Surgeons and systems working together to drive safety and quality

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Cardiac surgical outcomes are some of the most scrutinised results in medicine, both by the public as well as the surgeons themselves. This has resulted in an extraordinary push for quality, and the result has been improvement year over year.[1] We now recognise that complex operations have high potential for error, and that no single individual should be relied on to ensure safe care. Indeed, even for high-quality cardiac surgery programmes with excellent outcomes errors still occur, and only about 10% of patients will experience zero error or near misses after open heart surgery.[2] Creating the teams and care delivery systems to minimise errors and mitigate their impact drives quality improvement. One new area of investigation that has received attention relates to variation in operative and postoperative care delivery systems with a focus on off-peak (evenings, nights and weekends) performance.[3 4]

With this background, Zhang and colleagues evaluate the association between procedure order (first vs non-first case) for each surgeon and complications following coronary artery bypass grafting (CABG).[5] The authors hypothesise that prior workload (a prior surgical procedure in the same day) would lead to more errors and complications, particularly for higher hazard procedures such as off-pump CABG. They performed a retrospective analysis of 21 866 patients in China who underwent CABG (between 08:00 and 19:00), stratifying into off-pump and on-pump CABGs. They found that for on-pump CABG cases the order of the procedure (first vs later cases) did not impact the number of adverse events in a composite including in-hospital mortality, myocardial infarction (MI), stroke, acute kidney injury and reoperation (nor any of the individual components of the composite). For off-pump CABG operations, however, non-first cases were associated with higher risk of the adverse event composite (rate ratio 1.29) as well as on the individual components of postoperative MI and stroke, with ORs of 1.43 and 1.73, respectively. These risks were mitigated by surgeon experience of more than 20 years or on at least 700 CABG cases. The results were robust to multiple sensitivity analyses including inverse probability weighting, propensity matching, surgeon-assistant-specific pairings and for only procedures performed after 11:00. A few notable limitations include being from a single very high-volume centre in Asia, which limits generalisability, as few centres worldwide perform 4500 CABGs per year. Furthermore, critical care capabilities and coverage were not able to be evaluated. Finally, unmeasured confounding such as missing clinical and anatomic details limits some clinical interpretations.

SURGEON VERSUS SYSTEM ERRORS

The manuscript raises several provocative reasons to explain the findings of increased risk of complications after non-first cases with the higher hazard operation of off-pump but not on-pump CABG. The question that cannot be answered directly from the data provided is why. Is it the surgeon, the system or both that are driving these differences in complication risks, and how should we focus our quality improvement efforts to rectify this possible risk? The authors' discussion largely focuses on the surgeon and the impact of workload and cognitive and physical fatigue. Indeed, physician fatigue is a real concern with such notable mitigation strategies as the resident work hour restrictions demonstrated in earlier work.[6] Although supporting evidence is shown from endoscopy, urology and spine surgery, cardiac surgery generally has more complex team dynamics and critical care requirements than these disciplines

and high-quality evidence for cardiac surgery so far is limited. There is also evidence to suggest prior surgeon workload is not associated with increased patient risk, although these data focus on elective cases after performance of non-elective surgery the night before.[7 8] Other factors are also known to increase the risk of task errors in medicine, such as interruptions and multitasking.[9] Yet surgeon-specific tasks (anastomosis times, need to revise anastomoses, incomplete revascularisation) and factors influencing errors in these tasks will need to be analysed to clarify the real-world impact of surgeon task error on outcomes.

Besides the individual surgeon and their workload and fatigue, there are many other system factors that may determine patient outcomes. The extensive team-based nature of cardiac surgery starts in the operating room but extends to the postoperative phase as well, which should be considered when evaluating outcomes. In the study by Zhang and colleagues, the operating room team (anaesthesia, nursing and perfusion) did not change over the course of the day.[5] Similar evaluation of task error should be performed for the whole team, not only the surgeon. Alternative models include shift-based staffing, and comparison between these models could help clarify any potential workload or fatigue-based issues.

It has been shown previously that cardiac operations performed on the weekend and those that start after 15:00 have increased risk of morbidity and mortality.[4 10] The difficulty comes in trying to move past the 'night and weekend effect', and identifying underlying causes.[11] Much of the increased risk for weekend cardiac patients relates to baseline patient risk profiles.[10] But patients are not the whole story and underlying system differences are important. For instance, during these off-peak hours the on-call operating room staff may not be the standard team and thus not familiar with surgeon preferences, instruments, operative sequence or cadence. A recent study demonstrated that team familiarity for cardiac surgical cases improved operative efficiency and reduced cardiopulmonary bypass times.[12] This effect was most pronounced in the highest risk cases. Late cases also finish at off-peak hours leaving their most critical postoperative phase to an intensive care unit (ICU) with limited staffing and resources, and known variation in critical care outcomes by time of day.[3 13] The Swiss cheese model of medical errors would therefore suggest that for high hazard cases where surgeon workload may lead to errors, a strong supporting system can prevent or rectify errors and complications by closing off any other holes in care.

TECHNICAL COMPLEXITY VERSUS BIAS

What about the observed association between increased risk with non-first case off-pump procedures but not for on-pump CABG procedures being potentially related to procedural complexity? The higher rates of periprocedural MI could indeed be related to technical complications such as occluded grafts or incomplete revascularisation, but these data were not available. There is strong evidence that off-pump CABG is associated with incomplete revascularisation, and in the long term this drives higher rates of MI and repeat revascularisation.[14 15] Therefore, having data around technical complications could help clarify the association of risk of postoperative MI and procedural complexity. Similarly, evaluating conversions could have helped clarify relationships between complexity and outcomes. Although outside the scope of this editorial, conversions have been extensively studied in off-pump CABG and can shed important light on operative risk, technical complexity and surgeon decision-making.[16] The risk factors for conversions and incomplete revascularisation are similar and focus on patient anatomy, which is not available in this analysis.[5] In addition, we know that during off-pump cases aortic manipulation increases the risk of stroke, as does presence of cerebrovascular disease but both these important datapoints are missing.[17 18] Finally, there are different strategies surgeons employ in scheduling multiple cases that could lead to non-random biases. For example, many anecdotally prefer to schedule more difficult cases second to avoid early delays. Further studies evaluating this possible effect should therefore also consider surgeon preference, frailty, aortic manipulation, cerebrovascular disease, coronary anatomy and case complexity. We agree with the authors when they say further work is needed to identify the mechanisms leading to increased risk, but also further clarification of the risk would be beneficial. After clarification of the risks, then evaluating the possible mechanisms such as technical complications or perioperative care delivery systems that may be resulting in the underlying risk would allow for quality improvement.

IMPLICATIONS AND CONCLUSIONS

Given the limitations of the study and limited prior literature, how should we interpret the results? We know that higher surgeon volume is strongly associated with better outcomes, for cardiac surgery in general and off-pump CABG in particular.[19 20] How do we reconcile the potential need for surgeons to be both high volume and well rested? How do early career surgeons accumulate the necessary experience? Common definitions of 'high-volume' off-pump CABG surgeons are roughly >20 cases/year, and for hospitals more than 30/year.[20] The thresholds in this study of having operated on at least 700 cases and 20 years likely are derived from high-volume surgeons (35 cases/year for 20 years to reach the 700 case thresholds). But what about low-volume surgeons or relatively higher volume surgeons at lower volume institutions? The volume and experience relationship requires careful consideration as there can be large

ramifications that limit access or stifle innovation should policies be enacted to address perceived quality gaps at low-volume centres.

Cardiac surgeons often perform the most complex operations, such as heart transplants and aortic dissection repairs, at night and between elective cases. These emergent cases do not have the luxury of being first-start cases with the same operative team and fully staffed and resourced ICU. Patient safety and quality outcomes are of paramount importance, but it is not yet clear how we can optimise surgical scheduling if we do not yet understand the mechanisms through which a non-first procedure might increase risk. To further complicate the situation, the nursing and general healthcare shortage in the USA and other countries exacerbated by the COVID-19 pandemic adds considerable logistical challenges, often leaving the operative schedule out of the control of the surgeon.

Further clarification is also needed on how to accurately measure workload. Many cardiac surgeons choose the specialty because of the surgical complexity, and their perceptions of acceptable workload levels may differ from other providers and among themselves as well. Rather than focusing on proxy variables such as a non-first procedure, late start or performed on the weekend, we should focus on the system and individual variables that might explain these associations such as staffing, team familiarity, technical complexity, surgeon, nurse and perfusionist workload, and cognitive and physical fatigue.

System inefficiencies and failures drive medical errors and result in complications, for to err is human.[21] While we continue to investigate the impact of workload on surgeon outcomes, it is clear that the systems surrounding the surgeon should be continuously improved. Creating high reliability systems within each phase of care and at off-peak hours is a unique need for often the highest risk cardiac surgery patients. Only by taking a system-based approach to quality will we be able to mitigate the potential risks of non-first cardiac surgical procedures.

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REFERENCES

1 Cornwell LD, Omer S, Rosengart T, *et al*. Changes over time in risk profiles of patients who undergo coronary artery bypass graft surgery: the Veterans Affairs surgical quality improvement program (VASQIP). *JAMA Surg* 2015;150:308–15.
2 Bacha E. Are errors ubiquitous in cardiac surgery? *J Thorac Cardiovasc Surg* 2015;149:411.
3 Krebs ED, Hawkins RB, Mehaffey JH, *et al*. Is routine extubation overnight safe in cardiac surgery patients? *J Thorac Cardiovasc Surg* 2019;157:e1532:1533–42.
4 Yount KW, Lau CL, Yarboro LT, *et al*. Late operating room start times impact mortality and cost for Nonemergent cardiac surgery. *Ann Thorac Surg* 2015;100:1653–9.
5 Zhang D, Gu D, Rao C, *et al*. Outcome differences between surgeons performing first and subsequent coronary artery bypass grafting procedures in a day: a retrospective comparative cohort study. *BMJ Qual Saf* 2023;32:192–201.
6 West CP, Tan AD, Habermann TM, *et al*. Association of resident fatigue and distress with perceived medical errors. *JAMA* 2009;302:1294–300.
7 Govindarajan A, Urbach DR, Kumar M, *et al*. Outcomes of daytime procedures performed by attending surgeons after night work. *N Engl J Med* 2015;373:845–53.
8 Sun EC, Mello MM, Vaughn MT, *et al*. Assessment of perioperative outcomes among surgeons who operated the night before. *JAMA Intern Med* 2022;182:720–8.
9 Westbrook JI, Raban MZ, Walter SR, *et al*. Task errors by emergency physicians are associated with interruptions, multitasking, fatigue and working memory capacity: a prospective, direct observation study. *BMJ Qual Saf* 2018;27:655–63.
10 Beller JP, Chancellor WZ, Mehaffey JH, *et al*. Outcomes of non-elective coronary artery bypass grafting performed on weekends. *Eur J Cardiothorac Surg* 2020;57:1130–6.
11 Marang-van de Mheen PJ, Vincent C. Moving beyond the weekend effect: how can we best target interventions to improve patient care? *BMJ Qual Saf* 2021;30:525–8.
12 Mathis MR, Yule S, Wu X, *et al*. The impact of team familiarity on intra and postoperative cardiac surgical outcomes. *Surgery* 2021;170:1031–8.
13 Zajic P, Bauer P, Rhodes A, *et al*. Time of day and its association with risk of death and chance of discharge in critically ill patients: a retrospective study. *Sci Rep* 2019;9:12533.
14 Hattler B, Messenger JC, Shroyer AL, *et al*. Off-Pump coronary artery bypass surgery is associated with worse arterial and saphenous vein graft patency and less effective revascularization: results from the Veterans Affairs randomized on/off bypass (ROOBY) trial. *Circulation* 2012;125:2827–35.
15 Hattler B, Grover FL, Wagner T, *et al*. Incidence and prognostic impact of incomplete revascularization documented by coronary angiography 1 year after coronary artery bypass grafting. *Am J Cardiol* 2020;131:7–11.
16 Novitzky D, Baltz JH, Hattler B, *et al*. Outcomes after conversion in the Veterans Affairs randomized on versus off bypass trial. *Ann Thorac Surg* 2011;92:2147–54.
17 Emmert MY, Seifert B, Wilhelm M, *et al*. Aortic no-touch technique makes the difference in off-pump coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 2011;142:1499–506.
18 Stamou SC, Hill PC, Dangas G, *et al*. Stroke after coronary artery bypass: incidence, predictors, and clinical outcome. *Stroke* 2001;32:1508–13.

19 Lapar DJ, Mery CM, Kozower BD, *et al*. The effect of surgeon volume on mortality for off-pump coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 2012;143:854–63.
20 Benedetto U, Lau C, Caputo M, *et al*. Comparison of outcomes for off-pump versus on-pump coronary artery bypass grafting in low-volume and high-volume centers and by low-volume and high-volume surgeons. *Am J Cardiol* 2018;121:552–7.
21 Kohn LT, Corrigan J, Donaldson MS. *To err is human : building a safer health system*. Washington, DC: National Academy Press, 2000.