

Decision Support in Cardiac Surgery: Early Exploration of Requirements with Cardiac Anesthetists and Surgeons

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Abstract. Successful implementation of clinical decision support tools is rare, the key barrier being the lack of user involvement during development. Following the idea, development, exploration, assessment, long-term follow-up (IDEAL) framework, this study aims to provide early insights into the current challenges, clinical processes, and priorities when developing new decision support tools in cardiac surgery. Using a qualitative approach, semi-structured interviews were conducted with cardiac anesthetists and surgeons from three Scottish cardiac centers. Thematic analysis identified adverse postoperative outcomes, ageing cardiac patient population and changing surgical procedures to be the main challenges in cardiac surgery. Existing risk prediction tools were largely not used due to a perceived lack of utility and validation. This study underscores the need to shift focus towards predicting postoperative complications, instead of mortality. It emphasizes the importance of early collaboration with clinical experts and stakeholders in developing decision support systems that are fit for purpose. By identifying the priorities of cardiac clinicians, the study lays the groundwork for developing clinically meaningful prediction models.

Keywords. Decision Support, Stakeholder Engagement, Cardiac Surgery, Postoperative Complications, Risk Prediction

1. Introduction

With the development of the Perioperative Medicine Programme in 2014 [1], the roles in surgical decision-making have shifted from a surgeon alone to multi-disciplinary teams, with anesthetists having a larger influence in enhancing perioperative care [2]. To allow for more streamlined decision-making, data-driven clinical decision support tools

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– such as risk stratification tools for perioperative assessment – are now an integral part of cardiac surgery [3]. While various tools have been developed for clinical decision support, the evidence of implementation and adoption of these prediction models is limited. Although there are numerous risk prediction models for outcomes in cardiac surgery [4], only a handful of these have been integrated into routine practice in UK cardiac centers.

Qualitative research with cardiac surgeons and anesthetists is scarce, impeding insights into postoperative outcomes and risk-scoring system utilization [5]. When developing new clinical risk prediction models, a clear understanding of stakeholders' requirements regarding the functionalities of these models is crucial. Hence, this study follows the early-stage innovation, development, exploration, assessment and long-term study (IDEAL) framework, which is a collaboratively developed framework for developing new surgical interventions and assistive technologies (incl. decision support tools) that balances innovation, usability and safety [6]. Specifically, this study pertains to the Stage 0 – Preclinical Stage [6] of the framework in which the “clinician perspective” and “device perspective” aspects are investigated. Thus, this study aims to gain insights from clinicians to facilitate the development of new, practical decision support tools in cardiac surgery by addressing the following research questions:

RQ1: *What are the current challenges in cardiac surgery?*

RQ2: *What are the current key processes to prevent and manage adverse outcomes in cardiac surgery?*

RQ3: *What are the clinical priorities for the development of new risk prediction models?*

2. Methods

This study was approved by the Department of Computer and Information Sciences Ethics Committee at the University of Strathclyde (ID: 837) and was undertaken as part of the project approved by the UK Health Research Authority (REC18/YH/0366, September 21st, 2018).

The study was conducted through n=11 semi-structured interviews with cardiac surgeons, cardiac anesthetists, and cardiac intensivists, and follows the IDEAL framework [6]. Interviews were conducted across 3 Scottish cardiac centers: Golden Jubilee National Hospital (GJNH), Royal Infirmary Edinburgh (RIE), and Aberdeen Royal Infirmary (ARI) between December 4, 2018, and July 16, 2019. Invitations for study participation were sent to a pool of n=64 potential participants, 27 of them were cardiac surgeons (18 from GJNH, 6 from RIE, and 3 from ARI), and 37 were cardiac anesthetists (16 from GJNH, 13 from RIE, and 8 from ARI). In total, the invitations were sent three times for an average response rate of 17%.

Open-ended questions were used to encourage exploratory and reflective discourse, placing an emphasis on the participants' perspectives on current challenges in cardiac surgery and capturing participants' views on how decision support systems could support clinical decision-making in cardiac surgical care. Interviews were transcribed by the authors, then reviewed, and participants' quotes were highlighted and coded for thematic analysis as recommended by Braun and Clarke [7]. To minimize subjectivity, sections of transcripts were coded separately by two researchers with extensive experience in conducting qualitative research. Discrepancies were discussed with the study team and

resolved per consensus. A thematic analysis was conducted using a framework approach using the methodology recommended by Ritchie and Spencer [8].

Themes identified in the framework analysis included: current *challenges in cardiac surgery*, *current processes to avoid adverse outcomes in cardiac surgery*, and *clinicians' priorities for improving clinical risk prediction models*, as described in the study results (Section 3).

3. Results

Eleven participants took part in the interviews: 9 from GJNH and 2 from ARI. 9 participants were cardiac anesthetists (8 consultants) and 3 were consultant cardiac surgeons. Regarding the involvement in patient pathway, 6 participants were involved in pre-operative assessment, 10 were involved in postoperative care and all participants took part in intra-operative care.

3.1. Current Challenges in Cardiac Surgery

The main challenges mentioned by interviewees included adverse outcomes, changing patient population, and changing procedures in cardiac surgery. Commonly mentioned adverse outcomes were: atrial fibrillation, bleeding, delirium, infections, renal complications, sepsis and stroke. The participants believe that complications have become more common in recent years, likely due to the increasing number of comorbidities in an aging population, which often leads to long-term adverse outcomes. They also noted changes in the types of surgical procedures performed.

The lack of cooperation between data collection, evidence-based medicine, and auditing was explained to be a barrier to avoiding adverse events. Because the emphasis is mostly on mortality, the clinicians have doubts about how well complications are recorded. Complications are yet to be objectively defined [9], which can cause variability in the quality of the data entered into electronic health records. Consequently, low-quality data makes it challenging to ascertain their true frequency in the patient population.

3.2. Current Processes to Avoid Adverse Outcomes in Cardiac Surgery

According to the participants, the ultimate way to minimize risk of adverse outcomes is patient selection, which is discussed in multi-disciplinary teams, with the final decision being made by the surgeon. While anesthetists were not always involved with preoperative clinics, all anesthetists agreed about the necessity to see the patient at least the night before surgery.

All participants had used some clinical risk prediction tools in one way or another, however, the routine usage was lacking. The interviewees know about various risk prediction models in cardiac surgery, however, they noted that most risk prediction tools use only preoperative data, lack personalization, offer no guidance on acting upon predictions, and often rely on outdated models. The main usage of the EuroSCORE was said to be for documentation to support certain decisions, such as defending yourself in doubts of malpractice.

3.3. Clinicians' Priorities for Improving Clinical Risk Prediction Models

Clinicians in the interviews expressed the need for personalized risk prediction models over population-based ones like EuroSCORE. Additionally, current models were criticized for predominantly predicting mortality. Various outcomes were suggested to be predicted, including intensive care unit stay, delirium, stroke, bleeding, infections, respiratory complications, and renal complications. However, it was suggested that improving data collection on complication incidence should take priority over prediction. Additionally, predicting combinations of complications, not just individual ones, was recommended. Overall, interviewees emphasized the importance of thorough model validation.

4. Discussion

In this study, explorative interviews were undertaken to understand the current challenges in cardiac surgery, the current context of which clinical prediction models are used in, and what requirements the cardiac surgeons and anesthetists have regarding a usable up-to-date clinical prediction model in cardiac surgery.

Clinical decision support is a rapidly developing area; however, these new tools are rarely implemented. While cardiac surgery clinicians have been involved in some projects to do with digital innovation in cardiac surgery [10,11], studies including potential users of prediction models are rare, and thus the advancements in risk prediction in cardiac surgery are considerably slow. To ensure smooth implementation in the future, this study recommends the following when developing a new clinical decision support tool in cardiac surgery.

New tools should be developed with multi-disciplinary teams and patients. Multi-disciplinary teams are increasingly included in deciding the appropriate treatment for the patient, and therefore creating a tool that is usable for clinicians from different disciplines in mind is crucial. Depending on the purpose of the tool, patients should also be included as stakeholders.

New tools should focus on outcomes that have a potential long-term negative effect on patients. To allow clinicians to be better positioned in preventing and diagnosing unwanted outcomes, new tools should focus on outcomes such as complications and long ICU stay – the main challenges found in this study. Currently developed perioperative risk stratification models mostly predict mortality or specific complications (4). However, a model that captures several complications at the same time would be beneficial.

New tools should encompass the full perioperative journey. While it was established that most decisions are made during the preoperative stage, considering the timing of the predicted adverse outcome is crucial, and therefore real-time prediction models that encompass the whole perioperative journey and use most up-to-date information account would offer more personalized prediction.

The main facilitator for clinicians to use a clinical decision support tool is appropriate and thorough validation. A number of steps are required for a clinical prediction model to be validated and to be ready for use in practice, including following reporting requirements, evaluation and involvement of stakeholders [12]. A thorough validation plan should be put in place right at the start when developing a new decision support tool.

To successfully develop an accurate, fit-for-purpose decision support tool, policy changes are paramount. Current surgical quality measures, collected by The Society for Cardiothoracic Surgery, still include only mortality [13]. The most recent National Adult Cardiac Surgery Audit report also included complications, such as bleeding, stroke, renal failure and deep wound sternal infection, however, the reporting of complications is still lacking [14]. Therefore, policy changes are needed in data collection on complications to help build a more accurate picture of the quality of care and patient outcomes.

This study addresses the sociotechnical gap between the development and implementation of clinical decision support tools in cardiac surgery [10], and provides early-stage insights for shaping the future development of risk prediction tools for cardiac surgery. Fulfilling the requirements of the Stage 0 – Preclinical Stage of the IDEAL framework, future studies should focus on the next stages of the IDEAL framework to understand the particular requirements for such tools, and how the tools could fit into a practical context. Though conducted in Scotland, this study's findings on the requirements for new clinical decision support tools can be applied to modern cardiac centers globally, given the consistency in practice guidelines across nations. The study identifies the priorities of cardiac surgeons and anesthetists for a clinical prediction model, emphasizing the need for a model predicting postoperative complications rather than mortality.

References

- [1] The Royal College of Anaesthetists. Perioperative Medicine: The Pathway to Better Surgical Care [Internet]. 2015. Available from: [https://www.rcoa.ac.uk/sites/default/files/documents/2019-08/Perioperative Medicine - The Pathway to Better Care.pdf](https://www.rcoa.ac.uk/sites/default/files/documents/2019-08/Perioperative%20Medicine%20-%20The%20Pathway%20to%20Better%20Care.pdf).
- [2] Partridge JSL, et al. The emerging specialty of perioperative medicine: a UK survey of the attitudes and behaviours of anaesthetists. *BMC Perioper Med*. 2020;9. doi: <https://doi.org/10.1186/s13741-019-0132-0>.
- [3] Moonesinghe SR, et al. Risk stratification tools for predicting morbidity and mortality in adult patients undergoing major surgery: qualitative systematic review. *Anesthesiology*. 2013;119:959–981.
- [4] Lapp L, et al. Dynamic Prediction of Patient Outcomes in the Intensive Care Unit: A Scoping Review of the State-of-the-Art. *J Intensive Care Med* [Internet]. 2023; doi: [10.1177/0885066623116634](https://doi.org/10.1177/0885066623116634).
- [5] Jowsey T, Deng C, Weller J. General-purpose thematic analysis: a useful qualitative method for anaesthesia research. *BJA Educ*. 2021;21:472–478. doi: <https://doi.org/10.1016/j.bjae.2021.07.006>.
- [6] Marcus HJ, Bennett A, Chari A, et al. IDEAL-D Framework for Device Innovation. A Consensus Statement on the Preclinical Stage. *Ann Surg*. 2022;275:73–79.
- [7] Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2008;3.
- [8] Ritchie J, Spencer L. Qualitative Data Analysis for Applied Policy Research. *Anal Qual Data*. London; 1994. p. 173–194.
- [9] Lapp L, et al. Definition and Classification of Postoperative Complications After Cardiac Surgery: Pilot Delphi Study. *JMIR Perioper Med*. 2022;5:e39907. doi: [10.2196/39907](https://doi.org/10.2196/39907).
- [10] Matthiesen S, Diederichsen SZ, Hansen MKH, et al. Clinician preimplementation perspectives of a decision-support tool for the prediction of cardiac arrhythmia based on machine learning: near-live feasibility and qualitative study. *JMIR Hum Factors*. 2021;8.
- [11] Greig PR, Higham HE, Darbyshire JL, Vincent C. Go/no-go decision in anaesthesia: wide variation in risk tolerance amongst anaesthetists. *Br J Anaesth*. 2017;118:740–746. doi: <https://doi.org/10.1093/bja/aew444>.
- [12] van Royen FS, Moons KGM, Geersing G-J, van Smeden M. Developing, validating, updating and judging the impact of prognostic models for respiratory diseases. *Eur Respir J*. 2022;60:2200250. doi: [10.1183/13993003.00250-2022](https://doi.org/10.1183/13993003.00250-2022).
- [13] SCTs. National Cardiac Surgery Activity and Outcomes Report 2002-2016. Soc. Cardiothorac. Surg. Gt. Britain Irel. 2020.
- [14] National Cardiac Audit Programme. NACSA 2023 Summary Report. 2023.