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Editorial

New techniques, new technologies and educational implications

M.M. LIRICI

4th Department of Surgery, University 'La Sapienza', Rome, Italy

Some considerations on laws governing animal testing and animal use for educational purposes, and the related ethical problems are fundamental [1]. There is a different approach from country to country: whereas in the United States, animals are widely employed for surgical training during postgraduate courses, the situation in Europe is slightly different, and animal models cannot be employed for these purposes in countries like the UK and in most others it is allowed only in the academic setting. Notwithstanding the importance of employing animal models in research and training is controversial, advancement in surgery and medicine in the last century is strictly related to this practice. The Council on Scientific Affairs of the American Medical Society has affirmed (1989) that progress in cancer, trauma, shock treatment, as well as in diabetes and cardiovascular diseases is proportional to the availability of good animal models.

Worldwide, animal experiments need the approval of local ethical committees. In Europe, the Council of the European Union has stated that animal experiments and animal-based training are always allowed for research and educational purposes, provided that they are carried out according to ethical principles and with great respect for any living being. In the Directive of the Council of the European Union (86/609/EEC), it is also stated that the number of animals used for research purposes should be restricted to the minimum requested and that any efforts should be made to avoid pain, physical and psychological trauma to animals, whenever it is possible; the same principles should be attained when animals are employed during teaching programs [1]. Animal used either for experimental or educational purposes should be cared for in accordance with the regulations of the National Institute of Health (*Principles for Use of Animals*) [2].

Animal models have some limits as educational tools, since their anatomy may differ from that of humans and because they need expensive dedicated facilities, special care and proper housing. This is especially true for the most used model, the pig. In future, surgical simulation will be the alternative training modality to improve skills of surgical trainees, lessening the present, unacceptable costs of their learning curve, and making possible what Sinclair calls *socially correct virtual reality* [3].

A highly sophisticated workstation has been developed by Sinclair and Peifer at Georgia Institute of Technologies to be used for computer-simulated eye surgery [3, 4]. The system components are: the operating station, the computer models of the eye anatomy and instruments, the force feedback system, the tracking system for instruments, the software for interaction control and visual and force feedback update. Residents may use simulators to explore anatomy and perform virtual operations under the direct control of an expert or instructor, with objective performance evaluation.

Computer technology in education is being increasingly applied to many fields of medicine and surgery: from laparoscopic surgery and videoendoscopy, to anaesthesia. Satava described the feasibility of virtual endoscopy diagnosis using 3-D visualization and virtual representation, in a system where viscera are reconstructed on a monitor after acquisition of high-resolution patient-specific digital images from helical CT scan or MRI [5]. In anaesthesia computer technology is used to improve management of critical patients, whereas in computer-assisted reconstructive craniofacial surgery, simulation is based on 3-D imaging to display all possible surface configurations after virtual bone manipulation [4].

Training on animal models

Basic surgical skills, like all tissue approximation techniques, may be learned and practiced using inanimate training models. Training endoscopic procedures requires different perceptions and the interaction with real tissues, facing intraoperative complications such as bleeding or bile duct and bowel injuries [6]. At present, this level of

Correspondence: Marco Maria Lirici, MD, IV Clinica Chirurgica, Policlinico Umberto I, Universita 'La Sapienza', Viale del Policlinico, 00161 Rome, Italy.

simulation of advanced surgery performed on humans is still provided only by animal models, in as much as even the most sophisticated anatomical model cannot be a valid substitute for live tissues and real anatomy, and virtual reality is still in an early stage, with several limits interacting with a dynamic and always different anatomical environment.

Use of an animal model in medicine and surgery has several ethical implications, either in the field of research or in that of education.

New training technologies offer alternatives to the conventional training modalities. These are: (1) skills labs and facilities, allowing acquaintence with basic skills and new procedures, while working on inanimate anatomical models and mixed models; (2) animal laboratories, where new procedures are first performed on proper animal models; (3) computer simulation, which allows the surgeon in training to perform surgical procedures in a virtual environment, like computer-driven flight simulators for pilots.

New technologies for surgical training

Simple, inanimate anatomical models made of silicon materials may be so perfect as to reproduce even the consistency of human organs. Nevertheless, it is nearly impossible to reproduce the anatomical disposition of whole systems in a dummy trainer. Thus, inanimate models are usually not suitable for training surgeons in more advanced procedures, such as colon resection or interventions on, for example, the junction, because they do not allow the execution of specific surgical manoeuvres like mobilization of viscera. An alternative, proposed for a long time by Buess and co-workers, is the use of mixed trainers, where integrated animal organs are introduced in a synthetic frame. Even though skills laboratories do not need the levels of keeping and care requested by animal labs, they are still demanding in terms of costs and personnel.

As stressed in the paper by Marescaux and Nord [7], conventional teaching and training techniques are rapidly becoming outdated with the evolution of modern computer and communication technologies. Simulation through virtual reality, tele-tutoring, tele-proctoring, multimedia databases will change the way not only endoscopic surgery will be taught.

The costs of custom-built computers for simulation, like those for flight simulators, are prohibitively high; but, presently, the new generation of high-performance computers and graphics software off-the-shelf make simulation of surgical procedures feasible and economically affordable. Several researchers are currently developing simulators for surgical and endoscopic training [8].

Endoscopic techniques have led to a revolution in surgery and to a need for changing the modalities of surgical training. The educational problems are mainly related to the way to teach surgeons in training (residents, registrars, etc.) and the way full-trained surgeons should learn these new techniques. Practising endoscopic surgery has meant adapting to a new environment in the operating room and performing surgical manoeuvres without direct view of anatomical structures, watching 2-D images on a monitor display, lacking hand-eye co-ordination, with the movements hampered by the small room available and instrument insertion through fixed points on the abdominal or thoracic wall. All this makes fundamental manoeuvres, like manipulation of tissue, knotting and suturing, more complex; therefore even experienced surgeons require specific basic skills training. Nowadays, training in endoscopic surgery has been included in many residency programmes [9–11]. Nevertheless, only some standardized procedures, such as laparoscopic cholecystectomy, hernia repair, fundoplication and appendectomy, may be performed by surgeons in training and only few institutional centres offer dedicated facilities for bench training.

Since the early years of the endoscopic revolution, surgeons who wanted to be trained in new laparoscopic and thoracoscopic procedures had to refer to non-academic centres or non-institutional organizations or enter training courses run by universities but not formally included in educational programmes. Furthermore, no regulation for the teaching and training activities in these centres exists and, as mentioned in Pellegrini's article [12], only in the last years 'organizations and individuals have proposed or ratified a structured approach to training and credentialing'. Dedicated to this purpose, the American College of Surgeons now has a Committee on Emerging Surgical Technologies and Education [13].

A major concern in teaching endoscopic procedures is the learning curve [14]. An increased morbidity rate has been reported when a practitioner first begins performing endoscopic procedures directly on patients [15]. The costs and the ethical implications of the learning curve on humans are extremely high. Learning curves are unavoidable but should be shortened.

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