(vii) Role of computer assisted surgery (CAS) in training and outcomes

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Abstract

Training in orthopaedic surgery, as in other specialities, is facing a great dilemma as new regulations in most countries limit the number of training hours for new trainees.

In this paper, we briefly overview the new regulations and their impact on training schemes in the UK but they are also applicable to other countries tackling similar issues. We reiterate the ethical principles that set the limits beyond which training would be neither acceptable nor safe. We also review the evidence in the literature that suggests that Computer Assisted Surgery (CAS) could help in training and answer the problems concerning both training regulations and ethical constraints. We focus our review on CAS as a surgical guiding tool rather than as a simulation technology. Several aspects are evaluated: reduction of learning curve, improving cognitive skills, immediate feedback, accuracy and precision in surgical techniques and the educational role of CAS. It seems that CAS fulfils the criteria in assisting trainees and trainers with new regulations without impinging on the ethical principles. However the ultimate role of CAS in training still needs to be assessed. Finally we explore the role that CAS could play in the Patient Reported Outcome Measures (PROMS).

Keywords computer assisted surgery; ethics; orthopaedic training; PROMs

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Introduction

Training in orthopaedic surgery, as in other specialities, is facing a challenge as new regulations in most countries (USA and countries within Europe) limit the number of training hours for new trainees.[1] At the same time, patients are becoming more demanding and less agreeable to allowing juniors to learn their surgical skills on them, even with the supervision of experienced trainers. Moreover, trends towards super-specialisation and new techniques in orthopaedic surgery challenge the learning curve for both trainers and trainees.[2] Given these observations, how can we adjust to these restricting regulations in training schemes for junior trainees within ethical constraints? New technology such as computer simulation and computer Assisted Surgery (CAS) may play a role in answering this question.[3]

We briefly overview the new regulations and their impact on training schemes in the UK but this may also be relevant to other countries tackling similar issues. We reiterate the basic principles of ethics that set limits beyond which training would be neither acceptable nor safe. We review evidence in the literature that suggests that CAS could help in training and address both training regulations and ethical constraints. We mainly focus our review of CAS as a surgical guiding tool rather than simulation technology as it is used in the aeronautical industry. Finally, we explore the role that CAS could play in the Patient Reported Outcomes Measures (PROMS).

Training principles

Learning technical skills is one of the most crucial tasks of the surgeon's training. In countries like Canada, trainees benefit from weekly cognitive and practical training sessions to develop their basic surgical techniques and perioperative skills.[4] Cognitive sessions are designed to provide teaching of instrumentation, preoperative preparation, general organization of the theatre, special instrumentations such as endoscopic kits and also intensive care. These programs explain the complex realm of the operating theatre so as to reduce the operative risks related to surgical technique. The operating theatre remains the ultimate arena in which to refine a trainee's technical ability. Some authors have complained that surgical teaching can become too passive and the trainee's cognitive level of involvement might be too low.[3] With the increasing complexity of operations and the associated technology now used in the operating theatre, the pressure on training locations other than the operating theatre (such as animal laboratories) is intensified. Moreover, the growing economic and medico-legal pressures are encouraging the introduction of more relevant training tools to make up for the restraints on training time.[5] Various techniques have been used to assess technical skills outside the operating theatre in the hope of accelerating the learning curve and improving the surgical dexterity necessary for some of the more complex procedures. An innovative medical teaching technique has been described which assists the efficient acquisition of surgical skills required to perform an inguinal hernia.[6] The authors assessed six surgical residents who were videotaped performing a McVay procedure for inguinal hernia with a pre-test and post-test assessment with a control group. The experimental group received expert cognitive modelling, auditory elaboration, and split-screen analysis after a pre-test. A distinct advantage for surgical instrument control and manipulation was demonstrated for the experimental group on the post-test surgery compared with the control group. Less time was required to perform the operation, and more purposeful movements were exhibited by the experimental group. However some of the training may be inadequate for complex surgical techniques requiring special skills. In a recent study Hall et al. showed that only 32% of fifth-year residents felt there was adequate time dedicated to arthroscopic training, compared to 66% of program directors ($p < 0.01$).[7] The authors concluded that it may be necessary to re-examine residency requirements to ensure adequate practice in developing their arthroscopic surgical skills. Even a meaningful, well-organized and well-monitored curriculum may not be sufficient to acquire all required skills, and simulation of surgical procedure may play a crucial role to compensate for the various constraints. It has been suggested that simulation of surgical procedures would allow complete transfer of techniques learnt in a skills laboratory directly to the operating theatre.[8] It was concluded that "there is little doubt that as computer hardware increases in power and as the technology becomes commercially more economical, then computer generated interactive simulations or virtual reality will play a greater role in skills training in surgery and indeed across the whole of medicine leading on to becoming a feature of assessment and the controversial area of accreditation".

Despite these promising developments, virtual training has still not reached the level that will allow trainees to limit their time spent in theatre with trainers to learn routine and difficult surgical procedures. Subjective results showed a decrease in theatre attendance, with an average of 10.8% of cases missed per trainee. The same study shows that US trainees who began training after the introduction of the 80-h working week will undertake fewer procedures.[1] Obviously, this may result in a decreased level of skill, or it may shift operative experience to the senior resident years thus prolonging the learning curve.

In addition to the technical skills required to become a good surgeon, there are other important skills that may not be easily assessed within a shorter training scheme. One study which looked at the teaching of surgeons about non-technical skills, concluded that adverse events in surgery were often caused by behavioural factors, such as communication failures.[9] We shall not elaborate further on these non-technical aspects which obviously remain fundamental to training, but we shall focus on the constraints that will critically affect and give a framework to the development of surgical skills. The most obvious constraints are ethical.

Ethics

By definition ethics are principles that govern behaviour or the conduct of an activity. In this case it is surgical activity, the ethics for which have been clearly described.[10]

The first principle is **beneficence** which is defined as the act to benefit others. This forms part of the Hippocratic Oath. It means that any medical or surgical intervention must benefit the patient and cause no harm. Benefits and risks of surgical intervention are constantly evaluated and discussed with patients. Both are the usual grounds of communication between patient and surgeon in critically assessing the ultimate goal of surgery. Balancing advantages and disadvantages of surgery is a duty of good patient care and is also obligatory to maintain competency.

The second principle is **non-maleficence** which above all prompts surgeons and practitioners to do no harm. This implies that we must achieve a high standard of care and strive to maintain the well-being of the patients. This principle underlies the necessity for continual education to insure that any proposed surgery achieves the required standard of care. It also requires the continual monitoring of surgical outcomes which conform to the required standards.

The third is **autonomy**. This means self-directing freedom and freedom from external control or influence as well as moral independence. It means that individuals must decide the most appropriate treatment based on their skills and knowledge of a particular surgical act without outside influence, such as that from a commercial or political source.

The fourth and the last is justice which encompasses confidentiality, life preservation principles and probity.

CAS and training

We have reviewed the literature to assess whether CAS would accommodate training requirements and the listed ethical principles. We examine the four main aspect of the technical training for surgeons in the future: learning curve, cognitive skills, immediate feedback, accuracy and precision in surgical techniques as well as the educational role of CAS.

Reduction of learning curve

In 2008, Seyler et al. published a paper assessing CAS with hip resurfacing and asked whether CAS could decrease the learning curve. Four groups of senior and junior residents were assessed using conventional techniques and CAS in performing hip resurfacing.[11] The accuracy of positioning the femoral component was analysed radiographically. When compared with the use of conventional instrumentation, the use of CAS reduced the number of outliers and facilitated valgus insertion. The conclusion of this article was that CAS resulted in a reduction in the length of the learning curve in hip resurfacing for beginners without compromising patient safety and accuracy. Confirmation of similar findings was published with knee replacement.[12] Around twenty CAS surgical procedures are necessary to pass the learning curve in TKA. Assessment of the learning curve in this paper was measured through the operative time. Operative time was significantly longer for the novice surgeon in the first

