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Mini Review

Hands-On Training Simulation in Cardiovascular Surgery

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Abstract

Simulation is an increasingly vital component of graduate medical education and is becoming the standard of practice in many residency programs, especially in the surgical specialties owing to the need, to move basic skills acquisition out of the operating room and into the surgical skills laboratories. Deliberate practice is an educational technique aimed at improving performance by intense training and preparation. These steps include repetition, assessment, and feedback, which lead to performance improvement

Keywords: cardiovascular surgery; aortic valve implantation

Introduction

Simulation is an increasingly vital component of graduate medical education and is becoming the standard of practice in many residency programs, especially in the surgical specialties owing to the need, to move basic skills acquisition out of the operating room and into the surgical skills laboratories. Deliberate practice is an educational technique aimed at improving performance by intense training and preparation. These steps include repetition, assessment, and feedback, which lead to performance improvement [1].

Training in surgery became progressivelly more complex, as a wave of innovation using new technologies introduced a series of procedures with less invasive potential, such as minimally invasive and robotics. Residents and young surgeons must learn these new techniques in a safe and effective way, so the advent of several simulators in surgery in activities called “Hands-On”. The “Hands-On” is a different strategy of teaching and learning because it allows interaction between the expert (surgeon with recognized expertise and competence) with surgeons in different learning curve phases such as residents, junior surgeons or even those with several years of surgical practice. It differs from other teaching activities once the trainees are directly involved in the whole procedure by “using their hands”. The trainee is incentivized to exercise the observation of all steps of the operation, to perform tactical movements and actions ordered in a logical sequence or may be, to incorporate new skills. All this is happening without urgency of time; and above all, under a qualified and committed guidance and supervision of an expert.

At the same time that it promotes teaching, it allows for both correction and evaluation of performance inducing satisfaction on trainees by creating the pleasant sense of mastery of new skills or consolidation of the previous ones that now could be executed with a more refined technique. These new skills will be definitely incorporated by salutary practice of exhaustive repetition that will make them automated. Once after its final registration in the brain centers that integrate knowledge with motor skills, it will emerge automatically when requested, completing the cycle: see-search-understand-perform [2].

As cardiovascular surgery training programs continue to evolve in response to abbreviated training pathways, patient safety concerns and increasing complexity of procedures, greater focus on simulation-based training to compensate for decreased operative experience has been recommended. Given the growth of transcatheter technologies and minimally invasive techniques, new challenges are imposed on the training of the contemporary cardiovascular surgeon. Nowadays, training of cardiac surgery residents is demanding several modifications to adjust to the rapidly evolving area of structural heart disease. Pelletier and colleagues [3] stated that increasingly, cardiac surgery residents are requesting exposure to the skills and techniques that will enable them to perform these procedures. In addition, they suggested that institutional simulation labs can be ideal to teach certain elements of endovascular procedures and skills, providing novice learners the opportunity to manipulate wires and catheters while objectively measuring performance. It is also challenging for the institutions responsible for the training programs, since they are expected to offer an efficient and adequate curriculum, which relies on a paradox of providing safe surgical opportunity without compromising the postoperative outcomes and excellent patient care. Operating room surgical training has significant limitations indeed, considering it provides short time to develop technical skills and has low tolerance for learning mistakes.

With respect to one traditional simulation model for surgery training, despite high fidelity, human corpse training has been desincouraged nowadays, for two main reasons. First, there are not always available corpses for use in good preservation conditions. Second is the short period of time that is speared for the training, since those patients have to be hand out to the families for the ceremonial. Conducting the training procedures on animal models offers the closest scenario to surgery in human beings; however, the completion of this kind of training requires the sacrifice of these animals culminating with great opposition by the animals' protection organizations as well as by the general population. This traditional method has well known limitations such as the need for a broad framework for hosting, maintenance and preparation of these animals and their subsequent disposal; which besides of high costs also requires the involvement of many professionals for the correct execution of these tasks. Routinely, these facilities are available only in medical schools and usually with restricted access to their own undergraduate or graduate students.

Biological models, compared to animal models "*in vivo"*, have the advantage of storage capacity for days in the refrigerator, and lower costs, which is very desirable considering the current financial constraints of most residency training programs. In addition, they enable a realistic tissue feel and excellent anatomical correspondence. In this context, we believe that incorporating simulation on biological models in our residency program could improve surgical training and patient safety, due to its potentiality to avoid surgical technical failure that would compromise the outcomes, bringing more safety, efficacy and better longer-term results.

Recognizing these challenges about technical skills acquisition for cardiovascular surgery, we started our simulation training program on biological models for the medical residency of cardiovascular surgery at our institution in 2015. A practical evaluation that addressed performance on specific skills was applied at the end of training program. The high notes obtained by our residents revealed the efficiency of the simulation in the acquisition of skills. Also, the resident responses in the subjective analysis revealed high satisfaction with the training program [4]. They highlighted as positive aspects the realistic tissue feels and anatomical representation, as well as the possibility to perform a specific technique multiple times thereby improving skill acquisition. In general, most believed that the program provided a realistic experience and was valuable in teaching surgical skills. We observed that biological models with porcine or bovine hearts provided a high degree of realism and in the case of cardiac surgery, where surgical failure may result in patient morbidity and mortality, such a realistic simulation could reproduce better surgical results, which is essential before clinical application.

The incorporation of new training techniques, such as "Hands-on" simulation, allows an improvement in residents formation, the training of new technologies for senior surgeons, minimazing possible technique fails and allowing better efficacy in the procedures and better results". These moments are a unique opportunity for a desirable interaction, in that the more experienced ones can help to qualify this critical mass of professionals eager to learn new knowledge, but also willing to incorporate special technical skills as a basic support for their professional performances [5]. In the cognitive domain, the transmission and retention of the essential theoretical knowledge are required and of paramount importance for the judgment and proper handling of each patient. That part has been widely covered by many mini-courses offered at numerous conferences in many different areas of the specialty, and also through continuing medical education programs carried out by schools and educational institutes created and maintained by the specialty societies and supported by pharmaceutical companies for equipments and instruments in surgery [6].

Congresses of some specialties has been modified each year to discuss the incorporation of new technologies by presenting the results of numerous studies well designed and well conducted on searching to validate, to disseminate and to extend their use in the daily practice. Watch an operation, usually a complex case or a new procedure, performed at distance in a specialized center and broadcasted to an audience of the event, offers to the participating surgeons an opportunity to interact with the team that performs the surgery and to learn from them some useful surgical aspects; however, this do not endow observers in developing new skills. Additionally, this format has limitations, including legal matters. The surgical team responsible for the operation is subjected to a stress level above the usual. They cannot repeat tactical maneuvers ever performed by the imperative need to continue the operation. Steps or details which were not clear, even if well explained, cannot be repeated. The operation needs to have its normal course and the patient must not be subjected to additional risks, such as stopping at each step of the procedure to allow controversial debates and opinions. The traditional video sessions, in which procedures can have their technical details presented and discussed, allowing for pauses or repetitions, when necessary, are very instructive in providing opportunities for learning technical and tactical details without putting pressure on the surgical team and not subjecting patients to additional risks. This mode helps to understand how to overcome the difficulties in their implementation and the new ways of executing it. Although it is a very useful and attractive format, it does not provide new psychomotor skills for those attending this activity. Therefore, these creative and innovative ways of transmitting knowledge, as described above, do not directly involve the community of observers in surgical procedures fields. The observer surgeons can even assimilate the steps and various tactical maneuvers essential to the operation; however, these do not give them the ability to implement it.

The task of producing scientific knowledge and validate it through the current methods of evidence-based medicine belongs primarily to the universities, which through its institutes and research laboratories, are prepared for this important and crucial stage of development of medical science. Some studies have validated the need for simulation in surgery [7]. Certainly, surgical simulation allows the medical resident to perform in a less stress environment and may provide structured graduated training for technical skills. Furthermore, educators recognize this activity as one method by which expertise may be developed and assessed. Another positive aspect of simulation-based skills training in surgery has been the notion that educators can spend more time teaching in a less stressful environment, promoting better understanding and retention of skills.

Surgical simulation is effective in the development of technical skills in cardiovascular surgery with numerous examples of low and high-fidelity simulators and several studies have validated the need for simulation in cardiac surgery residency programs. Ribeiro et al. [8] in a systematic review of 16 studies about simulation-based skill training for trainees in cardiac surgery concluded that simulation-based training is associated with improved learning outcomes for cardiovascular surgery trainees with large effect sizes. They observed that junior residents seem to benefit most and low-fidelity simulators are most frequently used and seem not to inhibit learning outcomes. Another systematic review performed by El-Andari et al. [9] investigated the current literature regarding the use of simulation-based training for trainees learning surgical valve repair and replacement. They observed that studies in which outcomes were evaluated showed improvement in surgical trainees' time to completion of tasks and skills scores, concluding that simulation-based training has been shown to improve the surgical skills of trainees in a relatively short period.

Despite the pressing need to train cardiovascular surgeons to perform transcatheter aortic valve implantation (TAVI), Tam et al. [10], in research about the current status of TAVI in Canadian cardiovascular surgery residency programs, through questionnaires designed for residents and program directors found only 14 residents (18%) and 4 program directors (36%), reported that TAVI training in their program was adequate. In addition, only 3 program directors (27%) reported that their residents had access to a TAVI simulator, suggesting that, currently,

there is a lack of structured didactic and hands-on training of TAVI in cardiac surgery residency programs.

Virtual reality such as Simantha (Medical Simulation Corporation, Denver, CO, USA) and Simbionix AngioMentor (Airport City, Israel) offer simulation for transcatheter aortic valve implantation to teach catheter wire and lead handling skills [11], however its use as an educational tool for official cardiac residency training programmes is unknown and probably very sparse or no-existent.

Whether improved performance in the simulation laboratory is transferable to the operating room is not easily addressed, but most trainees reported that they felt much better prepared and less anxious to perform each skill in the operating room environment. These findings support those found in the published literature that providing structured teaching sessions improves the confidence level of the learners [12]. In addition, concerns have been raised about the safety of training surgeons in the performance of surgery. In fact, there is growing demand for improved clinical results and excellent outcomes, with intense public scrutiny of their clinical performance. That's why surgical training in this field requires balance between standard of care delivered to patients and provision of sufficient operative exposure to trainees who are the cardiac surgeons of the future.

Training programs dedicated to robotic surgery are still very limited. This creates a physical barrier that does pulls back the widespread use of this technique [13]. Learning curve is steep and the senior's surgeons that would be responsible to teaching the residents and trainees, are not able to offer this modality. To share knowledge, stimulate learning and disseminate the use the robot, the American Association for Thoracic Surgery (AATS) and The Society of Thoracic Surgeons (STS) have offered postgraduate and fellowship programs [14]. However, since the number of centers performing robotic surgery is still low, it has been hard to determine the best training method to teach new surgeons.

Based on that, a randomized trial evaluated the best method to simulate robotic surgery was published in 2016. On this trial, 40 surgical trainees had to dissect 10 cm of the left internal mammary artery and to place sutures on the mitral annulus. After that they were exposed to four types of training and reevaluated: wet lab, dry lab, virtual reality and control group [15]. A score was used to evaluate their improvement in these two tasks, focused on depth perception, bimanual dexterity, force sensitivity, autonomy, and robotic control, making it a far more robust evaluation tool than time-based scoring systems. The results of this trial showed that wet lab simulation was the most efficient training for robotic surgery. If wet labs are not available, the virtual reality simulation also proved to be good alternative, because it provides for familiarization with the robot's instrumentation. Moreover, virtual reality training has a lower cost and the advantage of being more readily available.

After finishing robotic training, it is necessary to start your surgical practice in your hospital, performing at least 1 case per week. In order to do that, there must exist both institutional and provider alignment in the commitment to education and staff training, as well as to program development to ensure sustained patient volume. Institutions that succeeded with the robotic program kept good administrative support and created a selected, limited, and dedicated team of providers committed to the program [16]. That includes a clearly identified surgeon leader, bedside first assistant, anesthesiology, scrub nurses, circulating nurses and perfusionists [17].

The development of new technical innovations will be of paramount importance to help the future of robotic cardiac surgery, such as other robotic platforms, new instruments and new devices. Creating new softwares aligned with artificial intelligence will play an important role if they are able to overlay the image visualized in the operating field with the ones from the 3D echocardiography and computed tomography. Close collaboration between surgeons and engineers will be essential to set research priorities and ensure incorporation of new tools in clinical practice.

The perception that a procedure requires fellowship training is a possible explanation for why most core and advanced surgical skills are considered above residency training. Proving competency in a controllable environment may allow residents to gain more autonomy in the operating room [18]. A pressing need exists to incorporate simulation-based training into existing and future cardiovascular surgery residency programs [19]. As mandates for quality measures and shorter training periods emerge, teaching alone using the traditional ''apprenticeship'' model in the operating room will no longer be sufficient. High-fidelity, low-technology tools such as a fresh tissue cadaver laboratory and a virtual operating room might be important adjuncts to successful curriculum implementation.

During the past several years, major shifts in surgical education have brought into question whether surgical residency programs are truly producing competent and technically proficient surgeons [20]. The combination of patient safety concerns, changes in resident education and more complex procedures in high-risk patients have generated greater interest in simulation-based learning in cardiovascular surgery training. Considering the current educational environment and the importance of training the next generation of surgeons, simulations seem an attractive alternative. We strongly believe that simulation may contribute to the development of technical skills and procedural knowledge required for adequate performance in the operating room in cardiovascular surgery.

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