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Adapting for the future: flexibility of UK postgraduate training

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Abstract
Postgraduate surgical training has undergone repeated reforms alongside changes in terms of employment. The broad structure of progression from Foundation years through core and specialist training to the award of a Certificate of Completion of Training is likely to continue for the foreseeable future. Technological developments including robotics, genomics and artificial intelligence together with an extension of the surgical team are likely to alter dramatically the nature of surgery in the future. Surgical training will need to incorporate training in new technologies, including simulation, which will be provided in the workplace, academic institutions and commercial facilities. There will be greater emphasis on non-technical skills and human factors, especially in relation to the use of new technologies and working in wider teams, including non-medical staff. Genomics will play an increasing role in determining individualized patient care, with a need for surgeons to have an understanding of this field and communicate this to their patients. Surgical training will need to be suitably flexible in order to accommodate these developments, to allow more part-time working and portfolio careers, and to encourage recruitment and retention.

Keywords Extended surgical team; future of surgery; genomics; non-technical skills; postgraduate medical education; simulation; surgical robots

The only person who is educated is the one who has learned to learn…and change. Carl Rogers

Aside from death and taxes, the only other certainty in life is that nothing stays the same. We live in a state of constant flux. At least, this appears to be the case for the National Health Service and postgraduate medical education. Although the cynic may say, ‘Plus ca change, plus c’est la meme chose’.

Training infrastructure
It is certainly true that there have been repeated attempts to improve postgraduate surgical training. All were introduced with the best of intentions to address perceived deficiencies in training, yet they were often geared towards satisfying the needs of service provision. Different generations of surgeons in training have experienced Calman, Modernising Medical Careers, Shape of Training and Improving Surgical Training.

The General Medical Council (GMC) has overseen increasing regulation of the medical profession with the introduction of appraisal and revalidation, greater involvement in the oversight of undergraduate medical education and assessment, and closer scrutiny of postgraduate medical examinations, in part as a response to data relating to differential attainment by candidates from different ethnic backgrounds and the requirements of the judicial review of the MRCGP examination. Training curricula require regular review and approval by the GMC, which has introduced the concept of Generic Professional Capabilities in order to define the core attributes that are common to doctors of all disciplines. There is also a recognition that doctors in training should be able to move between different specialty training programmes, maintaining recognition of the knowledge and skills that they have acquired previously, without a need to start again from the beginning. While many doctors decide upon their career choice at an early stage and often at medical school, as indicated by the thriving surgical and specialty related societies run by medical students and provided by the Surgical Specialty Associations, many doctors do not wish to commit at such an early stage and may change their minds later on.

In 2017, the Shape of Training Review addressed how medical training could be improved to help meet the needs of patients and service providers over the following 30 years. The review highlighted the need to adapt medical training in the context of an increasingly elderly population with multiple comorbidities, the need to improve the overall quality of training and to ensure that doctors are able to deliver safe and effective general care in broad specialties.

The Royal College of Surgeons of England (RCSEng), in collaboration with Health Education England, introduced the Improving Surgical Training (IST) pilot in General Surgery in 2018, extending to Urology and Vascular Surgery in 2019. This provides run through training without a further selection process after 2 years and a greater emphasis on training rather than service provision, with rotas designed to enhance training opportunities during daylight hours. Trainers at IST pilot sites have received enhanced training at dedicated boot camps. Other specialties have also introduced pilots of run through training.

Employment arrangements
Changes in training have occurred alongside changes in terms of employment. The European Working Time Directive, introduced in the 1990s, resulted in the end of the previous excessive hours and onerous long periods of duty. However, it also saw a move towards fewer doctors covering more patients when on call, often with periods of duty, which though shorter, were busier. The concomitant move towards shift working and required periods of rest resulted in disruption of continuity of care and a loss of the traditional firm structure. These processes continued with the imposition of the Junior Doctors’ Contract in 2016, resulting in concerns about the clinical experience and training opportunities available to doctors in training.

There are ongoing negotiations regarding the NHS Consultant contract. This still largely expects Consultants to be capable of fully independent practice at appointment and to continue with a similar work pattern until retirement, which may be at the age of 70.
68 years and which may well increase in the future. This does not take into account the impact that changes in training have had upon the experience of newly appointed Consultants and the increasing need for super specialization. Although approval of Consultant job descriptions by RCSEng requires a commitment from Trusts to provide a mentor on appointment, such approval is not mandatory for Foundation Trusts and it is not clear in practice what provision is made. It is perhaps no surprise that there is a peak in suspensions in the first year of consultant practice. Greater support and the ability to make proleptic appointments prior to a period of highly specialized training would help to address this.

**Future of surgery**

In 2017, RCSEng established the Future of Surgery Commission in order to predict how surgery is likely to develop in the future with the introduction of new technologies, changes in demographics and the development of the wider surgical team. It seems very likely that the surgeon of the future will be rather different to today with a need for a detailed knowledge of robotics and genomics, an ability to apply information provided by artificial intelligence and big data and an ability to work in and lead teams.

The Future of Surgery Commission recommended that molecular biology, especially genomics and stem cells, data literacy and human factors training should be embedded into undergraduate and postgraduate curricula. Surgeons in training should be encouraged to take time out of traditional training to spend time working in industry, academia and teaching in the UK and overseas.

We are on the verge of a technological revolution, which is likely to result in major changes in the way in which surgeons are trained. This, combined with ethical and governance considerations, will mean that it will no longer be acceptable for surgeons in training to operate on patients until they have undergone training and assessment in a simulated environment. Anatomy will increasingly be taught making use of digital technologies and three-dimensional printed materials. Augmented and virtual reality will allow simulated operations to be performed with assessment in a way that ensures competence before putting patients at risk. Trained surgeons will also be able to practise surgery in a virtual environment prior to performing complex cases.

**Simulation**

The challenge for the technology companies is to develop products which closely simulate the real operative environment. These will need to be combined with immersive technology and appropriate human factors training to ensure that skills developed in the virtual world can be transferred to a real patient setting.

Suitable facilities will need to be developed for such training to take place. These may be located in hospitals, academic institutions or commercial facilities and will need to be sufficient to allow easy access for surgeons in training. There will be a requirement for adequate time free from clinical commitments in order to devote to simulation. This could be provided on a rolling basis alongside a clinical workload or perhaps as a block of time as part of a rotation. This is likely to vary by specialty as the ability to simulate specific procedures increases.

While assessment of competence in a simulated environment is likely to be carried out by a surgical expert, new technologies will provide objective data on performance that can supplement this process. With widespread adoption of such techniques, trained surgeons may be required to undergo periodic re-assessment, as is seen routinely in the aviation industry.

**New surgical technologies**

Innovation in many fields has seen dramatic changes in surgical practice in the second half of the 20th and into this century. CT and MR scanning have revolutionized the investigation of surgical conditions. Fibreoptic and rigid endoscopes have extended assessment and allowed minimally invasive treatments through every orifice and into every body cavity thus reducing morbidity. A wide array of equipment and prostheses has been designed for specific procedures across all surgical specialties. Developments in anaesthesia have made surgery safer and quicker. All of these innovations promote quicker recovery resulting in earlier discharge from hospital and return to normal activities. All have required trained surgeons to adapt and learn new techniques with concomitant incorporation of appropriate training into specialist training programmes. This process will continue as new technologies are developed.

The use of robots is in its relative infancy. Robot assisted prostate surgery has become well established and robots are likely to be used increasingly in other fields. They have the advantages of being able to make precise movements in a predictable, repeatable fashion without any risk of fatigue. As their use increases, surgeons will spend less time operating on patients and more time operating machines. It is likely that more time will be devoted to planning operations to be performed with robots.

Artificial intelligence and machine learning will see the next generation of robots able to undertake more complex procedures and potentially to learn from surgeons. However, it seems very unlikely that robots will be able to take over from the surgeon entirely in performing a complex surgical procedure in its entirety. Nevertheless, the need to work in synergy with machines will require the surgeon of the future to develop new skills that must be embedded in surgical training.

**Training for new technologies**

The Future of Surgery Commission predicted that the current broad structure of postgraduate training from Foundation years, through core training, into specialist training and culminating with the award of a Certificate of Completion of Training (CCT) is likely to remain the backbone of surgical training.

In order to make use of new technologies, the surgeon of the future will need to develop an understanding of their principles, applications and limitations. As with simulation, surgical trainers will continue to be key to the delivery of training, but there is likely to be greater involvement of technicians with detailed knowledge of the theoretical basis and functioning of new machines and systems. This is likely to be provided, at least in the short term, by greater collaboration between industry and the medical profession. This will build on existing relationships, which already see surgeons being trained by manufacturers of implantable devices and prostheses in a variety of surgical specialties from spinal surgery to cochlear implants. Surgeons will
continue to be essential in helping manufacturers develop and modify these new technologies as they become part of routine surgical practice.

There will need to be robust measures in place to evaluate the outcomes and cost-effectiveness of new technologies in comparison with existing techniques. Surgeons will need to be trained in the science of assessment and be familiar with the methods used by statisticians, health economists and epidemiologists.

**Fellowships**

Fellowships have been an important part of surgical training for many years. Unfortunately, in recent years the term has been used rather loosely to include posts of limited training value designed to provide personnel to fill rotas and shift patterns. In 2012, RCSEng in collaboration with the Surgical Specialty Associations introduced its Senior Clinical Fellowship scheme in order to recognize posts that offered training, usually in a highly specialized area, supplementing the syllabus and generic training leading to a CCT in that specialty. By June 2019, there were 75 approved Fellowships across eight of the ten surgical specialties.

Ultimately, new technologies that are used in everyday clinical practice will be incorporated into existing training programmes. However, before they are widely adopted, it is likely that there will be limited opportunities for training and that, especially for new techniques and procedures, this will be provided through fellowships at a small number of centres. There will also be a need to become familiar with other disciplines including genomics, bioengineering, and digital technologies, along with greater overlap with medical specialties, which may be provided through appropriate fellowships.

**Wider surgical team**

The role of the consultant surgeon has changed dramatically. The concept of an omnipotent autonomous individual is now rightly in the domain of fiction. There is a greater emphasis on team-working with well-established multidisciplinary teams working together across specialties to improve the care delivered to patients.

In addition, many roles that were traditionally within the remit of doctors are increasingly undertaken by other healthcare practitioners. This in part reflects a practical approach to a limited medical workforce, but also allows doctors to be freed up for other activities including training. In surgery, it is now commonplace for teams to include advanced or specialist nurse practitioners, surgical care practitioners and physician associates. These non-medical staff carry out a range of tasks such as routine administrative work, delivering care in outpatient and ward settings including a range of investigations and treatments, and acting as surgical assistants.

It is very likely that these roles will develop further in the future. While there has been some concern that the use of associated healthcare professionals might have a negative impact upon the training of surgeons, in general, this has not been the case and their introduction has been viewed positively.

With an ageing population with increasing associated comorbidities, it is clear that the management of surgical patients in the perioperative period, especially after major surgery, has become more complex. Traditionally, anaesthetic colleagues have been able to offer advice in medical management, but there is an increasing role for perioperative care physicians. Including physicians in the surgical team can help to optimize patients prior to surgery and improve postoperative care, resulting in better patient outcomes and earlier discharge from hospital. It will continue to be important for surgeons to be trained in perioperative care and medical management of the surgical patient, but an increasing workforce of perioperative care physicians will release surgeons in training from the need to be entirely responsible for ward care and provide additional time for surgical training.

**Non-technical skills**

The defining characteristic of a surgeon is performing operations, although even this has become blurred as other healthcare professionals take on some less complex procedures. In reality, especially in the UK, surgeons spend relatively little of their time in the operating theatre. While it remains critical that surgeons in training acquire the necessary surgical skills, there has been increasing emphasis in recent years on non-technical aspects with training courses such as the Non-technical Skills for Surgeons (NOTSS) course provided by the Royal College of Surgeons of Edinburgh.

As new technologies are introduced and multi-disciplinary working increases, the different elements of situation awareness, decision making, communication and teamwork, and leadership will become even more important. Surgeons will find themselves leading larger and more diverse teams, but will also find themselves in teams led by others. The ability to communicate with professionals from non-medical disciplines, who may have limited knowledge of medicine and the organization of healthcare delivery, will be crucial. To some, these skills come easily, but there will be a need to provide greater training to support these activities. The Royal College of Surgeons in Ireland includes a training programme in Human Factors in Patient Safety as a compulsory element of surgical training.

**Genomics**

The influence of nature and nurture on human development has been argued for centuries. The genetic basis of diseases, such as Huntington’s disease or sickle cell anaemia, has long been recognized. Some genetically determined conditions demonstrate variable expressivity and incomplete penetrance. Epidemiology has shown that certain populations may have a predisposition to certain conditions. As we gather more information about the genetic basis of disease and how genes interact with disease processes, we are beginning to understand how our genes affect outcomes and how treatments can be tailored to patients’ genetic background. Harmful variants of *BRCA1* and *BRCA2* genes have been identified, which significantly increase the risk of breast cancer.

Now that the human genome has been sequenced completely and the field of genomics is expanding rapidly, there is a need for surgeons to be trained in this area. Surgeons will have an important role in collecting appropriate tissue samples and ensuring that they are correctly processed. Although genetics experts will be responsible for analysing and reporting, surgeons will need to be able to interpret the results and apply them appropriately to the management of patients. This will involve an
understanding of stratification of risk, an ability to communicate this to patients and to support them in using this information to decide upon treatment regimes.

Understanding research methodology and taking part in research projects has always been a key element of surgical training. This ensures that surgeons are able to assess research data critically and incorporate relevant findings into their clinical practice. For some surgeons, continuing involvement in academic surgery becomes the main focus of their careers. With genomics developing rapidly, this is likely to be a fruitful area for surgical research. There is significant financial and political backing through Genomics England and the 100,000 Genome Project.

Flexibility

There is a tension in medical training between producing generalists who can treat the majority of conditions in one of the defined medical disciplines and providing specialists who have detailed knowledge and skills in a restricted subspecialty area. In some cases, such as complex sarcoma surgery or the management of neurofibromatosis type II, there is a requirement for only a handful of experts across the UK.

The GMC recognizes ten surgical specialties, of which vascular surgery is the most recent. It has stated that it does not envisage expanding this number in the foreseeable future. Therefore, surgeons in training will continue to work towards a CCT in their chosen surgical specialty. In most specialties, there will be an opportunity to develop a subspecialty interest. As surgical practice becomes more complex with the introduction of new technologies, application of genomics and so on, it is likely that there will be a need for a wider range of subspecialists and that each new area will require a period of training dedicated to that discipline.

It is, therefore, unlikely that adequate training can be provided through the format of current training programmes. There will be a need to make use of a wider range of training facilities and personnel, including those from other medical disciplines and from outside medicine. Just as surgical treatment will increasingly be tailored to the individual patient, it is likely that training programmes will need to be adapted to suit the requirements of the individual surgeon in training, while maintaining provision of an appropriate surgical workforce.

The need to acquire knowledge and skills in other areas will necessitate time away from the traditional workplace. This will require a sophisticated approach to workforce planning in order to create sufficient flexibility. In addition, it is likely that there will be an increasing need to accommodate less than full-time training, especially if surgical specialties wish to broaden their appeal to a more diverse workforce. There remain significant gender and racial imbalances in surgical specialties, which are only changing slowly. By making training and working patterns more flexible, surgery will become a more attractive career option for those who have additional commitments outside work, want to create a portfolio career and are looking for a work-life balance rather different to the traditional surgical model.

Governance

The GMC’s statutory obligations are laid out in the Medical Act 1983. Its primary objectives are to protect, promote and maintain the health, safety and wellbeing of the public, to promote and maintain public confidence in the medical profession, and to promote and maintain professional standards and conduct of doctors.

Postgraduate surgical examinations at MRCS and FRCS level are organized on an intercollegiate basis on behalf of the four surgical Royal Colleges within the British Isles. Candidates choose the College to which they wish to be affiliated. The Specialist Advisory Committees (SACs) under the jurisdiction of the Joint Committee on Surgical Training (JCST) oversee training at core and specialist levels and make recommendations to the GMC for the award of a CCT and a Certificate of Eligibility for Specialist Registration for those who have not followed a traditional training route. The GMC approves the curriculum for each specialty and the structure and content of postgraduate medical examinations, all of which are subject to periodic review.

All doctors are required to undergo an annual review of their practice. For surgeons in training, this is provided by the Annual Review of Competency Progression within their training programme. Consultants and non-consultant career grade or SAS surgeons are subject to an annual process in the workplace. Satisfactory assessment over a five year period results in a recommendation by the Responsible Officer to the GMC that the doctor should be revalidated.

High profile cases of rogue doctors such as Shipman and Paterson have led to increasing scrutiny and regulation of the medical profession in keeping with the GMC’s statutory requirements. Several independent inquiries and bodies such as the Royal Colleges have made recommendations to try to ensure that similar cases can be prevented in the future. This is likely to require doctors to provide increasing documentary evidence of their competence and efforts to keep up to date through a commitment to lifelong learning and continuing professional development.

COVID-19

The first few months of 2020 have seen the spread of a global pandemic which has had a dramatic impact upon healthcare systems across the world. There has been a major re-organization of healthcare provision within the UK, with the priority to provide adequate resources to treat patients infected with Covid-19. This has resulted in a temporary cessation of almost all non-urgent medical activity.

It is likely that the pandemic will have a long-lasting impact upon the way that surgeons interact with patients. Until there is a reliable method for ensuring that patients are free of the virus or it has disappeared completely, there will be a continuing need to use appropriate personal protective equipment (PPE). This will have a significant effect upon how operations are performed and how surgeons in training learn in the operating theatre.

The pandemic has seen changes in communication with an increase in telephone and video consultations and the use of internet based platforms for meetings and education. Many of these changes are likely to be permanent, resulting in an acceleration of the use of new communication technologies.

Summary

It is an exciting time to be training in surgery. New technologies will make it possible to treat patients in ways that would have
been previously unimaginable. This will require surgeons to train in and understand new techniques and disciplines, to be able to communicate with a wider team of professionals including those from a non-medical background and to be able to impart more complex information to patients and support them in their decision making. Surgeons’ working patterns and the ways in which surgical training is structured will need to adapt accordingly. These changes will make surgery an even more rewarding career and our patients will be the beneficiaries.

REFERENCES
1 Calman KC. Hospital doctors: training for the future. The report of the working group on specialist medical training. London DH, April 1993.
2 Modernising Medical Careers. The next steps, April 2004. London DH.
3 Shape of Training. www.shapeoftraining.co.uk/.
4 Royal College of Surgeons of England. Improving Surgical Training, www.rcseng.ac.uk/careers-in-surgery/trainees/ist/.
5 General Medical Council. Generic Professional Capabilities Framework. www.gmc-uk.org/education/standards-guidance-and-curricula/standards-and-outcomes/generic-professional-capabilities-framework.
6 Future of Surgery report. futureofsurgery.rcseng.ac.uk/.
7 The Royal College of Surgeons of Edinburgh. Non-Technical Skills for Surgeons. www.rcsed.ac.uk/professional-support-development-resources/learning-resources/non-technical-skills-for-surgeons-notss.
8 Medical Act 1983.