


openheart Death in low-risk cardiac surgery revisited

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ABSTRACT

Background A systematic review of low-risk death has been shown successful in identifying system weaknesses. The aim was to analyse early mortality in low-risk patients undergoing cardiac surgery and to determine the cause of death, classify if they were unavoidable or potentially preventable as a result of technical or system errors.

Methods We included all low-risk patients who underwent cardiac surgery at our institution from 1 September 2009 to 31 August 2019. In patients operated between 2009 and 2011, we defined low risk as an additive European System for Cardiac Operative Risk Evaluation (EuroSCORE) I less than or equal to 3, and from 2012 and onwards as a EuroSCORE II less than or equal to 1.5. The medical records for the patients who died within 30 days of surgery were thoroughly examined and the cause of death was classified as cardiac or non-cardiac. Furthermore, deaths were categorised as not preventable, preventable (technical error) or preventable (system error).

Results During the study period 3103 low-risk patients underwent surgery, and 11 patients died within 30 days of the operation (0.35%). Six of these (55%) were classified as preventable and five non-preventable. Four of the preventable deaths were classified as technical errors and two were due to system errors.

Conclusions A repeated systematic review of deaths in patients with a low preoperative risk showed that a majority of deaths were preventable, and therefore potentially avoidable. Similar to the previous assessment at our unit, mortality was very low and failure to communicate remains a modifiable factor that should be addressed.

INTRODUCTION

In open heart surgery, the operative risk can be estimated using the European System for Cardiac Operative Risk Evaluation (EuroSCORE)^{1–3} risk model. Perioperative death does unfortunately occur even in very low-risk patients but the knowledge about the cause of death and the sequence of events resulting in mortality is limited. The Failure to Achieve a Satisfactory Cardiac Outcome (FIASCO) study⁴ was first to systematically analyse failures in achieving a satisfactory cardiac outcome in low-risk cardiac surgery patients. Inspired by the FIASCO study, we undertook a similar analysis at our institution and reported the Stockholm experience

Key questions

What is already known about this subject?

- ▶ A structured and systematic review may unmask systemic errors leading to death in low-risk cardiac surgery.

What does this study add?

- ▶ A repeated systematic review of deaths in patients with a low preoperative risk showed that a majority of deaths were preventable, and therefore potentially avoidable. These findings were to some extent different from our prior study conducted a decade ago, underscoring the need for repeated analyses.

How might this impact on clinical practice?

- ▶ A unit could improve outcomes by regularly revisiting the topic of death in low-risk cardiac surgery.

almost 10 years ago.⁵ Since then a study from Turkey was published⁶ including low-risk patients undergoing coronary artery bypass grafting surgery. The authors of the original FIASCO study repeated the analysis some years later and published the results of the FIASCO II study.⁷ Interestingly, important lessons were learnt resulting in the elimination of systemic errors, suggesting a benefit of systematic regular study of modifiable factors in institutional practice. Based on their experience in having performed repeated systematic review of low-risk deaths, they encourage other units to use the described methodology in order to unmask systemic errors. Analysing death in a low-risk population can provide valuable information which might benefit other patients in the future and help improve the quality of care. Our aim was to analyse early mortality in low-risk patients undergoing cardiac surgery during the last 10-year period and to determine the cause of death, classify if the death was unavoidable or potentially preventable as a result of technical or system errors. We also investigated possible changes during the last 10 years compared with the prior decade.

PATIENTS AND METHODS

The Swedish Cardiac Surgery Register,⁸ a national quality register for cardiac surgery



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procedures within Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies,⁹ was used to identify all patients with low EuroSCORE who underwent cardiac surgery at Karolinska University Hospital in Stockholm between 1 September 2009 and 31 August 2019. We included low-risk patients who died within 30 days of the date of operation. In patients who underwent surgery between 2009 and 2011, we defined low risk as an additive EuroSCORE I less than or equal to 3. In patients who underwent surgery from 2012 and onwards, we defined low risk as a EuroSCORE II less than or equal to 1.5. The electronic medical records for the study group were thoroughly examined by each of the authors independently. Subsequently, a discussion within the group of authors led to consensus regarding the cause of death and if the death was preventable. First, the cause of death was classified as cardiac or non-cardiac. Second, deaths were classified into three categories: not preventable, preventable (technical error) or preventable (system error). This approach was similar to previous studies.^{4 5 7}

RESULTS

During the 10-year study period, a total of 9338 patients underwent cardiac surgery at Karolinska University Hospital, Stockholm, Sweden. Of those 3103 patients (33%) considered to be low risk according to EuroSCORE I or II. Among the low-risk patients, we identified 11 patients who died within 30 days of operation and constituted the study group. None of the patients in the study group had any documented rare comorbidities or other potential risk factors not captured by the EuroSCORE risk model. The overall mortality in the study group was of 0.35%. We classified 10/11 (91%) deaths as cardiac

deaths and 6/11 (55%) were considered to be preventable. The results are summarised in [table 1](#). Of the five deaths that were considered non-preventable there was one myocardial infarction on postoperative day (POD) 10, two cardiac arrests on the ward POD 3 and 16, respectively, where no technical problem was identified. One patient who underwent tricuspid valve replacement died from right ventricular failure on POD 14 and one patient died on POD 5 due to bowel ischaemia, septic shock and multiorgan failure. This patient was the only one who had a non-cardiac-related cause of death. Of the six deaths considered to be preventable, four was classified as technical errors and two as system errors. Among the four patients classified as preventable deaths due to technical errors, two died of myocardial infarction. In one patient, a postoperative coronary angiogram confirmed a non-functioning and occluded left internal thoracic artery to left anterior descending artery anastomosis and the patient died on POD 4. Another patient had a severe myocardial infarction due to inadequate myocardial protection. The mechanism was that the cardioplegia was given directly into the coronary ostia, and due to a very short left main stem, no cardioplegia reached the circumflex artery territory, and the patient died on POD 5. One patient died from iatrogenic aortic dissection. An aortic wall injury occurred during the removal of the aortic cannula. The injury was repaired, but on POD 3 the patient demonstrated signs and symptoms of bowel ischaemia and a CT scan confirmed a type A aortic dissection starting from the cannulation site and further down into the descending aorta and the patient died on POD 5 due to bowel ischaemia and multiorgan failure. The fourth patient classified as a preventable death had a hypoxic cardiac arrest on the same day as the operation. The patient was extubated since several hours but started

Table 1 Surgical procedure, cause of death and problems identified in low-risk cardiac surgery patients

Patient	Operation	Cause of death	Cardiac death	Preventable	Problem identified
1	CABG	Perioperative MI	Yes	Yes, technical	Occlusion of graft
2	AVR	Postoperative MI	Yes	No	
3	CABG	Arrest on the ward	Yes	Yes, system	Miscommunication; delay in re-exploration due to tamponade
4	TVR	RV failure	Yes	No	
5	MIA	Perioperative MI	Yes	Yes, technical	Inadequate myocardial protection
6	MIA	Hypoxic cardiac arrest; anoxic brain damage	Yes	Yes, technical	Failure to secure an adequate airway
7	AVR	Arrest on the ward	Yes	No	
8	CABG	Bowel ischaemia, septic shock	No	No	
9	CABG	Aortic dissection, bowel ischaemia	Yes	Yes, technical	Iatrogenic type A dissection
10	AVR	Arrest on the ward	Yes	No	
11	MIM	Hypoperfusion; anoxic brain damage	Yes	Yes, system	Miscommunication; delay in re-exploration due to bleeding

AVR, aortic valve replacement; CABG, coronary artery bypass grafting; MI, myocardial infarction; MIA, minimally invasive aortic valve replacement; MIM, minimally invasive mitral valve repair; RV, right ventricular; TVR, tricuspid valve replacement.

to desaturate and technical difficulties delayed re-establishment of a secure airway causing further hypoxia and cardiac arrest. Two deaths were classified as preventable and due to system errors. One patient presented on POD 12 with signs of tamponade and had a transcatheter pericardiocentesis with a small drain left in the pericardial cavity. For 5 consecutive days large amounts of pericardial fluids were aspirated and the patient required blood transfusions. The patient had a cardiac arrest on the ward on POD 16. Due to miscommunication and lack of clarity in the chain of responsibility, the necessary chest re-exploration was unduly delayed, and therefore this death was classified as preventable and due to system errors. The second death identified as a system error was a patient undergoing minimally invasive mitral valve repair. The patient was bleeding postoperatively and a decision was made to return to the operating room for wound re-exploration. However, due to miscommunication there was a delay in the transport to the operating room. The delay resulted in patient deterioration followed by cardiac arrest. Cardiopulmonary resuscitation including external chest compressions caused in a tear in the right ventricle. Eventually, the chest was opened and the tear could be repaired and there was a return of spontaneous circulation. However, due to long periods of severe hypotension and circulatory shock, the patient suffered from ischaemic brain damage and died on POD 3.

DISCUSSION

Failure to achieve a satisfactory cardiac outcome is expected to a certain extent even in low-risk cardiac surgery.¹⁰ One-third of the cases operated on at our clinic during the last 10 years were low-risk cardiac surgery performed with an early mortality of 0.35% which was similar to previous studies (table 2). The cause of death was cardiac in 10 of 11 patients. In comparison to the previous study from our institution,⁵ the current study found a higher proportion of potentially preventable deaths and the underlying causes were more heterogeneous. The two preventable deaths categorised as system errors were at least partly related to miscommunication between healthcare professionals. Regrettably, this finding was similar to our previous systematic review. The relationship between miscommunication and poor patient outcomes is plausible and well described in the literature.¹¹ It is equally plausible that communication, collaboration and shared decision-making are important

to achieve excellent patient outcomes.¹² Interprofessional communication could be improved by training using standardised tools, team training and simulations.^{13 14}

Unlike in our previous study, one of the patients was operated on by a junior surgeon and this patient had an iatrogenic aortic dissection. The junior surgeon had help to repair the aortic rift by a senior surgeon, and there was no indication of a more advanced aortic injury or dissection during the operation. Given that junior surgeons have proper training, appropriate supervision and support, patients are not at increased risk during cardiac operations performed by surgeons in training.¹⁵

In the original FIASCO study,⁴ the dominant cause of preventable death was poor myocardial protection. In the current study, one patient had a massive myocardial infarction due to inadequate cardioplegia. The cardioplegia was given directly into the coronary ostia and due to a very short left main stem, the cannula went into the left anterior descending artery and no cardioplegia reached the circumflex artery territory. This technical error could have been avoided by using another method for delivery of cardioplegia.

In the study from Turkey, the main preventable (technical) error was identified as perioperative myocardial infarction due to occlusion of the left internal mammary artery graft.⁶ In our study, we also found one patient with graft occlusion and perioperative myocardial infarction. Intraoperative graft flow assessment by transit-time flow measurement could be an effective strategy to mitigate this preventable complication.¹⁶

In one patient, death was categorised as preventable and due to technical error because of failure in securing a free airway. This case illustrates that not all technical errors are surgical or directly linked to the operation. Among the five non-preventable deaths, four were cardiac. The only non-cardiac death was bowel ischaemia which developed sepsis and multiorgan failure. Intestinal ischaemia after cardiac surgery is known to be a rare but severe complication with a high mortality.¹⁷

Overall, a 30-day mortality of 0.35% is an acceptable result in low-risk patients, and in line with previous reports. However, 55% of these cases were found to be potentially preventable suggesting that there is a clear potential for further improvement. In order to establish which areas within a unit that might be potentially modifiable, a structured and systematic review must be undertaken. We fully agree with the FIASCO II authors⁷

Table 2 Summary of studies systematically investigating death in low-risk patients undergoing cardiac surgery

First author (year)	Period of study	Patients, n	Deaths, n (%)	Preventable (%)
Freed (2009) ⁴	1996–2005	4294	16 (0.37)	7 (44)
Janiec (2010) ⁵	2001–2009	3924	15 (0.38)	2 (13)
Cakalagaoglu (2013) ⁶	2002–2007	2570	24 (0.93)	11 (46)
Farid (2013) ⁷	2006–2012	2549	7 (0.27)	3 (43)
Current study	2009–2019	3103	11 (0.35)	6 (55)

that the proposed methodology is useful to detect such modifiable factors within a unit. We found the methodology straightforward, easy to implement and inexpensive. According to prior work by Pasic *et al*, our repeated analysis is important because it requires a review of the literature that leads to increased knowledge on a team level. Furthermore, it stimulates comparisons between own and other institutions thus generating awareness of shortcomings and inspires actions for improvement.¹⁸

Limitations

The major limitation of this study was the lack of an objective definition of a preventable or non-preventable cause of death. In order to determine the cause of death and categorise a death as preventable or non-preventable we relied on consensus between the authors. The reviewers were not blinded to the identity of the operators and did examine their own results. One way to improve the study design could be to collaborate with another cardiac surgery unit and review each other's results. Another limitation of this study was the use of different versions of EuroSCORE. EuroSCORE I was used in 2009–2011 before it was replaced by EuroSCORE II in 2012. However, only two patients were included before 2012.

In conclusion, a repeated systematic review of deaths in patients with a low preoperative risk showed that a majority of deaths were preventable, and therefore potentially avoidable. These findings were to some extent different from our prior study conducted a decade ago. This provides a strong argument for a unit to regularly revisit the topic of death in low-risk cardiac surgery.

Contributors US and TI contributed to the conception and study design. KL performed data collection and drafted the first version of the manuscript. All authors contributed to data analysis and interpretation. TI and US critically revised the manuscript for important intellectual content. All authors approved the final version of the manuscript to be submitted. US is the guarantor of this work and, as such, had full access to all data in the study and takes responsibility for the integrity of data and accuracy of the analysis.

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Competing interests None declared.

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