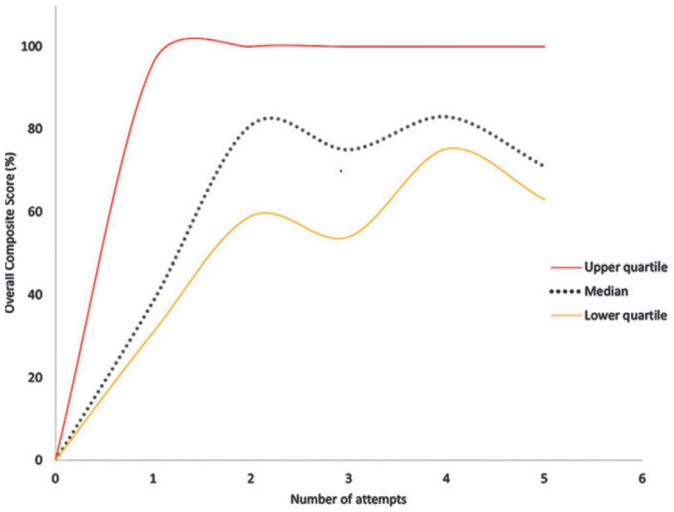
Learning curves and the costs to surgical training

Learning curves within surgical training and how they have impacted healthcare has become a popular topic over the past decade, especially in the UK. This whitepaper discusses four key issues, i) surgical training in relation to ethical issues (training on patients); ii) cost effectiveness (length of time it takes to train a surgeon); iii) patient outcomes; and iv) how VR simulation can play a vital role in changing the shape of surgical training in the future.

Learning Curves

Learning any type of new skill, whether the basic skills of handling surgical instruments or learning a new surgical procedure (as a beginner or even an established surgeon), involves a learning curve (Hasan et al, 2000)– the time and effort required when learning something challenging or new. Competence levels generally improve with experience, the more you do something the better you become at it, and if you plot competence (vertical axis) against experience (horizontal axis) you can visualise the learning curve.



(Graph taken from Brown, 2019)

The concept of learning curves began in industry as a way to measure production efficiency and today its relevance to surgery remains controversial, as does the shape and steepness of surgical learning curves. There is a common misconception that a steep learning curve equates to a difficult task, when in fact it is the opposite. A steep learning curve means it takes a short amount of time to reach a certain level of competency. Whereas a long shallow curve means it takes a longer amount of time to reach the desired competency level.

High caseloads for surgical training in the UK

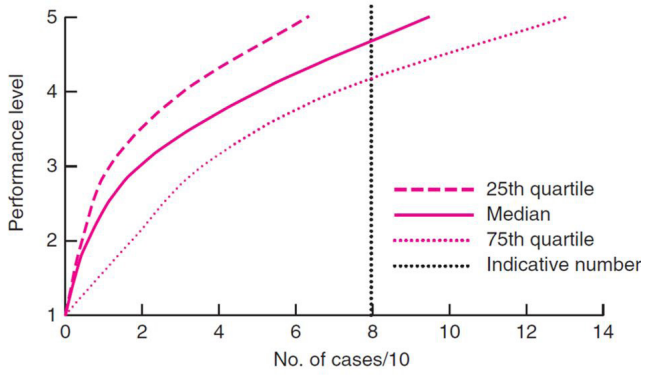
Recently, there has been an increased focus on learning curves and surgical training. Some interesting research in Wales investigates the fact that in the UK the Joint Committee on Surgical Training (JCST) requires experience of over 80 appendicectomy caseloads before achieving a certificate of completion of training (CCT) (Lee et al, 2016) The research sets out to assess why this caseload is so high and whether it is an appropriate figure.

In *Operative learning curve trajectory in a cohort of surgical trainee*, Brown et al (2017) looked at median caseload to achieve surgical competency (3 x Level 4 PBAs Competent to perform the procedure unsupervised) in several different key surgical procedures.

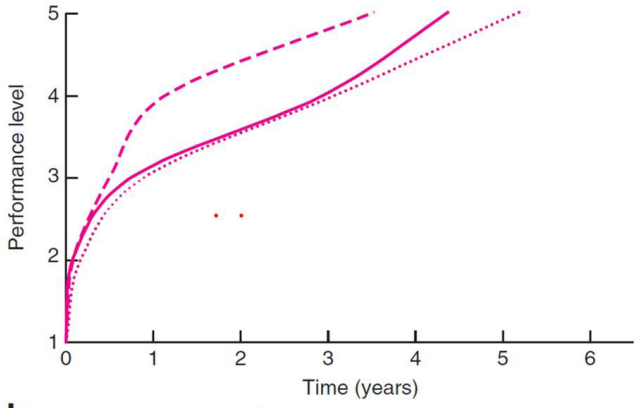
PBA Level	Definition
0	Insufficient effidence observed to support a summary judgement
1	Unable to support the procedure, or part observed, under supervision.
2	Able to perform the procedure, or part observed, under supervision
3	Able to perform the procedure with minimum supervision
4	Competent to perform the procedure unsupervised, deal with complications

Table 1 definition of procedure based assessment scores (Brown, 2017)

For appendicectomy the median caseload for competency was 95 PBAs, and the caseload is similarly lengthy for other key procedures, such as 64 PBAs for inguinal hernia and 87 PBAs for laparoscopic cholecystectomy.



a Appendicectomy – caseload



b Appendicectomy – time

(Graph taken from Brown, 2019)

This is an extremely high number of caseloads – indicated by the long, shallow learning curve, that would take over 4 years to complete. This is a long and costly training schedule for a resident to become competent in a relatively simple procedure.

There is also a concern that such levels are unachievable, and this demonstrates that there is a need for a more efficient and cost-effective approach to training our future surgeons, especially during these difficult times with Covid-19, where elective surgeries and training opportunities are limited.

Should VR simulation training, combined with traditional supervisory learning, become of part of the national surgical curriculum?

Accelerating the learning curve to make surgical training more effective

There is a push to shorten the time to certification, i.e. left shift the learning curve. In another study, Prospective Cohort Study of Haptic Virtual Reality Laparoscopic Appendicectomy Learning Curve Trajector, (Brown et al, 2019) VR simulation with LapSim® was used to examine the value of haptic laparoscopic VR simulation as a predictive training tool related to laparoscopic appendicectomy, one of the most frequently performed emergency surgical operations. This was the first study to examine this.

28 trainees (9 female, 19 male) comprising 19 Core Surgical (CST) and 9 General Higher Surgical trainees completed a standardised program of haptic laparoscopic VR appendicectomy simulation training, using a LapSim simulator. Training was separated into 3 modules: 3 basic exercises, eight haptic laparoscopic VR simulation benchmark tasks and performing a VR appendicectomy.

The eigh tasks and the appendicectomy procedure were rated and assessed by combining scores derived from the simulator parameters. An overall score was calculated, including the simulated appendicectomy, based on the performance of a team of six experieced consultants, who had already completed the training.

The results of the study show that simulation can improve surgical training and accerlerate the learning curve (left-shift effect) as there was a reduction in the number of procedures and time required to achieve 3-level 4 competence PBAs.

The authors concluded that by using VR simulation training,

“The learning curve trajectory can be measured, influenced, and accelerated significantly; a pronounced left-shift effect, with translational potential for enhanced shorter training time and improved patient safety”

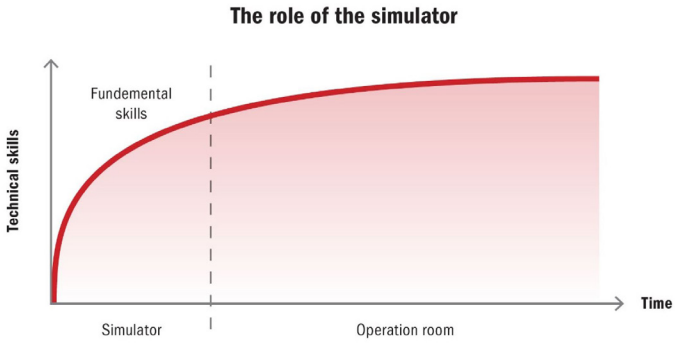
Ethical issues, costs and patient outcomes

Training away from patients

How does a surgeon learn a new surgical procedure without training on patients? No surgeon would want to attempt a procedure that is beyond their competence. And a patient does not want to be the guinea pig the first time a surgeon performs a procedure. Yet every surgeon has to perform a surgical procedure for the first time at some point.

Currently, traditional training before a trainee performs their first operation is the equivalent to having no “hands-on” training, only observing and assisting the senior consultant. Then, a trainee surgeon would train on their first procedures under the supervision of a consultant surgeon on patients. They may have learned their basic handling skills on traditional box trainers and expensive cadavers but the first time they do an actual procedure is with a real patient.

So, could a trainee’s first 20 caseloads be carried out on a simulator rather than a patient? The fundamental skills of a procedure could be developed using VR, without supervision, which is not only more cost effective, but also more ethical. This is analogous to aviation training with flight simulators.The graph above shows the learning curve for a typical surgical resident. The role of a VR



simulator is to shorten the time (the left-shift effect) it takes your residents to be trained in surgical skills. Using a VR simulator, such as LapSim, you can reach a high level of technical skills in a short space of time.

Cost effectiveness

Strict regulations in the United Kingdom prevent surgeons practising a new operation on animals and the use of cadavars is extremely expensive, so combining traditional training methods with VR simulation would be a more cost-effective method of training.

With VR simulation there is better use of consultants’ supervisory time, especially useful in the early stages of training, as trainees can train on their own, when they want, 24/7. They still receive training feedback from the simulator, they can re-watch their performance and get data driven reports and analysis on what they are doing right and wrong.

Patient outcomes

Training plays an important role in patient outcomes, having a well-trained and experienced surgeon helps reduce medical errors (Ahlberg et al, 2007). Experience using VR simulation can make sure residents feel prepared, safe and confident to start laparoscopic or endoscopic surgery on real patients (Larsen at al, 2009)

It makes sense that having a trainee who has trained on a surgical procedure virtually several times would make less errors when they perform a real procedure on a real patient in the operation room. Not only would trainees improve their surgical skills (perceptual and psychomotor skills) and surgical knowledge (the procedure and the regional anatomy), but with didactic learning programs, such as the LapSim simulator, they would also learn diagnosis, indications and contraindications for an operation. It may also improve their confidence for when they enter the real operating theatre.

Summary

Learning curves play an important role in surgical training and it currently takes a long time for a surgeon to train in common surgical procedures. This can have a big impact on training costs, patient outcomes and the ethical issues of training on real patients.

Combining traditional surgical training methods with VR simulation training is one way to confront the current issues that affect surgical training – VR simulation can accelerate the learning curve, lower training costs and reduce medical errors.

References

Ahlberg, G., Enochsson, L., Gallagher, A. G., Hedman, L., Hogman, C., McClusky, D. A., 3rd, Ramel, S., Smith, C. D., & Arvidsson, D. (2007). Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies. American journal of surgery, 193(6), 797–804. https://doi.org/10.1016/j.amjsurg.2006.06.050

Aggarwal, R., Ward, J., Balasundaram, I., Sains, P., Athanasiou, T., & Darzi, A. (2007). Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. Annals of surgery, 246(5), 771–779. https://doi.org/10.1097/SLA.0b013e3180f61b09 Brown, C., Abdelrahman, T., Patel, N., Thomas, C., Pollitt, M. J., & Lewis, W. G. (2017). Operative learning curve trajectory in a cohort of surgical trainees. The British journal of surgery, 104(10), 1405–1411. https://doi.org/10.1002/bjs.10584

Brown C, Robinson D, Egan R, Hopkins L, Abdelrahman T, Powell A, Pollitt MJ, Lewis WG. Prospective Cohort Study of Haptic Virtual Reality Laparoscopic Appendicectomy Learning Curve Trajectory. J Laparoendosc Adv Surg Tech A. 2019 Sep;29(9):1128-1134. doi: 10.1089/lap.2019.0332. Epub 2019 Jul 30. PMID: 31361560.

Brown, C., Abdelrahman, T., Patel, N., Thomas, C., Pollitt, M. J., & Lewis, W. G. (2017). Operative learning curve trajectory in a cohort of surgical trainees. The British journal of surgery, 104(10), 1405–1411. https://doi.org/10.1002/bjs.10584

Hasan, A., Pozzi, M., & Hamilton, J. R. (2000). New surgical procedures: can we minimise the learning curve?. BMJ (Clinical research ed.), 320(7228), 171–173. https://doi.org/10.1136/bmj.320.7228.171

Larsen, C. R., Soerensen, J. L., Grantcharov, T. P., Dalsgaard, T., Schouenborg, L., Ottosen, C., Schroeder, T. V., & Ottesen, B. S. (2009). Effect of virtual reality training on laparoscopic surgery: randomised controlled trial. BMJ (Clinical research ed.), 338, b1802. https://doi.org/10.1136/bmj.b1802

Lee, M. J., Bhangu, A., Blencowe, N. S., Nepogodiev, D., Gokani, V. J., Harries, R. L., Association of Surgeons in Training/National Research Collaborative Consensus group, Akinfala, M., Ali, O., Allum, W., Bosanquet, D. C., Boyce, K., Bradburn, M., Chapman, S. J., Christopher, E., Coulter, I., Dean, B. J., Dickfos, M., El Boghdady, M., Elmasry, M., ... Sutton, P. A. (2016). Academic requirements for Certificate of Completion of Training in surgical training: Consensus recommendations from the Association of Surgeons in Training/National Research Collaborative Consensus Group. International journal of surgery (London, England), 36 Suppl 1, S24–S30. https://doi.org/10.1016/j.ijsu.2016.08.236