# EDITORIAL COMMENT

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## Shifting the learning curve in robotic cardiac surgery

Cardiac surgery remains one of the most technically demanding specialties in modern practice. Historically, the training required to acquire technical proficiency has been expected to take place largely in the operating room[1]. While this apprenticeship tradition has produced generations of skilled surgeons, it implicitly accepts a model where learning unfolds alongside live clinical care, embedding the cost of that learning onto the patient. In the era of robotic cardiac surgery, this assumption is no longer defensible.

These are high-stakes procedures performed in patients with limited physiological reserve, where complications escalate rapidly and margins for error are exceptionally narrow. The robotic platform amplifies this complexity through the loss of tactile feedback, altered depth perception, and a heavy reliance on advanced technology. At the individual level, mastery of the robotic platform begins not with complex manoeuvres but with physical ease and control. Effective console positioning and the development of efficient motor patterns directly influence precision, consistency, and overall error rates.

The central question is therefore no longer whether a learning curve exists, a concept recognized since Hermann Ebbinghaus' early research on memory and repetition, but where it is allowed to reside.[2] Too often, it remains dangerously embedded within active clinical practice. The aviation and military industries have long recognized the flaws of this approach, successfully displacing their learning curves away from the end user through extensive simulation.[3, 4] No passenger boards a commercial aircraft expecting the crew to acquire critical skills in real time. Instead, competence is continuously assessed and buffered by simulation, standardization, and layered redundancy.

Surgery must adopt a similar paradigm. Training entirely within the operating room is an inefficient process.[5] Deliberate, high-fidelity practice outside the operating room, using immersive video-based review, dry-lab readiness, and structured wet-lab simulation, is essential for acquiring foundational robotic competence before any clinical expansion.[6] The consequences of misplacing this learning curve are stark. The UK Newcastle experience serves as a grim reminder of the outcomes when complex robotic programs are launched without sufficient preparation, systemic oversight, or institutional safeguards.[7] While expert testimony in that specific case suggested a minimum threshold of 40 operations to achieve competency, programs must view such numbers critically. Minimum thresholds must account for each surgeon's unique technical ability and institutions must possess the humility to remove individuals from the program if competency is not achieved. Innovation cannot justify exposing patients to avoidable risk. Arrogance has no place in high-risk surgery because the ultimate cost is measured in human lives.

The 2026 Society of Thoracic Surgeons consensus provides a vital corrective lens, reframing robotic cardiac surgery as a staged, team-based pathway rather than an individual pursuit.[8] This framework progresses through defined phases, from program initiation to mastery, contingent on demonstrated capability rather than assumption. It situates learning within a unified team construct where surgeons, bedside assistants, anesthesiologists, perfusionists, and nursing staff evolve together. Mentorship and institutional commitment are non-negotiable. Robotic programs require protected time, structured scheduling, and deep leadership engagement. Without this infrastructure, even the most technically capable teams are likely to fail.

Furthermore, robotic surgery offers an opportunity to fundamentally rethink operative safety through dual-console systems. In complex systems, safety arises from persistent redundancy. Just as aviation does not abandon co-pilots once a captain is deemed competent, surgery must also maintain cross-checking and shared responsibility. Dual-console systems enable continuous, active oversight, allowing a second operator to observe, guide, and intervene in real time. This role, suited for any skilled robotic specialist with an acute understanding of procedural flow, acts as a structural safety layer that distributes responsibility and mitigates both human and technological vulnerabilities.

Ultimately, the learning curve is not an individual burden but a systemic challenge demanding design, discipline, and accountability. The expansion of robotic programs must be driven by outcome auditing and transparent review, not institutional prestige. Normalizing the conversion from robotic to open surgery as a proactive safety decision, reflecting sound clinical judgement rather than inadequacy, is paramount. Our profession now possesses the frameworks, simulation tools, and global experience to relocate the learning curve away from the patient. The development of the profession must not be paid for by patients. The remaining question is whether we have the collective discipline to enforce this, recognizing that a global strategy for qualification and certification is essential.[9]

**Conflict of Interest**

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