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SHORT REPORT

Conceptual framework for a cardiac surgery simulation laboratory and competency-based curriculum in Pakistan — a short innovation report

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Abstract

Simulation is a commonly utilized technique in healthcare education as it provides trainees a realistic, but safe, environment to learn a variety of skills. Trainees belonging to fields known for high stakes with low margins for error, such as cardiac surgery, can greatly benefit from simulation-based education. We propose the establishment of the first multi-tier high fidelity cardiac surgery simulation lab with a structured curriculum that will eventually provide multidisciplinary training to promising cardiac surgeons across Pakistan. The simulation lab may also be used for research, grant acquisition and patent development. Our setup will include the following levels of simulation: a simple bench model, a virtual reality simulator and a unique human performance simulator. Our multitiered approach allows for appropriate sequential trainee skill progression. Finally, we hope that our model inspires the development of similar curricula and modules for trainees belonging to other surgical fields.

Keywords: Cardiac surgical procedures, Simulation training, High fidelity simulation training, Medical education.

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Introduction

With the advent of the 21st century, cross-cutting, innovative, and demonstration-based simulation has been established as a powerful tool for training health care providers.[1] The ubiquitous use of simulation for training healthcare providers in Advanced Cardiac and Basic Life Support (ACLS/BLS) is a testament to this paradigm's success.[2] The application of simulation in skill-based fields like surgery is even more significant, because not only does it allow greater standards of real-time training, but it also reduces the risk to patients who would otherwise be the first point of practice for new trainees.[3]

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This need is further pronounced in high-stakes, high-precision fields featuring a low-margin of error, like cardiac surgery.[4] High fidelity simulation (HFS) is still relatively nascent in cardiac surgery, owing to the challenges of setting up a tissue-based simulator of exceedingly complicated procedures. However, contemporary advances have not only made this possible, but also highly refined and developed.[5] The added aspects of intense research, interest by grant awarding bodies, and patent development aptly complement these advances.[6]

Precision-oriented simulation employed in cardiac surgery can pave the way for improved simulated training in healthcare sciences across the board. In this innovation report, we propose a concept note for a well-developed cardiac surgical simulation lab which would be complemented by the backbone of a carefully curated simulation curriculum. This initiative has the potential of becoming a groundbreaking advancement in medical training at both national and regional levels. In addition, the experience gained by developing such a complex simulation system will help push the frontiers of surgical simulation in Pakistan, and the lessons learnt will pave a pathway for other surgical fields to develop similar simulation systems.

Methods and Results

Primary Objective: The strategic establishment of a multi-tier, high fidelity cardiac surgery simulation lab, with a formal structured curriculum, would provide a platform for advanced multidisciplinary training at institutional, national, and regional levels.

Secondary Objective: Further concurrent and subsequent arms include curriculum development, research in simulation education, grant acquisition and patent development.

Modus Operandi: Three core principles lie at the center of a fully functional cardiac surgery simulation lab: it should be based on Evidence-Based Medicine, designed for comprehensive sequential training, and tiered with an appropriate progression of skills. This allows for a more cost-effective, trainee-specific approach instead of investing in a single high-fidelity simulation module alone. At the same time, our objective is to develop a resource-

agnostic comprehensive system that can integrate the already available resources in Pakistan, such as ACLS and Harvey manikins, with a newly developed simulator.

This concept note discusses the development of a novel cardiac surgery simulation lab in a low-middle income country like Pakistan, which would include the following three models:

1) Simple Bench Model (SBM): This is a low-cost instructive set up to be used in conjunction with locally sourced animal-based hearts or synthetic tissue e.g. The Chamberlain Group HeartCase.[7] This system is especially effective for instructing larger groups in surgical approaches and techniques. Similar systems, such as the animal hearts without simulation case, have already been piloted and have been run as wet labs by many institutions in Pakistan. The set up provides realistic challenges of texture, exposure, access, and suture angulation in the depth of the pericardial well that cannot be emulated with an animal heart alone. The versatile nature of the model will serve as a basic platform for cardiac surgery workshops held in future.

2) Virtual Reality Simulator: This system focuses on advanced, high-technology systems designed to simulate haemodynamic parameters in the safe environment of the simulator, as opposed to the operating room (OR) on a live patient. The systems are programmed with advanced algorithms that can be triggered to allow the simulation of regular scenarios as well as disaster scenarios. The objective is to create exposure to well-known, common complications associated with cardiac surgery and to inculcate the requisite reflexes in the safe environment of a simulation. This will improve the essential response and reaction times in real life situations by enhancing the overall training of the residents, and thus, improve patient outcomes and overall costs due to shorter OR time, similar to Califia 2 system by Biomed Simulation (U.S.A) and Orpheus (Australia).[8]

3) Human Performance Simulator: This apical tier for surgical trainers is represented by high fidelity simulators that allow near-complete simulation of the entire cardiac surgical procedure on a beating animal heart. These devices are animated by programmable pumps that can mimic most intraoperative scenarios which would require critical thinking from the trainee. These systems can allow practice of highly complex procedures such as: 1. Great vessel cannulation, 2. Coronary Artery Bypass Grafting, 3. Valve replacement and repair procedures, 4. Atrial/Ventricular Septal Defect repairs. The system can be used in conjunction with the Virtual Reality Simulator to emulate complete procedures, including hands-on surgical skills and appropriate responses to intraoperative complications. The best-known representative simulator is the Ramphal Simulator designed at the University of the West Indies and now utilized by major institutions across North America.[4]

Framework and Outcomes: Economic sustainability is a cornerstone to optimizing the development and upkeep of this simulation lab. Our tripartite strategy for long-term economic sustainability has been described in Figure-1. The United States-based Thoracic Surgery Directors

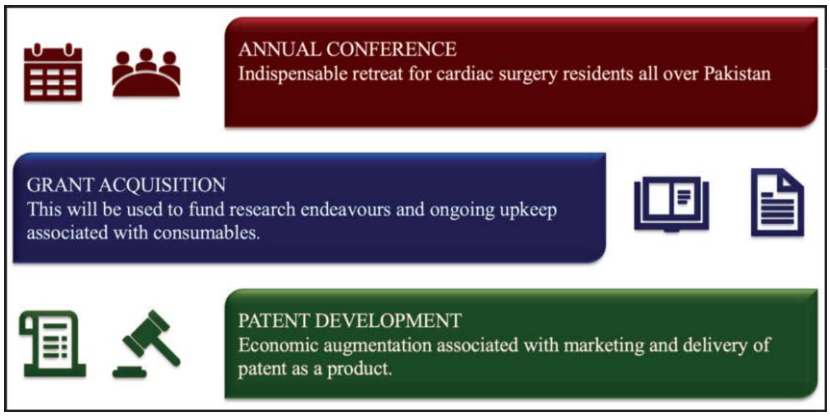

Figure: Overview of the trimodal strategy to provide economic sustainability for the cardiac simulation laboratory.

Table: Overarching framework of 12 curricular teaching modules and an annual cardiac surgical retreat.

	Curricular Teaching Module	Description
1.	Cardiopulmonary Bypass Module	Primary procedure module (Component 1 of 6)
2.	Ischaemic Heart Revascularization on pump plus off pump	Primary procedure module (Component 2 of 6)
3.	Aortic Valve Replacement	Primary procedure module (Component 3 of 6)
4.	Mitral Valve Repair plus Replacement	Primary procedure module (Component 4 of 6)
5.	Atrial Septal Defect/ Ventricular Septal Defect	Primary procedure module (Component 5 of 6)
6.	Aortic Aneurysm Module	Primary procedure module (Component 6 of 6)
7.	Massive Air Embolism Module	Advanced scenario module (Component 1 of 6)
8.	Acute Intraoperative Aortic Dissection Module	Advanced scenario module (Component 2 of 6)
9.	Sudden Deterioration in Cardiac Function Module	Advanced scenario module (Component 3 of 6)
10.	Minimally Invasive Valvular Surgery + Maze Procedure	Advanced scenario module (Component 4 of 6)
11.	Complex Multicomponent Surgery - Valve + CABG	Advanced scenario module (Component 5 of 6)
12.	Redo Cardiac Surgery	Advanced scenario module (Component 6 of 6)
13.	Annual Cardiac Surgical Retreat	7 Day condensed culmination of in-house curriculum for Cardiac Surgical Residents from all over Pakistan

Association (TSDA) 'boot camp' has already applied this three-tier system for the past few years to train Cardiac Surgery residents from the top institutions around the country.[9] However, given that the variability of centers across different settings also translates downstream to integral differences in resources and protocols, it is important to develop a home-grown and contextual curriculum for Pakistan. It is also imperative to keep surgeons at the forefront of designing such curricula. Details of our training curriculum framework have been provided in Table-1.

Given the dearth of such ventures on a global scale, and especially in low- and middle-income countries, there is a likelihood of attracting an international group of trainees and academicians as well. In this manner, there is also a potential to recover and even exceed the original investment utilized in the setting up of the lab. The lab would also serve as a valuable research source for the study of curriculum teaching in the highly complex field of Cardiac Surgical Education.

Conclusion

Cardiac Surgery is a high-precision, high-stakes, multidisciplinary field involving complex surgeries with very little room for error. Adequately training residents and other members of a cardiac surgery team in the safe environment of a high-fidelity simulation lab will improve their skill levels, leading to safer operations and shorter operative times in real life situations. Extensive training in cardiopulmonary bypass-related disaster situations, ubiquitously recognized as life threatening, will improve patient outcomes significantly.

Concurrently, it is paramount to establish Pakistan's first full-fledged simulated surgical curriculum simultaneously with the provision of adequate equipment and extensive training scenarios, including evaluation checklists and educational research. Future directions could be to pilot this at the intra-university level, as an annual high fidelity simulation course with a complete workshop curriculum for trainees at the national and international levels. Finally, the concept note for this innovative model can be used to extrapolate similar training modules in other fields of surgery.

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Conflict of Interest: None.

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