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Promoting Technology and Collaboration

Low-Cost Pressurized Porcine Heart Model with Physiologic Coronary Flow for Cardiopulmonary Bypass and Off-Pump Skills Training

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Background: High-fidelity cardiac simulators are rarely able to provide a platform to perform realistic on and off-cardiopulmonary bypass procedures and simulate the wide variety of scenarios that can be encountered during both of these modalities. We present a low-cost porcine heart platform for technical skills, crisis rehearsal, and team training that be easily-assembled and re-used for cardiac surgical skills practice.

Technology Overview: Fresh porcine hearts are prepared by sealing all major vessels with exception of the aorta and superior vena cava. The heart is seated in an aluminum tray, and a small peristaltic pump recirculates blood-analog through the coronary sinus, providing controllable coronary flow independent of systemic pressure. An adjustable pressure bag with a Y connector is then attached to the aorta and superior vena cava, and inflated until the entire heart and major vessels are pressurized, allowing for authentic back-bleeding during cannulation. Quick-connects toggle between perfused off-pump practice and a closed cardiopulmonary bypass loop for on-pump drills.

Potential Application in Surgical Simulation and Education: The platform enables practice of a variety of essential cardiac surgical skills including purse-string placement, cannulation/decannulation, flow initiation/termination, cardioplegia, venting, proximal anastomoses on a pressurized aorta, among others. It can also be scaled from individual technical drills to interprofessional scenarios involving surgical assistants and perfusionists in training. Future work will involve developing an AI model to evaluate trainee performance for improved self-assessment and informed simulation practice.

Potential Opportunities to Collaborate: This pressurized, coronary-perfused heart model enables realistic practice of core cardiac skills across the learning curve performed on a truly pressurized aorta and coronary vasculature. Trainees encounter authentic cues such as back-bleeding, and root distention, allowing for practicing troubleshooting scenarios. This simulator facilitates tracking of realistic objective metrics (e.g., safe time-to-CPB, cannulation errors, etc.) for longitudinal assessments of skill acquisition and transfer to the OR.



Figure 1. Pressurized, coronary-perfused heart trainer enabling off-pump and CPB skills simulation.

(A) Coronary distal anastomosis performed on the pressurized/perfused model with active antegrade back-bleeding from the target vessel, providing physiologic cues for lumen identification, flow testing, and suture-line hemostasis. (B) Bovine heart demonstrating perfused coronary arteries (dye-tinged perfusate for visualization) during off-pump practice. (C) Porcine heart configured for CPB simulation with aortic arterial and right-atrial venous cannulas in place, and simulated aortic-root cardioplegia delivery. Coronary circulation is driven by a peristaltic pump, while an inline pressure bag sets adjustable aortic afterload, allowing for off-pump and on-pump (closed circuit) scenarios.