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Innovation in surgical training: Simulating prosthetic heart valves and annuloplasty rings using pacifiers for cardiac surgery wet-labs in a resource limited setting

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COMMENTARY

Innovation in surgical training: Simulating prosthetic heart valves and annuloplasty rings using pacifiers for cardiac surgery wet-labs in a resource limited setting

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Abstract

Conducting a hands-on cardiac wet-lab on valvular surgeries in a resource-limited setting is restricted by the lack of prosthetic heart valves and annuloplasty rings for developing cognitive and technical skills required to understand and protect the three-dimensional cardiac anatomy. In recent times, simulation is regarded as an effective tool in surgical education and has proven to improve the technical skills of trainees. The current short report presents a novel simulator to mimic heart valve replacement surgeries by using a pacifier as a prosthetic valve and annuloplasty ring. Considering resource-constraints in the local context, pacifier-based valve simulators can be usedful as they are cost-effective, readily available, easy to assemble, sturdy to use and have been remarkably helpful in teaching heart valve surgeries to residents and junior surgeons.

Keywords: Cardiac Surgery, Wet Lab, Innovation, Prosthetic heart valve simulator.

Introduction

To perfect the art of surgery, a physician undergoes extensive training to attain the level of dexterity and proficiency required for performing a safe and successful operation. Spent under the supervision of experienced surgeons, these training years are composed of long hours in an operating room (OR) where cognitive, clinical and technical skills are developed. However, OR-based learning is labelled as ineffective in recent times due to ethical reasons, time constraints, increased complexity of cases and limitation in resident working hours.[1] This is particularly true in cardio-thoracic surgery (CTS) training where critical illness, no margin of error, time limitation due to cardio-pulmonary bypass and intricacy of micro-surgery make OR-based skill acquisition complicated.[2]

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Incorporation of wet-labs into CTS residency is an effective simulation for teaching surgical techniques, suture and tissue handling, economy of movements and operative safety. Practising on animal tissue ensures that the trainees have some practice before treating humans, which protects human subjects from complications.[3] Valve surgeries, in particular, require a thorough understanding of the three-dimensional (3D) anatomy of the valve and its surrounding relations and are, hence, the main focus of wet-labs curriculum. To simulate valve replacements and ring annuloplasty in wet-labs, prosthetic valves and rings are required which are not affordable for resource-limited training programmes.

Time and again, Aga Khan University (AKU), Karachi, has organised wet-labs on different domains of cardiac and thoracic surgery. These were designed as part of various national and international conferences to educate the residents and junior cardiac surgeons at both institutional and national levels. To practise valve surgeries, a unique simulator has been devised to mimic prosthetic valves and annuloplasty rings by using the pacifier of a feeding bottle. Due to its easy availability and minimal cost, the pacifier is regarded as a suitable alternative to prosthetic valves and rings for low and middle income countries (LMICs). To the best of the authors' knowledge, this technique has not been reported in literature before and the current paper was planned to share this unique simulation method to facilitate other resource-limited residency programmes.

Methods and Discussion

To enhance surgical skills of cardiac surgery residents at AKU, bi-weekly wet-labs are organised at a dedicated anatomy learning studio within the hospital. Each wet-lab is attended by cardiac surgery residents ranging from year 1 to year 4 of training, and all have a prior 2-year general surgery experience. Each resident is instructed and supervised by a cardiac surgeon attending on a one-on-one basis.

For valvular wet-labs, readily available bovine hearts are acquired a day prior to the cardiac wet-lab. These are set

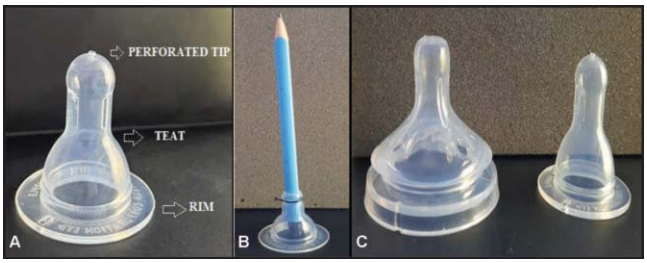

Figure-1: (A) A pacifier made of silicon; (B) Cutting the perforated tip of the pacifier and passing a pencil through it to act as handle; (C) Different sizes of pacifiers for different annular sizes.

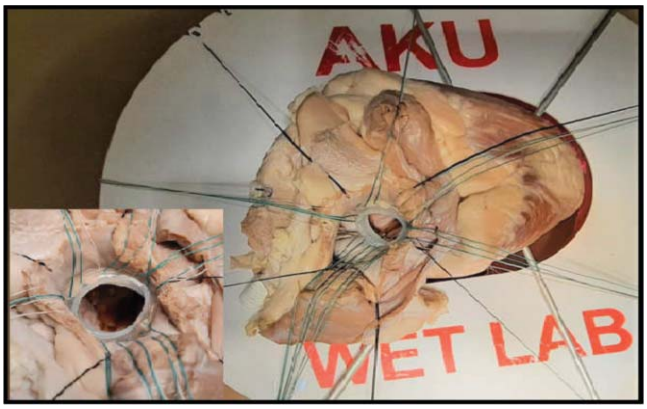

Figure-2: Mitral valve replacement using bovine heart skewered with discarded chest drain trocars for anatomical positioning, Ethibond sutures and a pacifier simulating mitral valve prosthesis. Inset shows a closer view of the simulator.

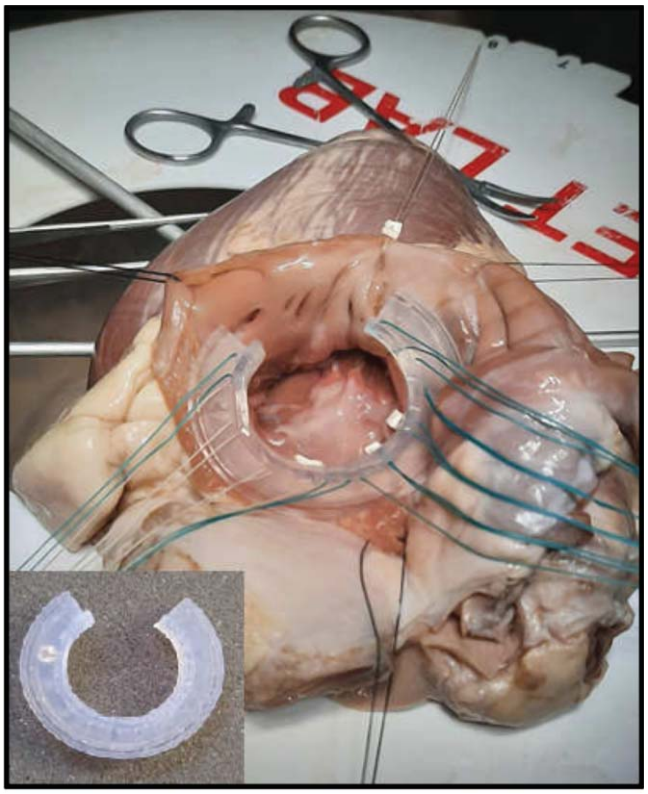

Figure-3: Mitral ring annuloplasty using rim of the pacifier shaped as an incomplete annuloplasty ring. Using similar method, these can also be used for simulating tricuspid annuloplasties.

in locally-designed tissue holders with suture retainers skewered in different anatomical positions using discarded sharp-tipped trocars from chest drains. All residents carry their own set of basic and micro-surgical instruments for the wet-lab, while expired and unused sutures are procured from ORs.

The session begins with a brief discussion on the valve anatomy, important surgical relations in respect to the valve and intra-operative assessment of valve pathology. Depending on the valve module planned, various alternative access routes, including transverse and oblique aortotomies, right atriotomies for tricuspid valves and mitral valve exposures through trans-septal, superior-septal and sondergaard's routes, are taught and these are practised by the trainee surgeons. Once the valve is exposed, annular sutures are taken using double-ended, pledgetted poly-ethylene terephthalate (Ethibond)® 2/0 in an inverting, everting or continuous manner while constantly practising needle-holding, needle angles, suture distancing, tissue-handling and preservation of structures surrounding annulus (Figure-2). The prosthetic valve is prepared by cutting the perforated tip of the silicon pacifier. A pencil is introduced through this tip and secured with a heavy silk tie which acts as the handle. The sutures are then passed through the rim of the pacifier ensuring equal distancing and preventing William-telling the suture. The prosthesis is lowered and the sutures are securely tied in place while the pencil handle is removed by cutting the teat of the pacifier along its circumferential attachment to the rim (Figure-1).

These pacifiers are used to practise mitral and tricuspid ring annuloplasty by cutting the teat off the pacifier. The rim of the pacifier is then fashioned in the form of either a complete or a partial ring (Figure-3). Their use clarifies the concepts of suture spacing, protection of nearby structures and methods of appropriate sizing for the ring. The residents are closely evaluated for their skills by the faculty and appropriate feedback is given. This results in correction of technique and enhancement of the knowledge base.

Different-sized pacifiers are used to cater to different annular sizes although some mismatch is always present. These pacifiers are inexpensive, readily available, and their silicon is sturdy enough to allow easy suture passage and

seating on the annulus, while they can be reused multiple times for wet-labs. In LMICs, like Pakistan, these pacifier-based prostheses for wet-labs are a cost-effective, easily reproducible, safe and quick-to-assemble simulators. They are used to learn a variety of surgical procedures, such as mitral and aortic valve replacements, mitral and tricuspid ring annuloplasties, supra-annular and sub-annular suture placement etc. After serial assessments, the residents have reported remarkable improvement in their surgical armamentarium with improved OR performance.

Conclusion

Practising in regular wet-labs is an effective training strategy for cardiac surgery residents. However, this can be restricted in LMICs due to lack of finances. With the use of bovine hearts, a basic instruments set and a dedicated space for learning, successful wet-labs can easily be conducted in resource-limited settings. The use of pacifiers is recommended as a cheap, durable, easily-available and easily-assembled simulator for perfecting the art of valve surgeries.

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