaluation of patient frailty can offer an objective tool for risk stratification. Ruiz et al. performed the Upper Extremity Function test in patients that presented themselves in the emergency room with intra-abdominal symptoms[33].

Summarizing, the use of wearable hardware and well-designed software can offer a unique field of progress and research in the management of surgical frailty. While frailty is a well-defined adverse outcome predictor, it is also an area of possible improvement, if the patient is well guided in the pre-operative setting. The ability of remote management, guidance and intervention is a modern, patient-centered approach that we need to further develop and work on. Even the events of COVID-19 pandemic have further stressed the importance of remote patient treatment and guidance, thus achieving the optimal care and patient quality of life. While there are still important steps to be taken and there is substantial room for development, such as protocols designed for better patient adherence or walking-analysis algorithms developed on patients instead of healthy individuals, the very words compiling this article might be rendered obsolete by the time this article is read. Smartwatches can offer a wide range of monitoring abilities, from heart rate variability and electrocardiograms to step count and exercise intensity. Daily activities, such as cooking and cleaning can be monitored via smart appliances and Wi-Fi location tracking systems, offering an even more detailed image of frailty parameters. And as our elderly or oncological patients are even more literate and even more technology familiar, our approach as practitioners has to evolve parallel to the needs of the modern surgical setting.

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Endovascular treatments for the common femoral artery: is there a revolution coming?

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Background

Peripheral Arterial Disease (PAD) is a common health problem, affecting almost 20% of those aged above 55 years in the United Kingdom (UK); it remains the commonest cause of major lower limb amputation[1-3]. When individuals with PAD develop symptoms owing to their disease, they typically present with either Intermittent Claudication (IC) or Chronic Limb Threatening Ischaemia (CLTI), characterised by the presence of lower limb pain at rest, tissue loss (in the form of gangrene or ulceration) or both(3). These conditions (IC and CLTI) both impact considerably on patients' quality of life, ability to ambulate, patients' autonomy, and they are both strongly and independently associated with future cardiovascular morbidity and excess mortality[1]. The treatment of patients with symptomatic PAD, either in the form of IC or CLTI, typically involves surgery or use of endovascular means to revascularise the affected limb. This is necessary in order to salvage the limb in those presenting with CLTI or improve the patient's ability to ambulate in the case of IC. Endovascular minimally invasive techniques have revolutionised the care of patients with PAD and are widely considered as first-line options in certain patients with disease of the iliac axis, superficial femoral artery or crural vessels[4, 5].

Atherosclerotic disease of the Common Femoral Artery (CFA) is a very common feature of symptomatic PAD(6). Surgery, in the form of CFA Endarterectomy (CFAE), has long been the mainstay of lower limb revascularisation in case the CFA is affected in patients with symptomatic PAD[6, 7]. Long-term results of CFAE have been favourable in terms of patency

Atherosclerotic disease of the Common Femoral Artery (CFA) is a very common feature of symptomatic PAD(6). Surgery, in the form of CFA Endarterectomy (CFAE), has long been the mainstay of lower limb revascularisation in case the CFA is affected in patients with symptomatic PAD[6, 7]. Long-term results of CFAE have been favourable in terms of patency and it remains one of the most commonly performed procedures in vascular surgery, often combined with endovascular techniques for the iliac arteries or the periphery (hybrid vascular procedures). At the same time, CFAE can be associated with a plethora of complications, such as: major peri-operative cardiovascular events (e.g. stroke or myocardial infarction), especially given the high-risk profile of patients with symptomatic PAD, and local complications such as Surgical Site Infection (SSI), seroma or lymphocele formation[7-9]. The latter are common in the case of CFAE, due to the location of the procedure (groin), necessity to dissect through the lymph chains surrounding the femoral vasculature, and associated patients' co-morbidities (e.g. diabetes, obesity, frailty, all of which are very common in patients with symptomatic PAD)[3]. Overall, based on results from recent series, CFAE can be associated with a combined short-term morbidity and mortality rate as high as 15%[7]. Endovascular procedures minimally invasive procedures have lower rates of peri-operative complications in the iliac and femoro-popliteal segment (superficial femoral artery and popliteal artery)[7]. The CFA, however, represents a particular challenge for endovascular reconstruction. Atherosclerotic disease of the CFA is almost always calcified and in extreme calcification of the plaque is not uncommon. The superficial and profunda femoris arteries are often involved (especially their origins at the level of the bifurcation); the patency of these arteries has to be maintained when addressing CFA disease. Further, the CFA is often used for percutaneous vascular access and therefore stenting across the artery might impact on the ability to puncture the CFA in the future for other endovascular procedures. We recently surveyed 244 surgeons and radiologists across Europe and the United States, using a structure online form (February 2021) in order to identify barriers in using endovascular techniques to revascularise the CFA. The most common barriers identified were: i) poor patency due to calcified femoral atherosclerotic plaques, ii) inability to maintain patency of the profunda femoris artery, and iii) impact on future endovascular access via the femoral vessels.

Endovascular techniques and devices developed in recent years might help overcome these challenges relating to the CFA[7]. Some non-randomised studies have reported outcomes after endovascular CFA treatment(3), even though there is significant heterogeneity in terms of the types of endovascular CFA procedures performed, duration and type of follow-up, and reporting of outcomes of interest. A fairly recent Randomised Controlled Trial (RCT) has reported that short-term outcomes (e.g. SSI and overall morbidity) are better after CFA endovascular treatment compared to surgery[8]. However, the study was underpowered and the 117 patients taking part were highly selected with a primary endpoint which was not focussing on clinical effectiveness and limb preservation. Based on the currently available observational literature, peri-operative major morbidity and mortality seem to be higher with CFAE compared to endovascular options; however, long-term patency remains an issue with most endovascular techniques[3]. This is probably the main reason why CFAE is still widely considered as the gold-standard approach in this clinical setting.

A number of recently developed endovascular techniques, however, might improve longer-term patency of the CFA. These include: intravascular lithotripsy, biomimetic self-expanding interwoven stent deployment, and directional atherectomy. These interesting techniques are increasingly being used worldwide and have the potential to create a paradigm shift in the treatment of patients with symptomatic PAD, avoiding the need for surgery in the groin.

Intravascular lithotripsy (IVL) - Figure 1

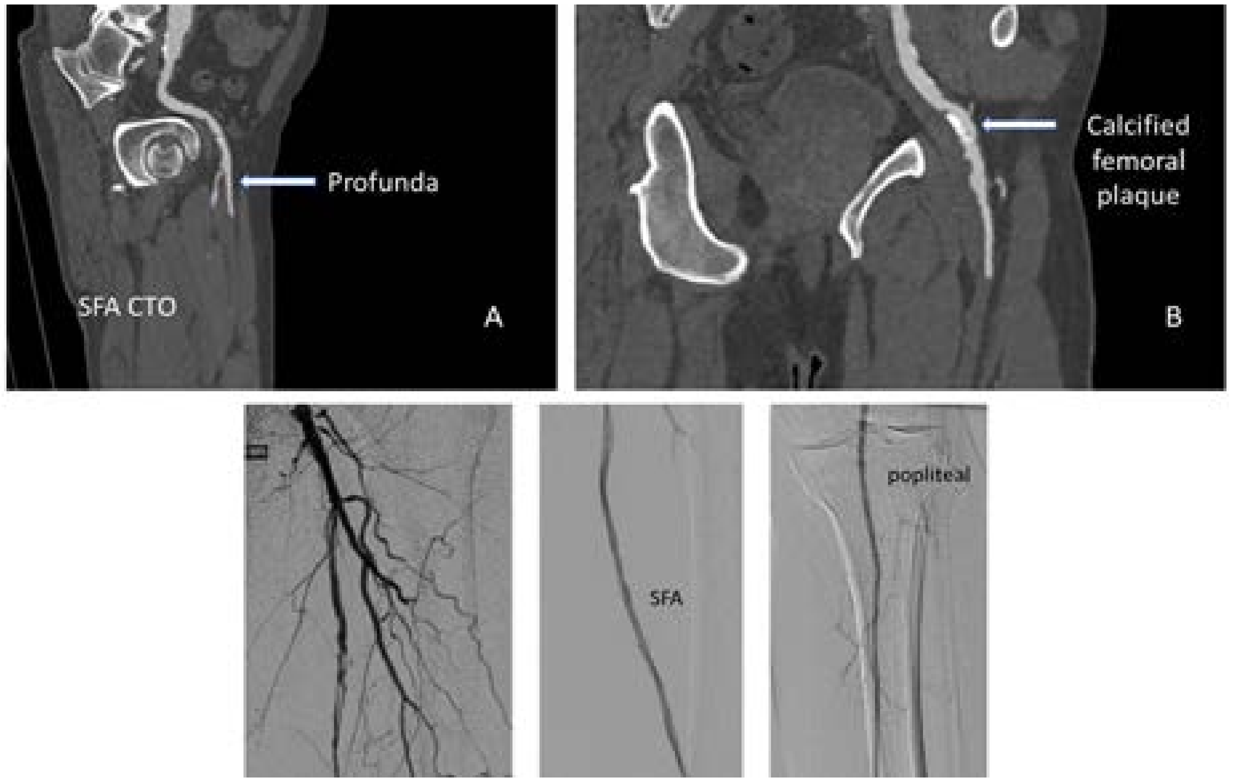

Figure 1. Treatment of a calcified Common Femoral Artery (CFA) plaque and associated Superficial Femoral Artery (SFA) Chronic Total Occlusion (CTO) with intravascular lithotripsy (fully endovascular approach), without the need for stenting.
A & B: pre-operative computed tomographic angiogram showing a CTO of the SFA and CFA disease, with significant calcium (arrow)
C: crossing of the CFA disease, SFA CTO, and treatment with intravascular lithotripsy
D & E: result post-treatment with four cycles of IVL at the CFA and SFA.

Patency of the profunda femoris is the main barrier identified in our recent survey regarding the use of endovascular techniques in the CFA. Indeed, the profunda femoris is of great importance in these patients, providing blood to the limb in case the superficial femoral artery occludes, which is common in symptomatic PAD. A 'leave-nothing-behind' approach is often preferred over CFA stenting by specialists who are keen to preserve the profunda femoris origin. Intravascular lithotripsy (IVL; Shockwave Medical, California, USA) uses intermittent pulsatile sonic waves to rupture luminal and medial calcium within an atherosclerotic plaque. It has been used over a number of years in coronary lesions with favourable results. Lesions in the CFA are typically calcified, with often circumferential calcium present in the artery. This is a major issue when applying endovascular techniques such as plain angioplasty, due to recoil or dissection (very common in calcified arteries). Recoil and dissections are usually addressed using an endovascular stent, which, however, might occlude the profunda femoris.

The use of IVL can improve the compliance of the calcified CFA, without the need for aggressive vessel preparation using plain angioplasty; IVL has been designed to fracture the calcium of the plaque with an inflation pressure of only 4 to 6 atm, without the potential of peripheral embolisation. Using IVL can therefore lead to CFA luminal gain with a lower risk for dissection, perforation or embolization compared to more traditional techniques such as plain, high-pressure, or cutting angioplasty. Oversizing of the IVL catheter plays an important role to procedural success, to ensure apposition across the length of the calcified lumen. Of note, IVL catheters are currently only commercially available in a diameter up to 7mm. As a result, sufficient oversizing might not be possible for larger CFA lumens and subsequent therapy with a plain balloon would be necessary. Following application of IVL and improvement of the vessel compliance (the calcium of the plaque has essentially been fractured, therefore improving "compliance"), the use of an oversized plain balloon or even a stent might still be necessary for adequate luminal gain. A re-stenotic treatment with either a drug-coated balloon (DCB) can then be considered, as per the operator's preference. Currently available observational results (non-randomised) show that IVL is safe in the CFA with favourable short-term patency[10]. Unpublished results from an ongoing randomised trial have shown that the rate of stent placement was 4.6% in the IVL group vs. 18.3% in the plain angioplasty group (p=0.0002) in the femoro-popliteal segment(11). Overall, 66% of the IVL patients achieved the goal of angiographic diameter stenosis ≤ 30% vs. 50% in the angioplasty group (p=0.02). Disadvantages of IVL in the CFA relate to the high immediate cost of the catheters and lack of unproven long-term results. An RCT with appropriate clinical effectiveness measures of success is needed, before large-scale adoption of this interesting technique. Until then, it is a promising tool in the endovascular armamentarium when addressing calcified CFA plaques.

Biomimetic self-expanding stents

Stents are often used in the femoro-popliteal segment in order to treat recoil or dissection post-angioplasty or in order to improve long-term patency in the case of extreme calcium or long chronic total occlusions. Stent fractures and re-stenosis due to intimal hyperplasia are main pitfalls of stenting in the CFA[7]. These may be overcome by using a biomimetic stent (i.e. Supera stent, Abbott Medical, Illinois, USA). These stents are flexible and have been designed to be deployed within heavily calcified lesions, due to their radial force and design. Blood flow into the profunda can be preserved, given that these stents are not covered with fabric. At the same time, if the profunda origin is affected by a very calcified plaque, patency of the artery does remain a concern. In the case of CFA disease recurrence following stenting (e.g. in-stent stenosis or stent occlusion), CFAE is still feasible, as the stents can be removed from the arterial lumen in a fairly atraumatic way. Stenting with such a device in the superficial femoral artery has been shown to achieve good primary patency, even in very calcified and long lesions, without many stent fractures reported in the literature[12]. The superficial femoral artery is more mobile than the CFA, therefore stent fractures in the CFA are not very likely. Using such a stent for CFA disease, therefore, has the potential to improve immediate/short-term technical success and potentially longer-term patency, without the risk of stent fracture. The key steps to avoid immediate complications when using these stents in the CFA are accurate sizing, which might be assisted by the use of intra-vascular ultrasound, and lesion-preparation with an adequately sized balloon, at least 0.5mm wider than the diameter of the stent. Future access via the femoral artery remains a possibility, as long as a sheath with a maximum diameter of 6Fr is used. An ongoing RCT is comparing the performance of this stent with CFAE[13]; however, the study includes patients with claudication and its applicability in a real-world setting remains questionable, especially since it will be underpowered to detect limb preservation differences in patients with CLTI.

Atherectomy for CFA disease

Atherectomy debulks the atherosclerotic plaque, which might be necessary in patients with intimal hyperplasia or extreme calcium. It has long been used alongside drug-coated/eluting therapies in the femoro-popliteal segment, distal to the CFA. Atherectomy catheters available in the market can be used to treat arteries up to 7mm in diameter. The main benefit, similar to IVL, is that atherectomy does not necessitate subsequent stenting and considerably debulks the lesion. The main drawback is the risk of peripheral emboli. As a result, intravascular filters are often used to prevent distal emboli and potential distal occlusions, which can be catastrophic, especially if both the profunda and superficial femoral arteries are affected. Further, some CFAs are larger than 7mm in diameter and might require alternative additional treatments. In a retrospective study, the 12-month primary patency after vessel preparation with directional atherectomy prior to using a DCB was higher than when using a DCB alone (88% vs 68%) but the difference was not statistically significant[14]. An ongoing RCT is comparing the performance of directional atherectomy with DCB over CFAE[9]. The inclusion of patients with claudication, however, might limit the reproducibility of the results, as is the case with the aforementioned RCT relating to the use of biomimetic stents in the CFA. The use of a debulking catheter can be particularly helpful in patients with re-stenosis after CFAE or bypass-anastomosis stenosis, where re-exploring the groin might pose difficulties and the main issue is addressing the neointimal hyperplasia.

Conclusion

Recent advances in endovascular technologies have greatly altered our approach to treating atherosclerotic CFA lesions, avoiding the various potential complications of open surgery. Results from ongoing RCTs are awaited to assess the efficacy of these strategies. At the same time, we urgently need to assess the clinical effectiveness of these methods, since they come at a cost which might not compare favourably to surgery. Recent lessons from the aortic endovascular literature have shown that the wide adoption of endovascular devices without a formal assessment of their clinical effectiveness can lead to major adverse events and poor outcomes. We urgently need to design and implement large-scale RCTs to evaluate these new techniques, especially since the prevalence of PAD is increasing and CLTI is becoming the main burden of the vascular workload internationally.

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GUEST EDITOR

Engagement of undergraduate students in medical education research: the eMERG experience

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Introduction

Medical Research holds a substantive role in improving patient care. Currently in the UK, most medical schools encourage students to undertake an intercalated research degree typically in the form of a Bachelor's or Master's in Science (iBSc/iMSc) degree during their studies[1]. Since the 1990s, there has been a largely growing trend of students seeking research opportunities in order to strengthen their CV, but also to acquire essential skills to contribute to the rapidly evolving medical practice. McManus et al.[2] reported over a third of medical students chose to undertake an intercalated degree; 20 years later this number has largely grown, and several medical schools have turned iBSc degrees into a mandatory requirement of the course. Despite some students being opposed to undertaking an extra year for an iBSc or iMSc[3], there is a national consensus, that medical students are becoming increasingly interested in undertaking any research opportunities. Evidence to this is the expanding number of students who apply for Academic Foundation Programmes (AFP) or Academic Clinical Fellowships (ACF).

Although one could argue that undertaking a formal degree focused on research methodology is the best way to familiarise oneself with medical research, different opportunities and pathways remain available that could potentially provide a similar range and quality of research skillsets, and, occasionally, more flexibility to students' needs. Such opportunities include involvement of students in research projects, where, with appropriate supervision, they could successfully contribute to groundwork tasks and/or higher expertise work towards the delivery of a quality manuscript. Other times, such opportunities may take the form of summer research placement scholarships for work to be undertaken in a laboratory setting or for work undertaken as part of a research network.

In this short communication, we describe a novel application of an educational research network (eMERG)[4] which focuses exclusively on training students on surgical education research[5].

Why surgical education research

Surgery is rapidly evolving and the demand for excellence in patient care is constantly increasing. Surgical innovation and the application of new technologies in clinical setting are increasingly evident, and undoubtedly give rise to steeper and more demanding learning curves subsequently. Hence, educating the future surgeons to achieve the highest possible standards can be challenging. Besides this, conducting research in the field of surgical education can be appealing to several students, especially those who would want to pursue a career in surgery, since teaching and education is an essential element of any surgical curriculum. Hence, research in surgical education is always a global trend, and many undergraduate students find it inspiring and appealing to acquire their basic research skills in this exciting field whilst simultaneously familiarising themselves with their future potential career.

MERG structure

ESMSC Medical Education Group (eMERG) is an international collaboration between senior academics, consultant-level surgeons, as well as senior and junior trainees with undergraduate medical students. eMERG was founded as part of the Essential Skills in the Management of Surgical Cases – ESMSC Marathon Course and served as its research engine to revolutionise the ESMSC curriculum. ESMSC is an international surgical course which combines high fidelity In-Vivo (live animal tissue) Simulation based learning (SBL) with lower fidelity ex vivo (animal tissues) or dry lab SBL, along with basic and applied surgical science workshops. It is structured on a flexible curriculum whose modules are covering in all surgical specialties. ESMSC's primary aim is to deliver a compact, intense curriculum which spans 3 days and fully covers all the essential practical and theoretical aspects of surgery that a final-year medical student with minimal exposure to surgery should know. This in itself can be extremely challenging and ambitious, hence most research projects are tailored to serve the development of a global surgical blueprint[6].

eMERG recruits undergraduate students from UK and EU medical schools in the form of scholarships in order to participate in surgical education projects focused on the ESMSC course. Recruitment is facilitated via a competitive process where students who have successfully completed the course are invited to submit their CV along with a personal statement declaring their interest and vision for surgical education research. Shortlisted applications were invited for structured interviews where the senior faculty of the ESMSC course were primarily looking for students dedicated towards a surgical career who were seeking their first research experience.

Successful students were allocated to pre-set research projects and were paired with more senior trainees (specialty registrar or senior house officer level) who would guide them to complete the groundwork of the project. Further involvement of consultant level clinical academics served as a teaching platform to facilitate the next steps of the project. The methodology and set up of the studies included a mix of systematic reviews, as well as prospective and retrospective observational studies and structured narrative reviews. All the projects served the vision of the ESMSC course to deliver a novel surgical curriculum blueprint which can be adaptable in any global setting and would provide the essential skills to manage any surgical case as a junior doctor who would have just qualified from medical school.

eMERG outcomes

Initially 11 students joined the pilot scheme followed but a second cohort of another 10 students. Several manuscripts were successfully delivered and published along with presentations of our work in prestigious conferences in the US and EU; a representation of which is referenced below[5, 7-23]. In the regular feedback meetings students reported that they enjoyed working within eMERG and acquired several vital research skills to deliver projects independently in the future. They also highlighted the invaluable benefits gained through mentorship from working in proximity with other trainees and senior colleagues, which acted as a networking boost allowing them to unlock and pursue further opportunities in their research and clinical career.

Discussion

eMERG represents an alternative route to engage students in surgical education research. Its primary role was to equip students with basic research skills for them to pursue further opportunities in the future with more confidence and passion. It also acted as a network hub for students to acquire key contacts who could further mentor and guide them towards a successful academic and clinical career. Additionally, eMERG was a means for students to undertake a positive research experience under the umbrella and mentorship of a network of qualified supervisors whose primary role is to train undergraduates in basic research methodology. Indeed, this undoubtably acted as a unique catalyst spearheading students' motivation and further heightening their aspiration to pursue a surgical career with more passion and inspiration. Strong emphasis on delivering a robust team structured by several training layers has been the utmost essential element for the success of eMERG. Beyond this, surgical education and any other educational research is at its core applicable to medical students' everyday reality, as they see themselves as the main stakeholders of any pilot educational initiative and are thus highly invested in improving their own education and training through novel evidence-based strategies. Hence, surgical education research seems to be a highly valuable and appealing topic to train medical students in research methodology. Further to this, every modern postgraduate training programme nowadays places an emphasis on teaching, hence such initiatives offer a multileveled benefit to a junior doctor's CV.

Challenges

Several challenges have been encountered throughout this initiative. Limited funding constitutes a longstanding challenge that any research project encounters. Selection criteria have also generated discussion, with several stakeholders arguing that eMERG should recruit less motivated students and build on their skills, rather than the most highly motivated ones. Finally, in the COVID era, we have discussed to a significant extent how the pandemic has imposed new rules on medical and surgical education as well as the relevant research[7, 24].

Future directions & Conclusions

Our vision for the eMERG collaboration is to strengthen its educational value by continuing to deliver high quality research projects in surgical education. We are focusing on expanding our services in collaborating with several UK institutions in order to establish a postgraduate course tailored to bolstering core knowledge and skills on the development of novel surgical curricula designs which are globally adaptable, and deliver high quality education in a short period of time with minimal cost. A classic example of this includes the development of the iG4 prototype which is a primary outcome of the eMERG research outputs[18, 20, 23].

iG4 encompasses an effort to describe several parameters of the modules of a surgical curriculum using mathematical language. Subsequently, this may act as a stepping-stone to introduce the use of Artificial Intelligence in the development of highly precise surgical curricula, that would expedite the systematic exploration of how the human brain acquires skills and knowledge. In the coming years we hope to present part of this work, thus contributing further to the advancement of the field of surgical education.

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Virtual Reality surgical medical training in the post-Covid-19 pandemic era

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Surgical training has progressed extensively from the historical apprenticeship of the early surgeons to a modern complicated structured training programme with numerous duties and evaluations. Expertise must be gained in a shorter period whilst requiring a greater set of skills than previously. Numerous novel surgical techniques have been developed, demanding the current trainees to learn a broader array of specialist skills, despite having less time to do so. As the number of trainees increases, the chances to acquire procedural and technical skills become gradually limited. Furthermore, the introduction of working hour restrictions and a drive towards senior-led care have reduced the available training hours during the des-ignated training period[1,2].

On the other hand, surgical treatment is now indicated more often than in the past. This, combined with an ageing population with higher treatment needs, has significantly increased the demands for surgery. The ensuing conflict between service provision and training has compelled the development of alternative methods to compensate for the reduction in 'hands-on' psychomotor experience.

E-Learning, simulation, and compulsory fellowship training programmes are various solutions that have been proposed to exploit learning opportunities within the existing resource con-straints. Simulation offers to the trainee the chance to obtain surgical skills in a controlled en-vironment while reducing the patient safety risks, operating theatre use and financial expenses[3,4]. Spanning from cadaveric models or arthroscopic simulators to advanced virtual reali-ty sets, there is a wide spectrum of simulation options in orthopaedics. While simulation training has several limitations, it is accepted that trainees need to get procedural experience before real-life practice. The cumulative trainee confidence and familiarity with the equip-ment are apparent advantages, leading to growing evidence that this simulation-gained expertise can be somehow transferred to the operating theatre performance.

Medical simulation is a technology or process that reconstructs the appropriate background, allowing the trainee to come across mistakes and collect feedback in a safe environment[5]. As the technological advances permit more complex situations to be modelled and tested, this definition will continuously grow being more valuable in the ongoing and future training and assessment of surgeons. The advantages of a VR-based simulation extend beyond simple technical and procedural skills. Simulation allows trainees to engage with a multi-disciplinary team and focus on individual and team-based cognitive skills, including problem-solving, deci-sion-making, and team behaviour skills in a realistic, reactive virtual environment, while hav-ing a unique hands-on experience.

Recently, considerable progress has been made in evolving novel and diverse simulation-based techniques to deliver virtual training in a protected and flexible environment[6-9]. The simulation improves learner's self-confidence and comprehension while allowing practice and training of specific technical skills[10]. However, real-life surgery is unpredictable mainly be-cause of the unique human anatomy per individual and the incapability to reproduce surgery 100% due to surgical or patient-related factors. During the previous decade, simulation of surgical procedures was mainly limited to a non-operator communication of static, non-interactive image or video-based examples of various procedural steps. Very limited cases of gamified VR approaches have been showcased[11].

Consequently, 3D simulations were not realistic enough for most trainees and of no use for specialist surgeons. The existing, cogni-tive-only virtual simulations were equivalent to a linear, video manual of a flight simulation for a pilot, lacking however any degree of immersive reality or ability to follow and react to dif-ferent scenarios with appropriate user hand-actions (psychomotor). The modern VR simula-tors aim to enhance 3D realism but most essentially to provide a natural, gesture-based in-teraction between the consumer-surgeon and the virtual patient.

Nowadays, the current training models cannot address the vast medical training needs on syrgery and anesthesia-related topics. Moreover, based on OECD estimates, technology is expected to transform roughly more than one-third of all jobs worldwide in the next decade. WHO supports that more than 40 million healthcare professionals will be required by the beginning of the following decade. This increasing demand for a permanent upskill and reskill has become more critical in the post-COVID-19 pandemic. Virtual Reality (VR), along with 5G spatial computing technologies, are presented as the upcoming absolute computing frontline concerning medical psychomotor/cognitive training, education, and empowerment[12].

The renovation of medical training is now accomplished by the virtual/augmented/mixed reality (VR/AR/MR) technologies (grouped by the industry as XR). This transformation is supported by numerous recent academic and industrial articles and case studies[13]. Over 20 clinical trials were published in primary science journals during the last year, evaluating the efficacy of medical VR training in transferring skills from a virtual environment to real-life situations. It has also been demonstrated that XR technologies may significantly improve healthcare professionals' practical and collaborative learning[14].

VR/AR may deliver the ways and methods to achieve remote qualitative education and training skills, via employing inexpensive technology with personalized, on-demand and smooth learning curves. Modern significant advances in 5G networking, spatial computing and neuroscience have demonstrated that the VR/AR shares with the human brain similar fundamental mechanisms like the "embodied simulations".

After more than three decades of intensive research, development and validation by early adopters, the medical VR technologies are now moving into the mainstream. Based on the recent developments in computer vision, innovative algebraic representations, real-time 3D graphics, simulation models, deep learning, gamification, analytics, and 5G cloud edge computing, these spatial computing applications optimize intelligent education & training while maximizing the anticipated learning outcomes. Such immersive technologies may promote lifelong education and offer training programmes and self-improvement opportunities that enhance medical professionals' abilities, reducing the training skill gaps.

It is well known that neuroplasticity and long-term potentiation, which relates to the consoli-dation of neuronal connections in the brain based on current activity patterns, are driven by the feeling of presence and the affordances of agency (body, hand interaction). Repeating the same movement enhances the neuronal cell-to-cell signalling and improves neural connections, strongly influencing learning, muscle, and spatial memory.

Nowadays, therapeu-tic VR has also been clinically proven to help in managing traumas and rehabilitation, phobias, stress and various mental illnesses.

The consequences of the Covid-19 pandemic have speeded up the advances in the field of spatial computing technologies. The 3000 medical schools worldwide, the 8400 medical de-vice companies and the 600 surgical training centres challenged by the covid-19 lockdowns have realized the ultimate need to embody this technology. The use of medical VR training is now not a myth but a modern reality, being part of the so-called "quiet revolution" in this sci-entific field[15]. Besides, health care professionals have now recognized that training simula-tors are the leading application of VR/AR in healthcare. It was recently reported that the growing demand for virtual training across industries drives the VR market, which is expected to grow from $15B in 2020 to $57B in the following years[16].

However, the extensive work of translating the 400+ basic medical procedures and their countless variations is pending[17]. Furthermore, as these medical procedures and the ap-propriate equipment (eg. robotic surgery) are continuously updated, the need for advanced and extensive training is exponentially rising. This constant demand for upskill/reskill in order to follow the latest advances is an endless challenge for healthcare professionals and institutions. Medical professionals and especially med-school students, residents, young or experi-enced surgeons or physicians of any specialty must continuously attend lec-tures/workshops/conferences and conclude self-training courses to deliver top treatment for their patients, while remaining compliant with the regulatory agencies. Traditionally surgeons are trained on cadavers or on-the-job. However, cadavers are limited and costly, while train-ing on actual patients poses other issues (limited opportunity, repeatability, not to mention possible adverse outcomes). On the grounds of the surpassed time in the operating room for trainees/residents and the fact that constantly fewer of them are entering the workforce, the puzzle is only getting more perplexed over time.

Despite the progress mentioned above, it remains unanswered who will finally transfer the enormous medical-training content in VR technology, both in extensive depth and breadth. Moreover, the lack of dedicated and specifically formed VR content authoring tools for medi-cal training should be noted. Although the outstanding de facto 3D/XR content creation indus-trial standards of Unity and Unreal Engines are employed as the fundamental enabling tech-nologies and general authoring platforms, they provide a general-purpose coverage (from games to automotive, engineering, construction simulation and film/broadcasting). Conse-quently, there is need of experienced doctors motivated in this educational direction as well as of various highly skilled technological developer teams (computer graphics, deep learning, computer networking, human-computer-interaction, gamification, game development, UI/UX design, affective computing), and of course, 3D artists/designers.

Novel integrated software platforms and simulation-training authoring tools are essential, permitting the fast prototyping of medical VR/XR training. These platforms should act in a new computational medical discipline that holds together medical education, preoperative planning, and real-time operative navigation under a new, holistic, integrated system ap-proach. All the involved parts, including medical and dental schools, nursing academies, medi-cal device companies and surgical training centres, should work with teams in-house or out-source parts of the job. However, the final source code owners will empower themselves to update this XR training content effortlessly. By developing, improving, and regulating their own XR training material, they can guarantee that their medical professionals are suitably and uninterruptedly trained while ensuring ideal patient outcomes with fewer medical errors and complications. These novel platforms will serve as the new 'WordPress' or 'Office suite' of medical VR/XR training so that progressively the subject-matter-experts themselves can create their own VR/AR learning modules, in the same manner they make their presenta-tion slides today. However, there is still a lot of technical work to provide these low-code/no-code authoring platforms[18].

Aerospace and aviation share a lot of similarities in regulatory complexities with the health care industry. For a long time, various aviation authorities have confirmed the exceptional benefits of mandatory simulation-based training of pilots for several aircraft types, leading to the added safety in aviation worldwide. It is widely suggested that medical simulation-based training is absolutely necessary and subsequently, it is probably only a matter of time until VR simulation education labs for training and competency assessment will be mandatory worldwide. Medical education will be considerably improved via experiential learning, since learning by doing has been proven much more effective than the traditional master-apprentice model and the "see one, do one, teach one" concept. The medical institutions must drive themselves medical VR training transformation via XR content curriculum simulators and continuous education of their professionals, for the immediate benefit of their patients with a significant impact on humanity in general.

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Pushing Surgical Education from Magic to Science...via new technologies and pedagogical practices

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Introduction

A few years ago, one of the largest, if not the largest, event for Medical Education research and practice, that of the Association Medical Education Europe (AMEE), featured a magician as the main keynote speaker of the conference opening. Obviously, the fact that a non- academic speaker, a magician, stood up in front of an academic audience composed of a few thousands of attendees, took everyone by surprise, even the keynote speaker himself! The main argument put across by the speaker in his wonderful introduction was the following:

In the past, when "religion" was strong and "science" was weak, people mistook "Magic" for "Medicine"; nowadays, that science is relatively stronger and religion is likewise weaker that the past, people tend to mistake medicine for magic..."

Proliferating this argument even further, and taking under consideration all the breakthroughs of the so called "new technologies" (e.g. "immersive technologies") applied in medicine, and surgery in specific, makes this a sound statement. A look at the Figure below, makes this obvious:

Figure 1. (Left): A "breath-taking" first presentation of the new augmented reality demo on the Apple iPhone 8 back in 2017, boosted the "magic" expectations of likely educational uses of the (smart) mobile phones. (Right): our research group's first exploration of mixed reality educational episodes by means of the MS Hololens back in 2017[1,2].

However, in the more humanistic and rational way of thinking, the long-term goal of any medical education effort or medical technology innovation should be targeting towards the positive impact on health (individual or public health). So, in this piece of work, light is shed on a few case studies, that support the following vision: how the use of new technologies may exploit that "magic" aura, so as to improve Medical/Surgical Education and the impact on health overall.

Thus, the remainder of this paper is structured as follows. After a short revisit of (immersive) technologies as well as, scenario and team based training, emphasis is placed on a series of funded projects, interlinked with one another and creating a chain of added values. In the final section, current hot issues of our research endeavours are pulled together in an effort to create a sound positive impact for the learners/trainees.

A Brief Account On Extended Reality Technologies

AR/VR/MR

Although the exact origins of virtual reality are disputed, the 60s are considered to be the birthdate for it. By Virtual reality (VR), owe tend to mean any interactive computer-generated experience within a simulated environment, which may in turn be enhanced/facilitated by

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multiple types of sensory feedback (auditory, visual, haptic). Augmented reality (AR) on the other hand, is a form of VR systems in which virtual information is layered (e.g. by means of a camera / headset / smartphone / tablet) giving the user the ability to view 3d images. Moreover, Hybrid or Mixed Reality (MR) is defined by the merging of real and virtual worlds; this paradigm pretends itself to be a new environment, in which physical and digital objects co-exist and interact in real time creating MR visualisations[3] and represents a mix of reality and virtual reality, encompassing both augmented reality and augmented virtuality" via immersion.

Finally, eXtended Reality (XR) or Cross Reality: refers to all real-and-virtual combined environments. On top of these one also considers as XR all those human-machine interactions generated by computer technology and wearables. That is, XR includes AR, AV, VR and is therefore a superset.

In recent years the domain of medical/clinical/surgical has witnessed numerous attempts that build upon this "magic feeling" created by XR technologies and show the feasibility of incorporating them in educational/training settings. Unavoidably, much hype has been created that such technologies could significantly increase educational impact of a learning episode thereby affecting (positively) educational outcomes[4].

3D printed materials

A recent breakthrough expanding that "magic" has certainly been the notion of 3d printing. Their incorporation in surgical education, for all types of learners, e.g. students and residents, covers a core need, that is the hands-on acquisition of skills. This is one of the most resource intensive endeavours in medical/clinical/surgical education. Admittedly, physical tangible resources and opportunities for such training, which have been so far inadequate on some occasions due to non-availability of resources or non-affordability of ethical paradigms, seem to find a way forward with 3d printing. In fact the aforementioned limitations and the requirement for patient safety, create a clear need for quality surgical simulation using tangible resources like 3D prints (of human anatomy or surgical instruments). For surgical residents to obtain and therefore improve their operative skills and experience, it is best to learn and practice before and after patient encounter.

Certainly, this magic is extended if tangible (3D prints) and intangible (AR/VR/MR) educational resources are combined. It is expected that such educational encounters can achieve by far a superior immersion and support excellence in training and patient safety.

a brief account of pedagogical approaches and the "Pandemic-Updated" needs of medical/surgical education

In general, in American/Anglo-Saxon medical education, but also surgical education in specific, case-based or problem-based learning (CBL/PBL) approaches have delivered many promises and thus, have been well-explored[5]. In addition, other small-group instructional models[6] including simulations, scenario narratives, as well as, other structured task-based learning episodes have also been exploited. Scenario narratives in the form of Virtual Patients (VPs)[7] in specific, custom-designed to the envisaged learning objectives but also aligned with expectations and skillsets of students have been providing the space for informing game-based approaches, enriching and saturating learning environments and recently fulfilling Massive Online Open Courses[8]. In all of these, major emphasis is placed upon training for decision-making skills: learners get to explore a case through multiple avenues, exercise their state of decision making and explore the impact of those decisions in a safe but engaging way[9].

Digital remote training, learning and teaching have received an urgent call for action/focus in recent times of the COVID19 pandemic. The recent lockdowns in education could be used as a best test for technology interventions for distance learning. But unfortunately, few systems arrived at this point fully prepared[10]. Thus, there was a clear need to exploit technology led simulations, which could rapidly facilitate hospital preparation and education of large numbers of healthcare learners (professionals and students of various backgrounds) with a proven value in many settings. In this context, the bet for Medical Escape Room Game Experience was introduced as an exercise to create experiential learning opportunities for healthcare students and professionals[11].

Escape rooms are settings where teams of participants come to solve puzzles, but also riddles, in a predefined and yet unknown overall closed space, with a particular theme to achieve predetermined goals, in a limited amount of time. Like in the case of serious-game-based training/learning, escape rooms put the focus on interactional dynamics thereby providing valuable insights on how teams work together.

Building on those experiences, our group conceived and started the ESCAPE4HEALTH project earlier this year[12]. As it will be shown later in its own case, innovative methods (like mixed/virtual/augmented reality) and their artifacts are fused with contemporary pedagogies and approaches, thereby leveraging the Edutainment role played by escape rooms to move learners towards increasing motivation (as a call to face pandemic scenarios) and enhanced learning outcomes[13].

Case Studies

Case study 1 - projects for the creation of XR resources: ENTICE and CoViRR

Recognising the existing limitations in surgical education and the need for quality immersive medical simulation resources and episodes, the ENTICE project[14] , funded by the Erasmus+ programme, aims at combining 3D printed models and AR/VR/MR resources in order to validate a systematic, integrative approach for education-centered experiential teaching episodes and resource content creation. More specifically, the project covers three pillars:

I. Tangible/Intangible integration in immersive educational resource design. Seamless integration of 3D printed models & AR/MR/VR with the educational episode for the first time is going to be implemented and evaluated for measurable increase in knowledge retention.

II. Learning Objectives-centered development of educational episodes with immersive resources. The content creation process will be based on specific learning objectives. Thus, educationally sound resources are expected to compound the learning efficacy and overall impact of learning episodes. Additionally, the project attempts to streamline the content creation process to reduce resources overheads.

III. Prototyping Knowledge Engineering methodology for education-centric immersive resources. An approach for VR content creation in medical education has been proposed using Knowledge Engineering.

So, ENTICE, is currently working towards fusing together (intangible) digital augmentations of learning resources with (tangible) 3d-printed anatomical/surgical objects and resources, so that a robust immersive e-classroom for surgical education is created. Exemplar resources are originally crafted in pure e-design tools and are then used to create parts of Mixed Reality resources. These are then put together as Augmented Reality-blended 3d printings, as shown in the figure below.

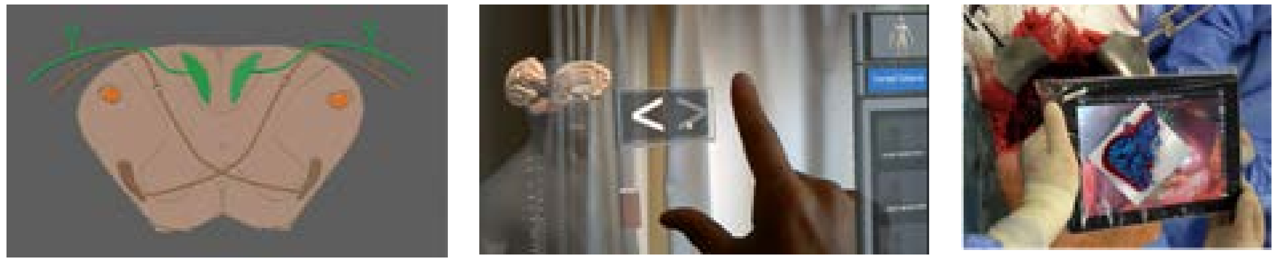

Figure 2. Surgery educational resources in the ENTICE project; originally crafted in simple e-drawings (left); these are then used to create Mixed Reality resources through the use of gadgets like Hololens and their advanced gesture interface (centre); the latter can be then fused with 3d printings to create augmented blends (right). Such resources are going to be put all together and piloted/evaluated in an immersive learning environment.

ENTICE has joined the VAM Realities EU project community, which is Europe's most comprehensive collection of transnational co-operations from the virtual, augmented, and mixed reality fields, and an opportunity for sharing any best practice examples[15].

ENTICE actually benefits from parallel work within another project, also funded by the Erasmus+ programme, namely CoViRR[16], standing for the co-creation of Virtual Reality reusable e-resources for European Healthcare Education.

The objectives of the project are first to identify the potential role of virtual reality reusable e-resources into the current healthcare curricula and then to co-create virtual reality reusable e-resources through participatory design of specifications/scenarios and their technical implementation. The distillation of best practices for the adapted co-creation methodology for virtual reality reusable e-resources, in order the procedure to be easily replicable by other European HEIs and the production of recommendations for use of virtual reality reusable e-resources in terms of pedagogical aspects, while implementing them in healthcare curricula are also highly expected project

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objectives.

CoViRR has proposed a co-creative digital content development pipeline, so that resources like VR/MR/AR are co-created by all stakeholders and likewise be repurposed by any of them to fit in different educational purposes/goals. Such an approach provides the methodology where the co-creation process can be piloted and where all different health education "actors" can learn, and co-develop new Virtual Reality reusable e-resources embedded into the curriculum, thereby creating knowledge added value chains. In recent project workshops, medical students, instructed and accompanied by clinical/medical and technical experts, experienced these co-creation sessions; story boards of learning episodes were finally created by teams of students; the latter may explore and exploit such VR resources. A typical example of a very promising such story board created and presented by Aristotle University of Thessaloniki medical students are shown in the figure below.

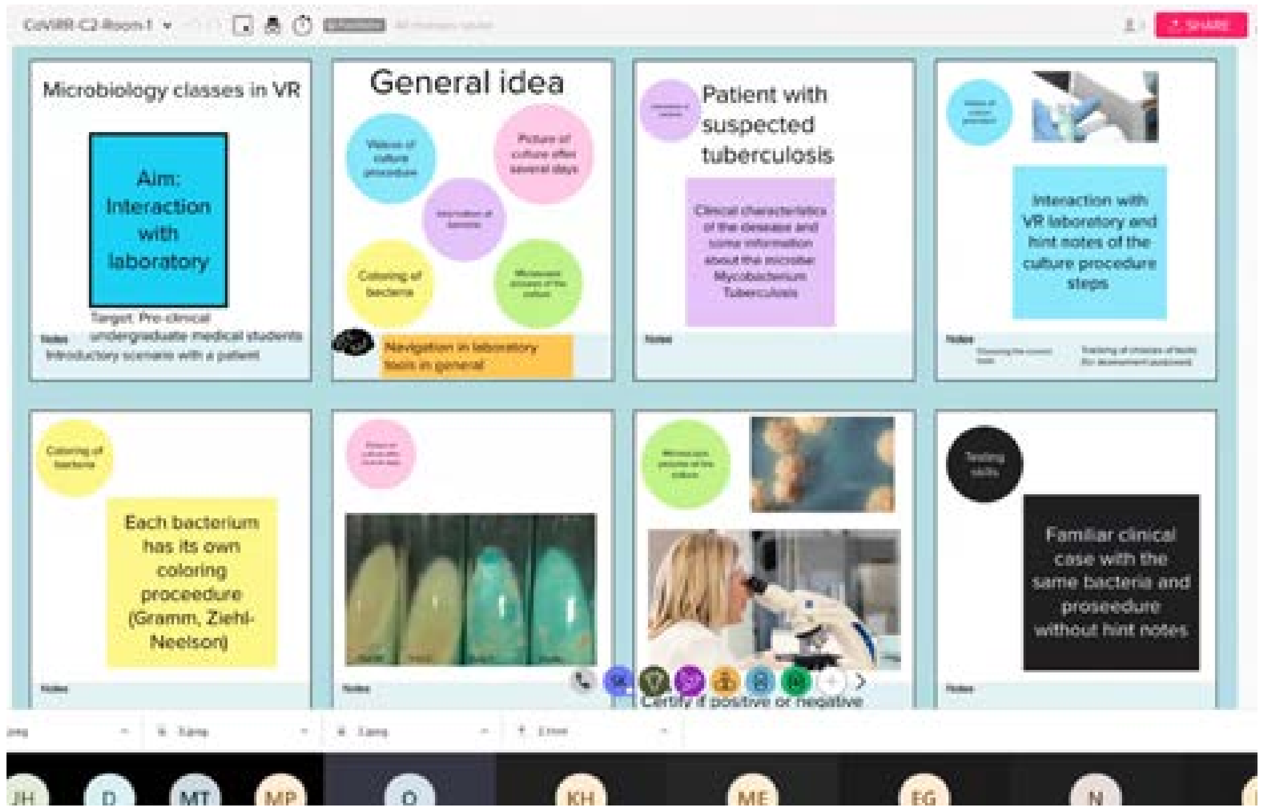

Figure 3. An example of (a Zoom-based presentation of a) student groupwork exploring the educational use of a Virtual/Mixed Reality resource though a storyboard scenario. Both the resource and the scenario, are considered as products of a co-creation approach in the CoViRR project, lending themselves in even further exploitation in curricula through (proper) repurposing.

Obviously, this has not been the first time that our research group is exposed to such an exercise. In fact, long time ago, these experiences were gathered by primitive tools available in previous decades. In fact, the mEducator[17] and DISCOVER[18] projects, provided much of the aforementioned background knowledge to create immersive resources and environments, but also produce design guidelines and implementation of scenario based learning in certain targeted topics (e.g. training for the care of vulnerable and older adult patients). An earlier example created in SecondLife/OpenSim is shown in the figure 4.

Figure 4. An example of virtual environment exploring a scenario based training episode. Early work on such Virtual Reality resources were lending themselves to initial experimentations following certain storyboards and student feedback. Further exploitation in curricula through (proper) repurposing was then sought in more contemporary tools/environments by repurposing certain 3D-assets[19].

Case study 2 - Scenario and team based training using ESCAPE rooms: the ESCAPE4HEALTH and CLUEDUP projects

As mentioned earlier, the ESCAPE4HEALTH project comes as a response to meet the new educational demands put across by the COVID-19 pandemic. It is also a project funded by the Erasmus+ programme, which aims to exploit technology led simulations, which by the way can well fit into surgical education scenarios, which in turn demand inter-professional training and team-based skill acquisition.

ESCAPE4HEALTH expands the Escape Room (game-based training) approach technically by introducing virtual/mixed/augmented reality versions of physical escape rooms. Four different escape room scenarios are being created, all for multi-professional, experiential training and education in healthcare, and all of them stemmed through efforts of co-design by healthcare stakeholders, both professionals and students. Some of these scenarios will also be also created for Virtual/Mixed/Augmented Reality environments, allowing remote training, on an elaboration of themes related to the COVID-19 pandemic.

The insights to be gained from the scenarios may and should be linked back to clinical practices. This form of learning is particularly attractive for generation Z students and can become an ideal tool for inter-professional, experiential learning. Another project novelty is the attempt to turn the scenarios into ready-to-use packages ready to be repurposed for different contexts.

Unarguably enough, Medical and Healthcare education rely much on Clinical Skills labs, which exist in many Universities and University Hospitals worldwide. These usually support both technical (TS) and non-technical skills (NTS); the latter, are equally essential for medical and healthcare students and professionals. Numerous papers report that transitions from classical clinical skills teaching to simulation-based training have contributed to better medical education, despite gaps that may exists between Clinical Skills Lab (CSL) training and the clinical setting. Moreover, it is expected that the material created and the guidance contained will allow a broader community to use escape rooms for different purposes.

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Figure 5. Aspects of the Escape4Health project (left and centre) and our group's current plan for creating the scenarios (right).

Grasping the opportunity of another call for educational research proposals, our group further embarked on an effort to expand and possibly maximise the benefits for such approaches given the pandemic pedagogic restrictions and limitations. So leveraging on the thought that by creating an innovative online Team-Based Learning (TBL), which however contains Escape Room elements, may form attractive Combined Learning Activity (CLA) solutions, the CLEUDUP project was recently launched[20] . CLUEDUP aims at first conducting a needs analysis to inform the adaptation of collaborative learning and then to design and implement learner-centered scenarios (CLAs), so as to improve training programmes in Medical Schools by providing evidence to support the effectiveness of delivering forms of CLA as individual learning suites.

What is currently in the plan in CLUEDUP is to deliver two (2) CLA versions (Learning Suites) : one for Problem Based Learning (PBL), one for Team-Based Learning (TBL). Three (3) scenarios representing topics relevant to the pandemic are in the hotspot, while a training programme for faculty staff in the design and implementation of these resources is also planned. This will form the basis finally delivering the training programme as an online Massive Open Online Course (MOOC).

The figure below illustrates how CLUEDUP capitalizes on the innovation brought about by the aforementioned flexible resource template, the CLA, and the tailored Learning Suites to impact different stakeholders of the learning process.

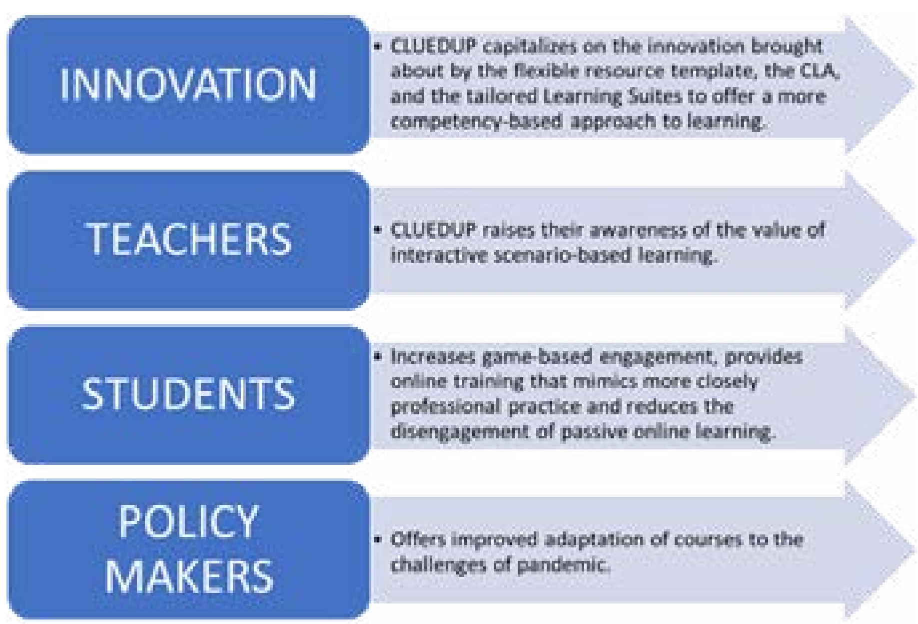

Figure 6. Impact target of the CLUEDUP project for which the envisaged success of ESCAPE4HEALTH provides the safety net for widening the impact to all three types of stakeholders, namely, medical/ clinical teachers, learners/ students and policy makers.

Bringing The Threads Together

Healthcare education in general, and surgical education in specific, has globally experienced a major disruptive change due to the COVID-19 pandemic and technology has been readily, rapidly and innovatively used to maintain teaching and learning. The future of healthcare education emerges uncertain, but several future scenarios embrace innovative approaches and technologies for the provision of teaching and learning. The use of emergent technology, such as virtual reality used in this work's case studies, seems to be an essential component of the transformative change and the future of healthcare education. In fact it has been recently recognised that virtual reality software could be a new focus of direction in the development of training tools in healthcare education. So, the innovative character of projects like ESCAPE4HEALTH or CLUEDUP put it at the centre of future developments.

In all case studies, the envisaged scenarios or learning episodes will allow multi-professional, experiential training and education in healthcare. Escape rooms exploiting these scenarios are going to be created over the next year. Creation of scenarios in VR/MR/AR environments will allow remote/distance training, thereby enabling mitigation of training/education in cases of pandemics, as well as, contribute to the sustainability beyond any project duration.

We have started this paper by considering the "magic notions" of these technologies. We are convinced and have so far been much determined for one thing: all these innovations should be targeting towards the positive impact on health (individual or public health). To achieve that, all project and research efforts need to create sound scientific evidence. Each of the projects has its own challenges, both technical and pedagogical. Thus, the research teams need to carefully move from exploratory methods to be robust and rigorous methodologies that will make an academic and scientific impact altogether.

This is particularly important as discipline specific pedagogical research has deep rooted issues of generalisability: how can one meaningfully transfer findings from one surgical training paradigm to another? What are those issues/parameters that drive the results and subsequently the impact? Is it the immersion, the game or the scenario, or the team players and the existence of leaders in each learning team? Much is still needed to be explored so that we obtain reliable answers to these questions. Such issues are well known obviously in pedagogical research and are now, with the emergence of these new technologies particularly acute within the area of immersive teaching and learning and/or experiential/interprofessional training. Concomitant with these, there is the sustained need to match expanding innovation with research and evaluation protocols to improve the statistical reliability and develop 'useful knowledge' while supporting educators in exploiting such resources, scenarios, paradigms or environments[21].

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The Future of the School of Medicine, Aristotle University: Challenges and Opportunities

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They say that "need is the mother of invention". This was the case for the School of Medicine, Aristotle University (AUSoM), as the strain that the global financial crisis placed on Greece led to an increasingly more difficult situation for the Aristotle University of Thessaloniki, which is a public University. This became more apparent given that the model that had been propagated over the years was that of a state-funded and financially supported University. As a result, this meant a small support for the educational, clinical and research activities of the School of Medicine, as well as a continuously decreasing faculty members, as most of those retiring were not replaced. Moreover, the connection between higher education and research community (academia) was lost. However, apart from the "need" described above, the other part of the equation was the emergence of a vision and a desire to respond to these challenges by reorganizing and streamlining the AUSoM, in such a manner that we would be able to meet the future needs of our students, faculty and society, while not forgetting our core values.

This mean a series of initiatives as well as a change in the management philosophy of the AUSoM. Specifically, the key initiatives are:

- Reformatting of the Medical School curriculum to achieve a better balance and increased connectivity between the basic science and clinical years, as well as increase the teaching of clinical skills, by introducing the OSCE techniques in most of the medical school years. New courses with a focus on emerging medical fields were introduced with great success. Digitalization of the various educational resources in an effort to improve teaching techniques, as well as respond to the challenges posed by the COVID-19 pandemic comprise the infrastructure of the modern curricula which were introduced in the School.

- Introducing the new English speaking Medical School curriculum, in an effort to attract students from all over the world who will have the opportunity to study modern medicine to the highest standards in English, while drawing their inspiration from medical heroes, such as Hippocrates (https://aristotlemedical.edu.gr/). This represents the first such endeavor in Greece and is already geared for a great start in September 2021. Both the Greek and the English speaking Medical School Curricula were recently accredited by an international team of experts for the Hellenic Authority for Higher Education.

- Increasing significantly both the quality and the quantity of the Postgraduate Programs of the AUSoM. This serve the educational needs not just of our graduates but of health care personnel from all over Greece by providing Masters Degree Courses in a full spectrum medical ground. Moreover, it reinforces the potential and the extroversion of the AUSoM and highlights its leading academic role (www.med.auth.gr/en/pms-all).

- Re-energizing the "Educate the Educators" course which is an instructor training program addressed to the faculty members, teaching and research associates, academic fellows, postgraduate students and PhD candidates. Its scope is to inform and train the participants in new teaching methods and available technology by providing training seminars on education, research and bioethics procedures and operation of AUSoM, innovative educational activities of AUSoM, support for e-courses and academic education services.

- Introducing the Hellenic Diaspora Medical Forum (HDMF) as the foundation of a dynamic collaboration between the AUSoM and the Academic medical leaders of the Diaspora from various prestigious academic institutions from all around the world, with the aim of establishing a network for collaboration, academic mobility and support as well as a guiding force in the effort for National development. Encouraged by the great enthusiasm that we encountered from both our International faculty, members of the HDMF form Europe and the US, as well as from our students and faculty at the AUSoM, we were able to move to the next level of the HDMF.

After the working groups had been established and after several teleconferences, it became obvious that this collaboration, also involving the Hellenic-American Chamber of Commerce and the Panhellenic Pharmaceutical Association, was ready and eager for the next step in terms of solidifying this collaboration (https://diaspora.med.auth.gr/).

- Establishing the "Aristotle Medical Forum" (AMF) as the next step following the great success of the HDMF. The goal is to open up HDMF and AUSoM activities by organizing an international, global scientific forum for health care innovation and wellbeing. This will take place on an annual basis and coincide with the first weekend of the Thessaloniki International Fair (in collaboration with the organizers), so as to increase the visibility and aura which places Thessaloniki and Northern Greece in the middle of the political, financial and business activity at an international level, thus attracting participants from all over the world. The AMF represents a common meeting ground of Medical Science and Innovation with Technology, Society and Industry along with the Hellenic diaspora members as well as eminent scientists (https://diaspora.med.auth.gr/).

- Re-organizing the School's website, to a multifunctional, modern and efficient portal meeting all the contemporary needs of the organization as well introducing a new digital monthly newsletter "Our News". Both of these initiatives serve as the window to the outside world, as well as e-secretariat and information source for the news and initiatives of the School (https://www.med.auth.gr/en). In parallel, by upgrading AUSoM scientific journal, the Aristotle Biomedical Journal, the aim is to provide a scientific venue for both our students and faculty, and an opportunity to showcase their achievements.

- Creating the AUSoM Alumni as well as former Professors and Personnel association groups (Quondam Groups) for both students and faculty in an effort to strengthen their ties with the School of Medicine, thus providing a critical resource for both our students and faculty.

- Establishing the Special Unit for Biomedical Research and Education (SUBRE), which is a key initiative in promoting biomedical research and education based on interdisciplinary approaches that include medicine, biology, genetics, molecular biology, pharmacology and bioinformatics. This promising Institute is set to bridge the gap with the academia (other institutes, researchers, industry), unite AUSoM and Aristotle University academic and research forces and offer high level services, research and education (continuous medical education, continuous professional development). For meeting its scope, SUBRE sets the Basic and Translational Research Unit, the Clinical Studies Unit, the Precision Medicine Unit and the Educational Unit. The goal is to facilitate two-way collaboration between various domains within the health sciences and biotechnology, to developing biomedical research in basic biosciences, in the area of translational research and applied biomedicine, to deal with innovative research and educational products, systems and services, to establish spin-off and start-up companies and to create a meeting and working point for the academic community and biomedical research industry (www.subre.auth.gr/en/home).

- Organizing the Annual Scientific Congress of the School of Medicine, in a web-based manner lately given the challenges of the COVID-19 pandemic, so as to provide a forum for our students and faculty to showcase their work, discuss issues of concern, as well as strengthen the camaraderie in the School. The interest of the society to the works of AUSoM is reflected to over 50,000 on-line visits and active participation of each of the last years' Congresses.

- Re-energizing several Committees to address the various educational and administrative issues of the AUSoM. The importance of this lies in the fact that these Committees have real decision-making authority and significant input in the management of the School of Medicine. This provided the faculty with the opportunity to be actively involved in the various challenges that we are facing and, more importantly, the sense that they have a real opportunity to address these challenges and guide their own future.

These are the main ongoing projects that have been implemented in the last several years by the AUSoM, serving its scopes. They have allowed the School to respond in a successful manner to the challenges of our times, and more importantly to follow a course marked by creativity, academic integrity and achievement, as well as an extroverted attitude; this will hopefully enable us to seek collaborators in planning not just our future but helping shape health care in Greece. So, as they say "if life gives you lemons, make lemonade"; and it certainly has a better taste when it is the creation of our students, faculty and personnel from the School of Medicine, Aristotle University of Thessaloniki.

Contributors

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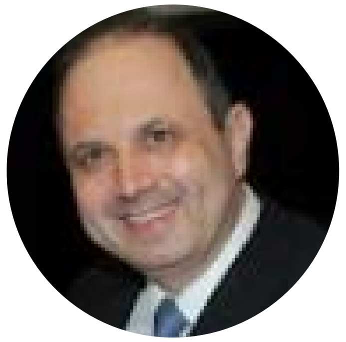

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Peter Angelos

Peter Angelos, MD, PhD, FACS, MAMSE is the Linda Kohler Anderson Professor of Surgery and Surgical Ethics; Vice Chair for Ethics, Professional Development, and Wellness; Chief of Endocrine Surgery; and Associate Director of the MacLean Center for Clinical Medical Ethics at the University of Chicago. Dr. Angelos completed his undergraduate degree, medical school, and a Ph.D. in Philosophy at Boston University. After a General Surgery residency at Northwestern University, he went on to complete fellowships in Clinical Medical Ethics at the University of Chicago and in Endocrine Surgery at the University of Michigan. Dr. Angelos has over 250 peer-reviewed publications and has authored or co-authored over 50 book chapters. He is a Governor of the American College of Surgeons, Member of the Academy of Master Surgeon Educators of the American College of Surgeons, Councilor of the American Board of Surgery, and past President of the American Association of Endocrine Surgeons.

Panagiotis E. Antoniou

Panagiotis E. Antoniou is a senior research associate in the Lab of Medical Physics, department of Medicine, Aristotle University of Thessaloniki. He received a degree in Physics from Aristotle University of Thessaloniki in 1997, a M.Sc. degree in Medical Physics in 2001 from the Democritus University of Thrace and a Ph.D. degree in Medical Physics in 2004 from Democritus University of Thrace. His research interests included Medical Signal processing, Medical Informatics, Educational Technologies and design based research. Currently he is actively researching the impact of Technology Enhanced Learning (virtual patients, AR and VR in education) and co-creative/ co-design paradigms in experiential educational techniques, exploring efficacy and implementation feasibility of these paradigms. He has participated and managed several EU and nationally funded research projects. He has authored more than 80 publications in peer reviewed journals and conferences (h-index:9, i-index:9, 432 citations), and 5 book chapters in collaborative scientific publications. He is a reviewer in several international journals and member of the organizing committee in several international conferences.

Panagiotis Bamidis

Panagiotis Bamidis is a Professor of Medical Physics, Informatics and Medical Education and Director of the Lab of Medical Physics and Digital Innovation in the School of Medicine at the Aristotle University of Thessaloniki, Greece. He designs, implements and evaluates IT and Assistive Technologies systems that improve everyday activities of elderly or other vulnerable groups and improves their health or life quality or improves the education and training of health professionals.

Giammauro Berardi

Dr. Giammauro Berardi earned his medical degree in Rome, Italy where he also took his general surgery residency. After graduating, he moved to Gent in Belgium where he took his PhD in surgery focusing on living donor liver surgery and the application of minimally invasive technique in HPB. He then moved to Japan for a fellowship in advanced HPB surgery under the proctorship of Prof. Go Wakabayashi. He finally spent one extra year of clinical fellowship in the United States where he focused on Surgical Oncology at the Memorial Sloan Kettering Cancer Center in New York. He has more than 100 publications in high impact international journals and his research focuses on liver and pancreatic cancers, liver cirrhosis and minimally invasive techniques in liver surgery. He is an active board member of the International Laparoscopic Liver Society (ILLS). He now works at the San Camillo Forlanini hospital in Rome where he specializes in HPB malignancies and Liver Transplantation.

Ruben Ciria

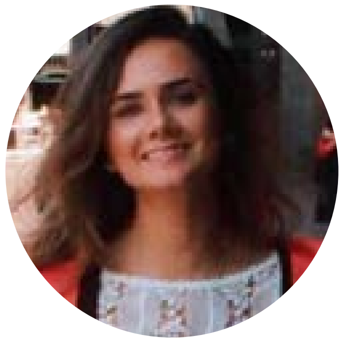
Ruben Ciria graduated in Medicine at Cordoba-Spain and started his training as a general surgeon. He achieved his PhD degree in 2009. He completed a fellowship in liver transplantation at King's College Hospital in London with Prof. Nigel Heaton during 2010 and 2011. In 2014, he spent 3 months at Morioka (Iwate University Hospital) with Prof. Wakabayashi and at Tokyo (Komagome Hospital) with Prof. Honda in order to improve his skills in minimally invasive liver surgery. From 2011 to date, he is a Consultant in HBP Surgery and Liver Transplantation at Cordoba-Spain.

He has the European Board certification of multiorgan retrieval and liver transplantation surgeon. He has published more than 80 manuscripts in the most relevant surgical journals. He was awarded in 2015 with the Young Investigator Award from the International Liver Transplantation Society and has been active member of the 2014 Consensus Meeting in Laparoscopic Liver Surgery held in Morioka and of the 2017 European Guidelines Meeting in Laparoscopic Liver Surgery held in Southampton. He has recently participated as the Scientific Coordinator of the Consensus Guidelines Meeting in Minimally Invasive Donor Hepatectomy held in Seoul in 2019 and is one of the members of the International Committee on Robotic Surgery from the International Laparoscopic Liver Society.

Aikaterini Dedeilia

Aikaterini Dedeilia completed her medical degree at the National and Kapodistrian University of Athens, Greece. She is interested in general and paediatric, as well as novel foetal surgery approaches. She has served as Undergraduate Lead at the ESMSC marathon course, and is Associate Editor of the peer-review "Novelmeds" journal. She plans to pursue an academic and clinical path in the USA.

Elif Iliria Emin



Elif Iliria Emin is currently a foundation year 2 trainee at Chelsea and Westminster University Hospital. She graduated from King's College London School of Medicine, and has undertaken research work in Cardiovascular sciences as part of her BSc at KCL. Iliria holds an interest in surgical education and has published as lead author and co-author several peer-reviewed publications as part of the eMERG collaboration.

Yuman Fong

Dr. Yuman Fong the Sangiacomo Chair and Chairman of the Department of Surgery at the City of Hope Medical Center.

Dr. Fong is best known clinically for his work in the field of liver and pancreatic surgery. His work helped establish hepatic resection of colorectal metastases as a safe, effective, and potentially curative option even at stage IV. He also helped in ushering in robotic techniques for HPB surgery. He is editor of the SAGES Atlas of Robotic Surgery. For his clinical work, he was awarded the Layton F. Rikkers Master Clinician Award from the SSAT. He has assisted in the design and deployment of many novel surgical tools and gene manipulation tools. His work in medical engineering has led to his election to the American Institute of Medical and Biologic Engineering.

Dr. Fong's laboratory is focused in the field of gene therapy. His group was the first to administer recombinant viruses into the blood stream of man as a cancer treatment. His leadership in this field on the national level has included serving as the Chair of the Recombinant DNA Advisory Committee (RAC) of the National Institutes of Health. He is currently Editor-in-Chief of Molecular Therapy Oncolytics (Cell Press). He has co-authored over 1000 peer reviewed articles and 20 textbooks (h-index>139). His papers have been cited >80,000 times.

Nikolaos Foroglou

Nikolaos Foroglou, MD,PhD is Professor of Neurosurgery in Aristotle University School of Medicine, Thessaloniki, Greece. His clinical, teaching and research activity focus on neuro-oncology and neuro-vascular surgery.

John J. Fung

John J. Fung, MD, PhD, FACS is the Director of the University of Chicago Medicine Transplantation Institute, Chief of the Section of Transplantation Surgery, and Professor of Surgery at the University of Chicago. His research has been funded by the National Institutes of Health and has yielded more than 1,300 articles and book chapters.

David Geller

David A. Geller, MD, FACS is the Richard L. Simmons Professor of Surgery at the University of Pittsburgh School of Medicine, and Director of the UPMC Liver Cancer Center. He has published more than 320 articles, has active research grants from the NIH and is also the Principal Investigator on Industry-sponsored clinical trials for liver cancer.

John Hanrahan

Dr. John Hanrahan is a Clinical Research Fellow at the WEISS institute, University College London. He previously completed his medical degree at King's College London and worked as an Academic Foundation doctor in Cambridge. He is passionate about a career in neurosurgery. In addition, he has been heavily involved in medical education and has published several peer review publications

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GUEST EDITOR

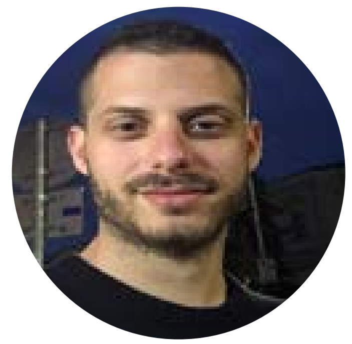
Argyrios Ioannidis

Argyrios Ioannidis is currently appointed as attending surgeon in the department of General, Laparoscopic, Oncologic and Robotic Surgery, Athens Medical Center. He holds a PhD from the National and Kapodistrian University of Athens. He is a reviewer for many colorectal surgery journals and sits in the junior editorial advisory board of Colorectal Disease journal. He is an alumnus of the Colorectal Surgery Department, Cleveland Clinic Florida.

Nektarios Mazarakis

Ion-Anastasios Karolos

Mr. Ion-Anastasios Karolos (male, AUTh) holds a diploma in Rural and Surveying Engineering (2012) and a Postgraduate Degree of Specialization in Geoinformatics (2015). From January 2016 until present, is a Ph.D. Candidate in School of Rural and Surveying Engineering, Aristotle University of Thessaloniki. His research interest mainly focuses on hardware and software development of high precision GNSS receivers using technologies like PCB designing (embedded design), 3D printing and smartphone applications. He is a member of the research Project tilted “Liver3D” (https://www.liver3d.com/) for 3D printing of human liver for medical purposes, co-funded by EU and National Funds. He has a lot of programming experience using a big variety of programming languages (Swift, Objective-C, Kotlin, Java, Python, C/C++) and software development kits (iOS SDK, Android SDK).



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Michael Konstantinidis

Michael Konstantinidis graduated from the Medical School of the National and Kapodistrian University of Athens. He is currently a research fellow in the department of General, Laparoscopic, Oncologic and Robotic Surgery, Athens Medical Center. He has a particular interest in minimally invasive general surgery and surgical outcomes. He has completed an observership at Massachusetts General Hospital.

Nektarios Mazarakis

Nektarios Mazarakis studied Medicine at GKT in London and obtained his CCT in Neurosurgery after successfully passing his FRCSEd(SN). He also holds a BSc in Psychology (Crete), an MSc in Neurosciences (Edinburgh) and a DPhil in Physiology (Oxford). He is post CCT fellowship-trained in spinal surgery and neuro-oncology

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Marios Nicolaides

Marios Nicolaides is a final year medical year medical student at Barts and The London. He has a keen interest in entrepreneurship, leadership, medical education and academia. He has published several original peer review publications at high impact journals and presented at national and international conferences. He hopes to pursue Academic Foundation training and specialise in Orthopaedic Surgery.

Ilias Marios Oikonomou

Ilias Marios Oikonomou is a Scientific Associate of the Department of Transplantation Surgery in the Aristotle University of Thessaloniki. He is pursuing a career around the management of surgical frailty, having already designed a research protocol on physical frailty in liver transplant candidates, as Lead Investigator for his university. He also carries a degree in Sports Medicine, acquired via his MSc studies, jointly run by the Department of Medicine and the Department of Physical Education and Sport Science.

George Papagiannakis

George Papagiannakis, Associate Professor at the Department of Computer Science, University of Crete and Institute of Computer Science, Foundation for Research & Technology - Hellas (FORTH),

Apostolos E. Papalois

Apostolos Papalois graduated from the Department of Biology, University of Athens in 1991 and has a PhD degree in biology – biochemistry from the University of Athens in close collaboration with the University of Cambridge, Department of Surgery. In February 2021 he was appointed Head of TranslationalExperimental Research for HEAL (HealthCare Education and Advanced Learning) for HHG (Hellenic HealthCare Group). Hei is a Member of the Scientific Committee for Education and Training. Deputy President of the National Committee of Experimental Research and Training according to the E.U. Directive 63/2010, for two terms (since 2016). He is a member of the Scientific Board for Human Resources and Skills Development of the National Committee for Research, Technology and Innovation. In January 2021 he was appointed General Secretary of NASCE / UEMS, (European Union of Medical Specialists – UEMS – NASCE - Network of Accredited Clinical Skills Centres), the official scientific representative of almost 1,6 mil. MDs in the European Union. NASCE is the official branch of UEMS for the accreditation of Clinical Skills Centers, Continuing Education and Development of Guidelines for Training.

Christos Pikridas

Prof. Christos Pikridas received in 1995 the Diploma in Rural & Surveying Engineering from School of Rural and Surveying Engineering of Aristotle University of Thessaloniki (AUTh)-Greece and in 1999 the PhD in Satellite Geodesy by the same University. He is currently the Director of the Geodetic methods and Satellite Applications Lab. at Department of Geodesy and Surveying of AUTh. He is an expert on GNSS data analysis. He has over 20 years' research experience on GNSS modelling error sources, algorithm development, quality check and specifications for permanent GNSS monitoring networks installation, GNSS applications in engineering projects and natural disaster monitoring and management. He has over 140 peer-review publications at scientific journals and conferences proceedings and he is also, co-author of the book "GPS and Geodetic Applications" 2nd Edition. ISBN: 978-960-456-346-3.

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Kathrine Rallis

Kathrine Rallis is a final year medical student at Barts and The London. She has an interest in oncology education and has previously set up a national oncology mentorship programme as president of the student oncology society at Barts and The London. She hopes to undertake Medical Oncology training in the USA and pursue a mixed clinical and academic career.

Athanasios Saratzis

Mr Saratzis is an Associate Professor of Vascular Surgery and Honorary Vascular and Endovascular Surgeon with an interest in clinical and translational research. His clinical focus is complex peripheral revascularisation. He is currently based at the NIHR Leicester Biomedical Research Centre (BRC), supported by an NIHR Advanced Fellowship and several other research awards.

Michail Sideris

Michail Sideris is currently a subspecialty trainee in Gynaecological Oncology at St James University Hospital in Leeds. Michail has completed his MDRes thesis in molecular oncology of early rectal cancer at King's College London. He has conceived and developed the ESMSC course, one of the largest mixed fidelity surgical simulation courses in Europe. ESMSC was funded by a research grant which was the basis of Michail's PhD thesis with University of Athens. Michail has co-authored around 65 peer reviewed publications to date.

Tanvi Subramanian

Tanvi Subramanian, MD is a General Surgery Resident at the University of Chicago. She received her undergraduate education at Northwestern University, and attended medical school at Washington University in St. Louis. She is currently in her lab years, conducting basic science research while completing the MacLean Center Surgical Ethics Fellowship.

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Ioannis A. Ziogas

Dr. Tsioukas Vassilios obtained Ph.D in 'Digital Photogrammetry' from the Aristotle University of Thessaloniki, Greece. He is a specialist in Digital Photogrammetry, Remote Sensing, Laser Scanning and CAD for Surveying Applications and Medical Applications, and since 1993 has been working in many national and international Research Programmes. He was an assistant professor in the Dept. of Architectural Engineering in the Democritos University of Thrace (2003-11) and since 2011 is an associate professor in the School of Rural and Surveying Engineering at the Aristotle University of Thessaloniki. He is serving as an invited Professor since 2005 in the "Environmental Management" Postgraduate Programme of The Mediterranean Agronomic Institute of Chania (M.A.I.Ch).

Ioannis A. Ziogas

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"I do look like a surgeon, because I am one"

Maria Irene Bellini

Consultant Surgeon, San Forlanini Hospital, Rome, Italy

Given the current situation in Afghanistan, with Kabul under attack and the other cities that have already fallen into the hands of the Taliban, I wish to comment on the reality of women surgeons in this country.

Our previous ASGBI report about gender inequality in the medical profession[1], showed a profound need to encourage and educate women in pursuing their career and leadership ambitions. Factors including work-process inefficiencies, excessive work hours and workloads, work–home conflicts impact predominantly on young female trainees or parents of young children or teenagers, contributing to a greater risk of burnout in these categories. The recent RCSEng review[2], led by Baroness Helena Kennedy QC, and to whom I had the honour to contribute, demonstrated that even in the Western Countries, where the reality of women is indisputably better than the one in Afghanistan, there is still a long way to go.

Lt. Gen. Dr. Suhaila Siddiq, the Afghanistan's most famous female surgeon, died last year, aged 72. She was Afghanistan's only female lieutenant general and one of a small number of women to hold a ministerial post in the country. She was a pioneer for countless others in uniform and will continue to be an inspiration, as many have affirmed. She was recalled by the Taliban in 1996 at the time when women's rights in Afghanistan were eroded: females were barred from education and employment, with stoning to death and flogging being used to rebels. But months after leaving her job, Ms Siddiq said the Taliban took the extraordinary step of asking her to return, realising they needed her surgical skills. She agreed, but only on the condition that she and her sister did not have to wear the all-covering burka. She also lobbied the regime to allow her to continue educating female medical students from her home[3].

Figure: Suhaila Siddiq[4]

This exemplary woman shows that attrition in surgery has little to do with the learners and their motivation. It has more to do with the institutional culture and their individual experience in that culture. We applaud to the initiatives to "Change the Norm"[5] that are already taking place, but we cannot ignore what it is happening in other countries. We are part it, if don't contrast it. The current health and human status of women in Afghanistan suggests that war-related trauma and human rights abuses by Taliban will perpetrate for generations and sum up to the gender inequalities women already experience.

We must not ignore it, but call it out to make a difference, for them, for us and for all.

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2. https://www.rcseng.ac.uk/about-the-rcs/about-our-mission/diversity-review-2021/.

3. Green A. Suhaila Siddiq. The Lancet. 2021;397(10271):273.

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WOMEN IN SURGERY

2021 Photographic Competition Finalists

Winner
Misty Morning Lough Swilly by Michael Sugrue

Finalist
Pattern by Sangramsingh Patil

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ART AND SURGERY

Finalist
King penguin, South Georgia 2020 by Graeme Poston

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Finalist

Voyage by Mohan Singh

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Finalist

Crystal Rock by Lisa Ishak

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ART AND SURGERY

CORESS Feedback

CORESS Feedback: Cases from the Confidential Reporting System for Surgery

CORESS is an independent charity, supported by the MDU and the WPA Benevolent Foundation

The series of cases in this edition of Surgical Life illustrates the perennial theme of poor communication contributing to many adverse incidents or near misses. These cases have occurred in a number of specialties, emphasising the need for good communication as a central theme across all surgical practice.

We are grateful to those who have provided the material for these reports. The online reporting form is on the website (www.coress.org.uk), which also includes all previous Feedback reports. Published cases will be acknowledged by a Certificate of Contribution, which may be included in the contributor's record of continuing professional development, or may form part of appraisal or annual review of competence progression (ARCP) portfolio documentation. Trainee contributions are particularly welcome.

CORESS would also welcome any reports which may have arisen as consequences of the COVID pandemic.

Professor Frank CT Smith
On behalf of the CORESS Advisory Board

Unrecognised limb ischemia following trauma (Case ref: 281)

A 37-year old man was admitted to the Emergency Department having been involved in a road traffic collision on his motorcycle. He had femoral shaft and tibial fractures in his right leg. He was taken over by the trauma team who assessed his limb and felt that perfusion was adequate and the limb viable.

The patient was placed on the emergency operating list for repair of his femoral fracture and placement of an external fixator, but the procedure was delayed due to a number of other trauma cases. Late in the day, some 12 hours after admission, it was recognised that the patient had a pale, cold leg with no ankle Doppler signals. A referral was made to the hub vascular unit and after further delay in securing transport, the patient was transferred for vascular assessment.

CT angiography at the receiving hospital confirmed occlusion of the femoral artery and complete occlusion of the distal arterial tree. The femoral artery was explored surgically, repaired with an interposition vein graft, and extensive distal thrombectomy was undertaken with fasciotomies, before the femoral fracture was fixed.

The appearance of the leg however failed to improve, and repeat CT angiography at 24 hours showed very limited perfusion of the leg from the level of the knee, with no run-off into the foot due to persistent thrombus. Four days after his accident, an above-knee amputation was undertaken.

Reporter's comments:

Despite initial satisfactory appearances, the extent of ischaemia in this patient's leg was not recognised, in association with an injury in which there was high risk of arterial damage. Any concerns at the time of admission should have led to early formal assessment of the limb circulation including documentation of ankle Doppler signals and pressures, and CT angiography if the patient was stable. The situation was compounded by delays in access to the emergency theatre and in transfer to the vascular unit, by which time the leg was beyond the limits of salvageability.

CORESS comments:

Many such patients will be sent directly to a Major Trauma Unit as part of a Trauma Network. Where specialist input is required, early transfer to a Major Trauma Centre which is able to provide pan-specialty services such as the vascular input required here, is indicated.

In this case there should have been high index of suspicion for concomitant vascular injury in the presence of extensive lower limb bone fractures. Regular monitoring of leg pulses and perfusion, with appropriate imaging, as suggested by the reporter, should have been undertaken. Early referral for vascular assessment and intervention might have improved the eventual outcome.

Differences of opinion in management for tongue laceration (Case ref: 282)

A 7-year old child with learning difficulties was brought to a tertiary unit by his mother and grandmother, having bitten his tongue with a resultant full thickness laceration of approximately 45% of the left lateral aspect of the tongue. Perfusion was judged to be adequate.

He was reviewed by the on-call Dental Core Trainee who had only recently started working in the hospital. The wound was not actively bleeding, but the region was sore and unlikely to heal favourably and was at risk of infection. The Core Trainee discussed the case by telephone with the registrar on-call, who was covering several local hospitals. The extent of the trauma was made clear and the Core Trainee indicated that she thought this would benefit from primary closure, the child having been starved since the incident.

However the advice from the registrar, who did not see the patient, was to treat the lesion conservatively, to explain the likelihood of a scar or polyp formation and to review the patient again in a few days. This was documented and the patient handed over to the day team with arrangements for a follow-up appointment.

On subsequent review one week later, the wound was not healing adequately. The parent reported that the child was in pain, was unwell and had reduced appetite. The child was then seen by a Consultant in the Trauma Clinic and was listed for theatre for debridement, revision and closure.

Reporter's comments:

The DCT could have requested that the patient be seen a senior member of the team if she was unhappy with the management advice. Failure to do this may have been compounded by lack of familiarity with the hospital, and potentially by lack of accountability of the registrar who was covering numerous units. In current surgical practice where specialties work in a team setting, no junior staff should be afraid to call the on-call Consultant if they have a query, although concerns about bypassing the normal "chain of command" may have influenced the trainee's actions in this situation.

CORESS comments:

On this occasion there was division of opinion amongst expert oral maxillofacial commentators on this report. One felt that provided that the tongue flap was not devitalised, it was likely to heal without intervention and that in this case it was reasonable initially to manage the wound conservatively. The other felt strongly that the registrar should have seen the patient, and that a primary repair was probably indicated. In either case it was important that someone with experience of such injuries examined the patient so as to provide an informed opinion. Small lacerations usually heal spontaneously, whilst it may be necessary to trim a vertical laceration, or indeed, to occasionally remove a piece of tongue to facilitate healing.

There were broader hierarchical issues with respect to communication here. A Board member commented that a photograph of the lesion could have been sent to the registrar to inform decisions about clinical management if he was not able to examine the patient personally.

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Lack of communication in patient discharge (Case ref: 283)

A 63 year-old man with diabetes, chronic Stage 3 kidney disease, and ischaemic heart disease was admitted with a necrotic 5th toe, cellulitis and hyperkalemia. Surgery to amputate the toe and debride localised tissue necrosis was undertaken under regional anaesthesia within 24 hours.

The wound was reviewed the next day by the Consultant, who took the dressing down on the post-operative ward round. The patient was discharged with a five-day course of antibiotics and an appointment for review in the diabetic foot clinic 2 weeks later. However, there was no communication with the patient about the frequency of required dressing changes. No nurses were present on the ward round and no information was given to the nurses about dressing changes on a verbal handover, nor was there a formal handover from the inpatient nursing team to the community nurses.

The patient was readmitted at 8 days postoperatively with spreading sepsis and subsequently required amputation of 3 other toes on the same foot.

Reporter's comments:

This case illustrates the poor outcomes associated with failed communication at different stages in the patient journey. Whilst the patient was seen promptly postoperatively, there was failure of the surgical team to communicate crucial management issues to the nursing team responsible for the patient's discharge. This could have been queried at this stage, but was not, and no instructions were issued to the community nurses who form a vital part of the postoperative care team. It is the responsibility of the surgical team to ensure that adequate postoperative instructions are directed to those responsible for the patients discharge and community care. Regular team meetings of all involved in surgical patient's care, surgeons, nurses, physiotherapists and occupational therapists, fosters team spirits and may enhance communication and patient care.

CORESS comments:

A collaborative care pathway with written protocols for patient discharges, and early community nursing involvement, might have reduced the risks of the adverse outcome which arose as a result of poor communication.

Consequences of Service Disruption during the COVID-19 Pandemic (Case ref: 284)

A 64 year-old man presented with a mixed arterio-venous lower leg ulcer. Duplex ultrasound and CT angiography confirmed mild deep venous incompetence and a 10cm superficial femoral artery occlusion. He underwent femoral artery angioplasty and placement of an uncovered stent, improving his Ankle Brachial Pressure Indices, allowing him to be placed in 4-layer graduated compression bandaging to treat the venous component of his ulcer.

Stent surveillance by duplex ultrasound would usually have been undertaken at routine 3 monthly intervals for the first year after stent placement, but this was postponed because of changes in routine practice due to the COVID-19 pandemic.

The patient was seen in the vascular Hot Clinic as an emergency referral 4 months after intervention, at which time his leg ulcers had deteriorated to the extent that tendons were exposed and there was severe necrosis of skin on the dorsum of his foot. Ultrasound confirmed that the stent had occluded, whilst he had remained in compression bandaging.

The foot was deemed non-salvageable and the patient underwent below-knee amputation. He was making a good recovery from amputation, with early mobilisation, when he developed a hospital-acquired COVID-19 infection. His respiratory function deteriorated rapidly requiring ITU admission. He developed further thrombotic sequelae of COVID-19 and SIRS, with digital necrosis of fingers, requiring a prolonged stay on ITU.

CORESS comments:

The impact that COVID-19 has had on routine clinical services is well-recognised. This case is a salutary reminder that expected clinical surveillance as part of follow-up protocols after emergency interventions should be adhered to wherever possible. Telephone follow-up clinics will not be suitable for some patients. Development of improved communication links between community services and the surgical team might have helped identify continued deterioration of this patient's presenting condition.

Systems and Communications Errors Leading to Orthopaedic Never Event (Case ref: 285)

An experienced surgeon put the wrong sized implant into a male patient during a hip replacement.

The surgical team work together regularly and use the WHO Surgical Safety Checklist. They are strong supporters of both pre and post-op briefings. They work in a very busy environment where rapid surgical technique and turnaround is the norm. Expectations regarding continuous efficiency gains are a part of daily life.

During the pre-operative briefing, implant sizes were discussed. The hip implant comprises four elements. The socket and a separate liner are packed together in one box, the head in a second, and the stem in a third. Each element can be of a different size to suit the patient, and each has specific measurement.

The head though has two measurements – the head diameter, which must fit snugly with the socket that is fitted, and the length, which is an independent variable. One combination of these implant sizes was considered most likely to suit the patient, but another was brought into theatre as a contingency.

The surgeon made the final size decisions regarding size during a visual examination after commencement of surgery. He was passed the correct sized socket, which was then positioned. When ready for the head of the implant, the surgeon asked for a "+5" a reference to the length not the diameter of the head. The diameter is not normally specified at that point as this it is automatically defined by the size of the cup, which had already been implanted. It was seen as a given by all involved.

The runner passed the head to the scrub practitioner who confirmed the length as "+5" but not the diameter. The surgeon assumed that he was being passed a head that matched the socket.

The socket and the head of the implants are packaged separately. The head length is identifiable on the box under a cellophane wrapper. The head diameter however is amongst other text and less prominent. Some manufacturers colour code the boxes, this manufacturer does not.

The operation was duly completed; the sticker from the implants attached to the operation notes and entered into the computerised national register.

The error came to light approximately 12 months later when the patient was reviewed in outpatients. The patient reported on-going discomfort and occasional looseness of the joint when coming downstairs. Whilst investigating possible causes, the surgeon reviewed the operation notes. He noticed that the implant stickers showed that the diameter of the socket and the head were incompatible.

The surgeon disclosed the error to the patient and apologised. The patient consented for a further operation to correct the error. The incident was reported and duly investigated. The patient made a claim for compensation and the Trust admitted liability.

When asked what he thought went wrong, the surgeon replied:

"The runner thought the scrub nurse would check the size, the scrub nurse thought the runner has already checked it, and I thought the scrub nurse had checked it. In practice therefore no one had checked it. We all believed that what we were being passed was the right thing."

CORESS comments:

Despite the surgical team working in a safety conscious environment, this incident arose out of a mixture of systems errors, which included variability in packaging of prostheses, communication problems, and failure to employ routine safety protocols for checking the prosthesis prior to implantation.

This case is taken from Report of NHS England Never Events Task Force to which CORESS contributed: Standardise Educate, Harmonise. Commissioning the Conditions for Safer Surgery. Feb 2014
http://www.england.nhs.uk/wp-content/uploads/2014/02/sur-nev-ev-tf-rep.pdf.

The findings of the former report led to the development of the National Safety Standards for Invasive Procedures (NatSSIPs) which all surgical teams should incorporate into practice.

http://www.england.nhs.uk/patientsafety/wp-content/uploads/sites/32/2015/09/natssips-safety-standards.pdf

A subsequent comprehensive report on this topic has been published by the Healthcare Safety Investigation Branch (HSIB), entitled: Investigation into the implantation of wrong prostheses during joint replacement surgery Jun 2018

https://www.hsib.org.uk/investigations-cases/implantation-wrong-prostheses-during-joint-replacement-surgery/

Too slick by half

(Case ref: 286)

A trainee surgeon, aiming to expedite a morning day-case list by efficient management of paperwork, pre-completed the consent forms for the 5 patients due to undergo hernia repair. This included signing and dating the forms, prior to seeing the patients. He was then called away to deal with a ward emergency, and a colleague took over, seeing the patients and marking the appropriate site of surgery. The colleague, seeing that the consent forms were already signed, and assuming that the patients had already been seen, merely asked the patients to sign them and marked the side indicated on the consent form.

The first patient arrived in theatre and in the pre-anaesthetic check, the anaesthetic nurse, during questioning, noted that the patient's symptoms were on the opposite side to that marked and indicated on the consent form. It transpired that the affected side had been incorrectly listed on the theatre list, to which the surgical trainee had referred, prior to completing the consent form.

Reporter's comments:

Despite the trainee's best intentions, this was an inappropriate short cut taken to try to improve efficiency at the expense of patient safety. It is the responsibility of the operating surgeon to make sure that he or she is undertaking the correct procedure on the appropriate side and site. Examination of the lesion and then marking the site/side is a vital undertaking prior to surgery. The thorough attention of the anaesthetic nurse in this case prevented the occurrence of a "Never Event".

CORESS comments:

This was a classic example of the "swiss cheese effect", where several errors lined up to contribute to a "near miss". The operating surgeon should check all patients before they are anaesthetised. A formal team brief and correctly performed WHO checks should have identified this problem. The psychologist on the Advisory Board noted that there is a tendency to re-affirm what has been done before, rather than to "check and challenge". The paperwork should never be completed and signed off before the clinical task is undertaken.

Journal of the Association of Surgeons of Great Britain & Ireland

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Journal of the Association of Surgeons of Great Britain & Ireland

Contributor Guidance

(As at Summer 2017)

The Association welcomes and encourages contributions from Fellows and asks that potential contributors take the following guidelines into consideration.

Aims

The Journal of the Association of Surgeons of Great Britain and Ireland (JASGBI) is a regular publication that has evolved from the previously named Newsletter. It aims to publish material of topical or general interest to members of the Association, which will promote and advance the reputation and functions of the Association to a wider professional audience.

JASGBI is not a peer reviewed, academic publication, and is not intended as a vehicle for conventional academic papers. We nevertheless welcome a wide range of subject matter which may include:

- Articles of national and strategic relevance in relation to surgical training, teaching, career development, and issues in national politics, as they bear upon surgical and professional practice.
- Articles of topical debate.
- News from the Regions, and from affiliated Specialty Associations and Societies.
- Articles on international surgical practice, as observed by members of the Association on their travels, attachments and secondments.
- Historical articles of interest and relevance to surgeons.
- Personal experiences, parallel careers, hobbies, activities and achievements which are out of the ordinary, or which would fit our popular 'Secret Lives' series.

This list is not exclusive. JASGBI is keen to encourage and help develop standards in professional writing and to act as a vehicle for new and original material.

Publication Standards

Although JASGBI is not a conventional, peer reviewed academic publication, we subscribe wholeheartedly to the highest standards in respect of Publication Ethics and the elimination of the various forms of publication malpractice, as set out by the Committee on Publication Ethics (COPE) and the World Association of Medical Editors (WAME).

Material submitted to JASGBI should thus be original to the author(s). The editors reserve the right to submit any manuscript to peer review and to seek any amendments which are deemed to improve the presentation or content of the article to meet the standards and style of JASGBI.

Article length

Each page of JASGBI can accommodate around 750 words with a small picture. While we are flexible as to content, articles should usually be of 2,000 words or less, with up to four original images and/or figures. In general terms, PowerPoint graphics detract from the quality of presentation and should be avoided.

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Authors must provide a 'for correspondence' email address with any article submitted. This will be published alongside your article.

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