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Research Article

Intraoperative Anesthesia Handoff Does Not Affect Patient Outcomes after Cardiac Surgery: A Single-Center Experience

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Background. Intraoperative team turnover is necessary given the duration of many cardiac surgical procedures, despite being an established risk factor for harm. We sought to determine if there was an association between intraoperative anesthesia handoff (AH) and patient morbidity and/or mortality after cardiac surgery. *Methods*. All adult cardiac surgery procedures from November 2016 through November 2021 were retrospectively interrogated for AH. These results were merged with postoperative patient outcomes data and analyzed for morbidity and mortality. *Results*. A single AH occurred in 1,087/5,937 (18.3%) procedures, and two or more AHs occurred in 224 (3.8%) procedures. Baseline characteristics show that AH is more frequently associated with higher complexity patients and operations. The primary outcome of operative mortality occurred in 113 (2.4%), 54 (5.0%), and 7 (3.1%) patients in the no AH, single AH, and multiple AH cohorts. After multivariable adjustment, the odds ratio for mortality was 1.15 (95% CI 0.79–1.67 and $P = 0.46$) for a single AH and 0.83 (95% CI 0.36–1.90 and $P = 0.66$) for multiple AH. There were no significant differences in readmission, length of stay, or a composite complication outcome between the cohorts after adjustment. *Conclusions*. In a large single-center experience, intraoperative anesthesia handoffs were not associated with adverse outcomes after cardiac surgery.

1. Introduction

The delivery of cardiac surgical care to patients is a highly complex process that requires a continuous exchange of information between a multitude of care providers. The procedures can be long and may therefore be associated with significant turnover among the various team members, resulting in an increased potential for error. Intraoperative team turnover is an established risk factor for patient care and applies to many different providers including attending physicians, trainees, nurses, and anesthesia providers [1]. While the outcomes of cardiac surgery are ultimately the result of many decisions and actions from multiple providers and health care personnel, the individual components of the entire cardiac surgery process should be continually assessed for areas of improvement.

Two large, multicenter studies have reported a significant association between intraoperative anesthesiologist handoff and mortality in patients undergoing cardiac surgery [2, 3]. However, the conclusions drawn from these multicenter studies may not apply to individual centers that have focused on improving the quality of transitions of care including the intraoperative anesthesiologist handoff process. This was a specific point of emphasis from our colleagues at the Anesthesia Patient Safety Foundation that sought to decrease the risk of miscommunications during intraoperative handoffs using evidence-based cognitive aids and checklists [4]. At our institution, we acted upon this call to action by implementing an electronic intraoperative handoff checklist several years ago with the goal of decreasing unintended patient harm attributable to intraoperative handoffs. Furthermore, a recent randomized trial comparing an anesthesia handoff to no handoff found no significant difference in mortality, readmission, or serious postoperative complications within 30 days [5]. In this study, we sought to assess whether the presence and number of intraoperative anesthesiologist handoffs during cardiac surgery cases were associated with operative mortality, readmission, length of stay, or a composite of complications in our institutional cohort.

2. Materials and Methods

This study was approved by the Mass General Brigham Institutional Review Board (Protocol #2004P001528, approved 4/27/2021).

2.1. Study Design and Population. This was a single-center, retrospective cohort study of patients over the age of 18 years who underwent any type of cardiac surgery from November 2016 through November 2021. The cohort was established by merging anesthesia records with our institutional cohort within the Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database which collects extensive preoperative, intraoperative, and short-term postoperative data on all patients undergoing cardiac surgery. Patients who underwent a reoperation during an index admission were not double counted.

2.2. Exposure and Outcomes. The exposure of interest was the number of intraoperative attending anesthesiologist handoffs (AH) which were categorized as no handoff, one handoff, or two or more handoffs. A handoff was defined as a complete nontransient transition of anesthesia care between attending anesthesiologists. The primary outcome was operative mortality (death during index admission or within 30 days of discharge). Secondary outcomes included readmission within 30 days of index hospitalization, prolonged hospital length of stay defined as greater than 14 days, surgical site infection, renal failure, and a composite of major complications occurring during the index hospitalization. The composite of major complications included one or more of the following: cardiac arrest, deep sternal wound infection, deep vein thrombosis, gastrointestinal complications, paralysis, pneumonia, prolonged mechanical ventilation, postoperative reintubation, pulmonary embolism, renal failure, reoperation for bleeding, reoperation for other reasons, sepsis, stroke, and surgical site infection. All outcomes were specified a priori.

2.3. Statistical Analysis. Continuous data are presented as mean ± standard deviation if normal or as median and interquartile range if nonnormal. Categorical data are presented as number and percentage. Baseline characteristics were compared using the Kruskal–Wallis test or Fisher's exact test as appropriate. Crude associations for the exposure and outcomes of interest were first assessed using univariable logistic regression. To adjust for potential differences between the exposure groups, the baseline and operative covariates were used to fit a multivariable logistic regression model to generate an adjusted odds ratio with 95% confidence intervals and a P value. Covariates were chosen based on clinical relevance. Model overfitting was avoided by using the "rule of 10." Interactions were not included in the models. A sensitivity analysis using the propensity score method of inverse probability of treatment weighting (IPTW) was performed to analyze the primary outcome, operative mortality, when no handoff occurred versus when one or more handoffs occurred. A propensity score for one or more handoffs occurring was generated by first fitting a logistic regression model with the handoff status as the outcome and including baseline characteristics covariates as predictors; a postestimation command was then used to generate the propensity score. The pseudo-R^2 value for the logistic regression model to predict treatment assignment was 0.22. Propensity scores were then used to generate the inverse probability of treatment weight which was used to check the balance of the covariates after weighting. A logistic regression model using the inverse probability of treatment weight was then fit for the primary outcome. Missing data was less than 0.1% for all variables. Observations with missing data ($n = 3$) were excluded from the regression analyses. All hypotheses tested were two-sided, and a P value of less than 0.05 was considered statistically significant. All analyses were performed using Stata 17 (College Station, TX: StataCorp LLC).

3. Results

In the total cohort of 5,937 procedures, a single AH occurred in 1,087 (18.3%), and two or more AH occurred in 224 (3.8%). Baseline and operative characteristics are provided in Table 1. The distribution of operation type, urgency status, procedure time, preoperative LVEF, preoperative cardiogenic shock, prior myocardial infarction, number of diseased vessels in patients undergoing coronary artery bypass grafting (CABG), heart failure, diabetes, dialysis, prior CABG, and prior valve surgery varied between the number of handoff cohorts (all $P < 0.05$). Notably, the baseline and operative characteristics for the multiple AH group do not conclusively suggest a more complex and sicker cohort than the single AH group, which had a higher proportion of low left ventricular ejection fraction (LVEF), cardiogenic shock, previous myocardial infarction (MI), heart failure, diabetes, and dialysis. However, both groups had a higher proportion of patients with low LVEF, cardiogenic shock, previous MI, more diseased coronary arteries, cerebrovascular disease, peripheral vascular disease, heart failure, liver disease, dialysis, and urgent/emergent status than patients without a handoff. Additionally, while only 11 minutes separate the median procedure times of the single AH (297.1 minutes) and multiple AH (308.0 minutes) cohorts, the median procedure time for the no AH cohort was 39 minutes shorter than the single AH cohort (257.8 minutes). For patients who underwent a procedure for which an STS Predicted Risk of Mortality is calculated, the predicted risk of mortality in the no handoff ($n = 3{,}012$), single handoff ($n = 627$), and two or more handoffs ($n = 133$) was 1.1%, 1.2%, and 1.3%, respectively ($P < 0.01$).

Table 1: Baseline and operative characteristics.

	No handoff ($n = 4{,}626$)	Single handoff ($n = 1{,}087$)	Multiple handoffs ($n = 224$)	P values
Age (years)[a]	66 (57–73)	66 (56–73)	67 (54–74)	0.76
Males	3,251 (70.3%)	780 (71.8%)	168 (75.0%)	0.22
LVEF				<0.01
<20%	106 (2.3%)	53 (4.9%)	5 (2.2%)	
20–40	351 (7.6%)	118 (10.9%)	21 (9.4%)	
>40%	4,169 (90.1%)	916 (84.3%)	198 (88.4%)	
Cardiogenic shock	125 (2.7%)	62 (5.7%)	10 (4.5%)	<0.01
Previous MI	1,216 (26.3%)	348 (32.0%)	67 (29.9%)	<0.01
Number of diseased vessels				<0.01
1	1,784 (42.6%)	310 (33.4%)	66 (34.0%)	
2	418 (10.0%)	88 (9.5%)	16 (8.2%)	
3	471 (11.3%)	124 (13.3%)	17 (8.8%)	
4	1,512 (36.1%)	407 (43.8%)	95 (49.0%)	
Cerebrovascular disease	876 (18.9%)	227 (20.9%)	55 (24.6%)	0.05
Peripheral vascular disease	562 (12.1%)	145 (13.3%)	38 (17.0%)	0.07
Heart failure	1,427 (30.8%)	415 (38.2%)	86 (38.4%)	<0.01
Chronic lung disease				0.55
None	3,944 (85.3%)	915 (84.2%)	188 (83.9%)	
Mild (FEV1 60–75% predicted)	494 (10.7%)	122 (11.2%)	26 (11.6%)	
Moderate (FEV1 50–59% predicted)	123 (2.7%)	30 (2.8%)	9 (4.0%)	
Severe (FEV1 <50% or room air PCO2 >50 mmHg)	63 (1.4%)	20 (1.8%)	1 (0.5%)	
Diabetes	1,298 (28.1%)	349 (32.1%)	60 (26.8%)	0.02
Liver disease	252 (5.4%)	70 (6.4%)	18(8.0%)	0.14
Dialysis	0	0	0	
Prior CABG	112 (2.4%)	58 (5.3%)	7 (3.1%)	0.01
Prior valve	463 (10.0%)	141 (13.0%)	26 (11.6%)	0.15
Procedure time (minutes)[a]	257.8 (205.3–318.9)	297.1 (231.6–373.6)	308.0 (245.8–389.0)	<0.01
Operation				<0.01
Isolated CABG	1,482 (32.0%)	346 (31.8%)	76 (33.9%)	
Isolated AVR	536 (11.6%)	61 (5.6%)	12 (5.4%)	
Isolated MVR	132 (2.9%)	29 (2.7%)	9 (4.0%)	
AVR/CABG	266 (5.8%)	75 (6.9%)	13 (5.8%)	
MVR/CABG	44 (1.0%)	19 (1.7%)	1 (0.4%)	
AVR/MVR	71 (1.5%)	25 (2.3%)	4 (1.8%)	
MV repair	474 (10.2%)	74 (6.8%)	16 (7.1%)	
MV Repair/CABG	80 (1.7%)	23 (2.1%)	6 (2.7%)	
Other	1,541 (33.3%)	435 (40.0%)	87 (38.8%)	
Status				<0.01
Elective	2,785 (60.2%)	467 (43.0%)	103 (46.0%)	
Urgent	1,673 (36.2%)	536 (49.3%)	100 (44.6%)	
Emergent	156 (3.4%)	78 (7.2%)	21 (9.4%)	
Emergent salvage	10 (0.2%)	6 (0.6%)	0 (0.0%)	

AVR, aortic valve replacement; CABG, coronary artery bypass grafting; FEV1, forced expiratory volume in 1 second; LVEF, left ventricular ejection fraction; MI, myocardial infarction; MV, mitral valve; MVR, mitral valve replacement. [a]Presented as median (interquartile range).

3.1. Primary Outcome. There were 113 (2.4%), 54 (5.0%), and 7 (3.1%) deaths in the no handoff, single handoff, and multiple handoff cohorts, respectively ($P < 0.01$). The results for a single handoff versus no handoff are included in Table 2, and the results for multiple handoffs versus no handoff are included in Table 3. The unadjusted odds ratio for operative mortality for single handoff versus no handoff was 2.09 (95% CI 1.50–2.91 and $P < 0.01$); however, after multivariable adjustment, the odds ratio was 1.15 (95% CI 0.79–1.67 and $P = 0.46$). The unadjusted odds ratio for multiple handoffs compared to no handoff was 1.29 (95% CI 0.59–2.80 and $P = 0.52$), and the adjusted odds ratio was 0.83 (95% CI 0.36–1.90 and $P = 0.66$).

3.2. Secondary Outcomes. Tables 2 and 3 show the unadjusted and adjusted odds ratios, 95% confidence intervals, and P values for the single and multiple handoff comparisons, respectively.

3.2.1. Readmission. There were 562 (12.2%), 158 (14.5%), and 35 (15.6%) readmissions in the no handoff, single handoff, and multiple handoff cohorts, respectively. The unadjusted odds ratio for a single handoff was 1.23 (95% CI 1.01–1.49 and $P = 0.03$); the adjusted odds ratio was 1.05 (95% CI 0.84–1.30 and $P = 0.68$). There was also no difference for multiple handoffs vs no handoff with an unadjusted odds ratio of 1.34 (95% CI 0.92–1.94 and $P = 0.12$); the adjusted odds ratio was 0.86 (95% CI 0.54–1.36 and $P = 0.52$).

3.2.2. Prolonged Hospital Length of Stay. Prolonged hospital length of stay occurred in 562 (12.2%), 217 (20.0%), and 48 (21.4%) patients in the no handoff, single handoff, and multiple handoff cohorts, respectively. The unadjusted estimate for prolonged hospital length of stay was increased for single handoff versus no handoff with an odds ratio of 1.80 (95% CI 1.52–2.14 and $P < 0.01$); however, the difference was no longer observed after adjustment with an adjusted odds ratio of 1.07 (95% CI 0.84–1.36 and $P = 0.57$). The unadjusted odds ratio for multiple handoffs versus no handoff was 1.97 (95% CI 0.1.42–2.75 and $P < 0.01$); the adjusted odds ratio was 1.12 (95% CI 0.70–1.78 and $P = 0.64$).

3.2.3. Complications. The composite of complications occurred in 845 (18.3%), 271 (24.9%), and 64 (28.6%) patients in the no handoffs, single handoff, and multiple handoffs cohorts, respectively. There was an unadjusted difference in the composite of complications for single handoff versus no handoff with an unadjusted odds ratio of 1.49 (95% CI 1.27–1.74 and $P < 0.01$); however, the difference did not persist after adjustment with an adjusted odds ratio of 0.95 (95% CI 0.77–1.16 and $P = 0.58$). The unadjusted odds ratio for multiple handoffs was 1.79 (95% CI 1.33–2.41 and $P < 0.01$); the adjusted odds ratio was 1.20 (95% CI 0.82–1.76 and $P = 0.34$). After multivariable adjustment, there was also no difference in surgical site infections or renal failure for single or multiple handoffs versus no handoff (Tables 2 and 3, $P > 0.05$ for both).

3.3. Sensitivity Analysis. To make our study findings comparable to prior studies that have evaluated handoff as a binary event, we performed a sensitivity analysis comparing any handoff with no handoff. The one AH and multiple AH cohorts were combined, resulting in 1,311 patients in the handoff cohort and 4,626 patients in the no handoff cohort. P values for the baseline and operative characteristics before and after inverse probability of treatment weighting (IPTW) are included in Table 4. Using IPTW, the odds ratio for the operative mortality occurring in the handoff cohort versus no handoff cohort was 1.11 (95% CI 0.75–1.64 and $P = 0.59$). Case start time was the only significant predictor of the need for anesthesia handoff as afternoon (1200–1559), evening (1600–1959), and overnight (2000–0559) start cases had 2.3 (95% CI 2.1–2.45), 2.7 (95% CI 2.5–3.0), and 2.4 (95% CI 2.0–2.8) increased odds of anesthesia handoff, respectively, compared to morning start cases (0600–1159).

4. Comment

The Joint Commission defines a handoff as a contemporaneous, interactive process of passing patient-specific information from one caregiver to another to ensure the continuity and safety of patient care. Standardized handoff communications have been a Joint Commission patient safety goal since 2006 [6]. A recent scientific statement from the American Heart Association regarding patient safety in the cardiac operating room recommends standardization and the use of protocols for handoffs [7]. The intraoperative handoff of information between anesthesiologists is an important part of the operation during which information related to the case progression, patient physiology and laboratory markers of end-organ function or ischemia, medication administration, anticipated needs, and more is exchanged.

Two recent studies have shown that anesthesia handoff is a predictor for worse patient outcomes after cardiac surgery [2, 3]. Sun and colleagues retrospectively analyzed 102,156 Canadian patients undergoing cardiac surgery from 2008 to 2019. Remarkably, anesthesia handoff only occurred in 1.9% of their cases but was associated with significantly higher risks of 30-day mortality (hazard ratio (HR), 1.89; 95% CI, 1.41–2.54) and 1-year mortality (HR, 1.66; 95% CI, 1.31–2.12), as well as longer ICU (risk ratio (RR), 1.43; 95% CI, 1.22–1.68) and hospital (RR, 1.17; 95% CI, 1.06–1.28) LOS [2]. Hannan et al. queried the New York State registry from 2010 to 2016 and in 103,102 cases found that 8.5% of the procedures involved anesthesia handoffs. After multivariable adjustment, the group with a handoff had higher short-term mortality (2.86% vs. 2.48%, adjusted risk ratio (ARR) = 1.15 [1.01–1.31]) [3]. Moreover, in a review of surgical malpractice claims, up to 43% of communication breakdowns associated with patient injury occurred in connection to handoffs [8].

Given that two large multi-institutional studies have demonstrated an association between AH and deleterious patient outcomes, we aimed to examine this association at our institution and found that there was no difference in

Table 2: Outcomes for single handoff versus no handoff.

	Unadjusted OR (95% CI)	*P* values	Adjusted OR (95% CI)	*P* values
Operative Mortality*	2.09 (1.50–2.91)	<0.01	1.15 (0.79–1.67)	0.46
Readmission+	1.23 (1.01–1.49)	0.03	1.05 (0.84–1.30)	0.68
Prolonged hospital length of stay+	1.80 (1.52–2.14)	<0.01	1.07 (0.84–1.36)	0.57
Complication+	1.49 (1.27–1.74)	<0.01	0.95 (0.77–1.16)	0.58
Surgical site infection+	1.32 (0.71–2.47)	0.38	1.27 (0.66–2.45)	0.47
Renal failure+	1.70 (1.26/2.29)	<0.01	0.96 (0.65–1.41)	0.83

CI, confidence interval; OR, odds ratio; LVEF, left ventricular ejection fraction. *Adjusted for age, gender operation, status, procedure time, cardiogenic shock, heart failure, diabetes, and dialysis. +adjusted for age, gender, operation, status, and procedure time; LVEF, cardiogenic shock, previous myocardial infarction, number of diseased vessels, cerebrovascular disease, peripheral vascular disease, heart failure, diabetes, liver disease, dialysis, prior coronary artery bypass, and prior valve surgery.

Table 3: Outcomes for multiple handoffs versus no handoff.

	Unadjusted OR (95% CI)	*P* values	Adjusted OR (95% CI)	*P* values
Operative Mortality*	1.29 (0.59–2.80)	0.52	0.83 (0.36–1.89)	0.66
Readmission+	1.34 (0.92–1.94)	0.12	0.86 (0.54–1.36)	0.52
Prolonged hospital length of stay+	1.97 (1.42–2.75)	<0.01	1.12 (0.70–1.78)	0.64
Complication+	1.79 (1.33–2.41)	<0.01	1.20 (0.82–1.76)	0.34
Surgical site infection+	1.48 (0.51–4.81)	0.51	1.47 (0.44–4.91)	0.53
Renal failure+	1.68 (0.94–3.00)	0.08	0.96 (0.45–2.05)	0.92

CI, confidence interval; OR, odds ratio; LVEF, left ventricular ejection fraction. *Adjusted for age, gender operation, status, procedure time, cardiogenic shock, heart failure, diabetes, and dialysis. +Adjusted for age, gender, operation, status, and procedure time; LVEF, cardiogenic shock, previous myocardial infarction, number of diseased vessels, cerebrovascular disease, peripheral vascular disease, heart failure, diabetes, liver disease, dialysis, prior coronary artery bypass, and prior valve surgery.

Table 4: Baseline characteristics before and after IPTW.

	Any handoff versus no handoff	
	Unweighted *P* values	Weighted *P* values
Age	0.394	0.801
Gender	0.153	0.573
Cardiogenic shock	<0.0001	0.943
Previous MI	<0.0001	0.996
Number of diseased vessels	<0.0001	0.759
Cerebrovascular disease	0.038	0.432
Peripheral vascular disease	0.081	0.719
History of heart failure	0.006	0.990
Diabetes	0.027	0.756
Liver disease	0.081	0.963
Dialysis	0.007	0.634
Prior CABG	<0.0001	0.941
Prior valve	<0.0001	0.957
Procedure time	<0.0001	0.086
Status		
Urgent	<0.0001	0.773
Emergent	<0.0001	0.618
Emergent salvage	0.038	1.000
Procedure		
Isolated CABG	0.020	0.646
Isolated AVR	<0.0001	0.842
Isolated MVR	0.394	0.841
AVR/CABG	0.859	0.915
MVR/CABG	0.284	0.479
AVR/MVR	0.408	0.692
MV repair	<0.0001	0.782
MV Repair/CABG	0.761	0.978

AVR, aortic valve replacement; CABG, coronary artery bypass grafting; IPTW, inverse probability of treatment weighting; LVEF, left ventricular ejection fraction; MI, myocardial infarction; MV, mitral valve; MVR, mitral valve replacement.

operative mortality, readmission, prolonged hospital length of stay, surgical site infection, renal failure, or a composite of major complications between patients who had one or more intraoperative anesthesia handoffs and those who did not have an intraoperative anesthesia handoff occur. In addition, we sought to assess for a stepwise increased risk which might be expected with the occurrence of two or more AH compared to only one AH, which has not been previously studied, and our results do not support such an increased risk.

There are several potential explanations for our discordant findings. First, our study period includes a more contemporary cohort, which may have benefitted from the recent increased focus on nontechnical skills in the operating room to improve patient safety. Next is the presence of an electronic health record (EHR). Our study includes patients from 2016 to 2021 which coincides with the use of EPIC (Epic Systems Corporation, Madison, WI) for intraoperative anesthesia charting. It is not clear from the prior studies whether there was use of EHRs in some or all of the participants. EHRs have been shown to increase patient safety and reduce errors related to handoffs [9–12]. Moreover, we know that the incorporation of checklists into patient care results in decreased mortality and morbidity [13]. In late 2015, researchers from our institution published a paper on the use of an electronic checklist for intraoperative handoff of anesthesia care [14]. One of the key components was the integration of this checklist into our EHR for a real-time assessment of the patient for a more accurate handoff of care; a concept that has been shown to be effective for improving intraoperative patient handoffs [15–17]. This work has been implemented at our institution in the cardiac surgical operating rooms since 2015 and throughout the study period (2016–2021). The handoff tool contains pertinent patient information to ensure a more streamlined transition of care; this tool is known as P.A.S.S. (Patient Summary, Action List, Situational Awareness, and Synthesis) and contains consistent information regardless of the cardiac surgical case. Information provided in P.A.S.S. includes: patient summary (Problem list, allergies, previous anesthetic concerns, indwelling lines and airway devices, intraoperative intake/output, and recent pertinent laboratory values), Action List ongoing ‘to-do” items such as (recheck glucose in 30 minutes, follow up on hemoglobin level, begin transfusing cell-saver blood products), Situational Awareness (phrases such as “If the patient becomes hypotensive, they responded well to 4 mcgs of norepinephrine), and lastly, Synthesis by receiver (The clinician taking over care will confirm their understanding of all the information “In summary. . ..”). These intraoperative handoffs occur in the operating room at the patient’s bedside and the attending cardiac surgeon at the time is notified of this handoff. Other communication strategies including S.B.A.R. (Situation, Background, Assessment, and Recommendation), have also been shown to be effective communication methods for handoff [18].

Over the study period, there was institutional turnover in the cardiac anesthesia attending staff, but the approach to intraoperative handoffs remained intact. There are other institution-specific factors that may explain why results from our study did not show an increased morbidity or mortality in patients with AH. As most intraoperative handoffs occur in the late afternoon and evening hours, it is important to note that during the study period, the anesthesia call system required the evening team to be in-house from the beginning of the day. Thus, those anesthesia attending may already be peripherally familiar with the case or were aware of the unique challenges that may have occurred during the case (difficult intubation, severe hemodynamic compromise, and so on). The daily operating room anesthesia team leader, who is briefed on all the cardiac cases scheduled for the day, is also the individual assigning the anesthesiologists to take over care; this may have led to a more nuanced approach for the assignment of handoffs. Furthermore, during the study period, over 50% of the staff cardiac anesthesiologists working in the operating room were also staffing the cardiac surgical intensive care unit (ICU); this is the primary location for all cardiac surgical patients. Therefore, it is possible that the same attending anesthesiologists were caring for a patient in the ICU the day before the patient was in the operating room.

Another potential explanation for our findings is the presence of anesthesia trainees in our cardiac surgical cases. Whereas the anesthesia trainee status was unknown in the aforementioned recent studies which showed a difference in mortality, nearly every cardiac case at our institution has a trainee (resident or fellow) involved in their care, and staff/trainee handoffs are typically staggered to ensure continuity which may reduce the potential for error, although we do not have data to support this.

Our study has several limitations. First, this is a single institution retrospective study and is thus subject to all the known bias. However, even though the prior studies included very large cohorts, conclusions about the risk of anesthesia handoffs are difficult to make at the multicenter level because there is likely substantial heterogeneity in the handoff process among institutions, which motivated us to assess our results. In addition, few single centers are likely to have contemporary, comparable-sized cohorts as the prior studies, which limits highly powered studies. Despite this, our study demonstrates discrepant findings than other studies in the literature. Considering the department of anesthesia at our institution has employed significant resources into an educational curriculum and infrastructure to optimize the exchange of information at patient care transitions, it is plausible that we are an outlier. There were higher proportions of patients who underwent a procedure in the “other” category which includes all other procedures and combinations other than the 8 procedures which have STS risk models. While this heterogeneous group includes aortic procedures which can introduce considerable variation in procedural duration and risk, there were no differences in outcomes between the groups which suggest the anesthesia handoff process is also effective for these complicated cases.

Finally, while our study involves a large population of patients, the majority (78.5%) of cardiac surgical cases had no turnover. Thus, the groups with AH may be underpowered to detect differences in rare events after cardiac surgery. This was our motivation in creating a composite outcome of *relatively* common events after cardiac surgery in hopes to elicit a difference. It is important to note that the previous two studies published in the literature by Sun (98.1%) and Hannan (91.5%) also had a majority of cases involving no handoff [2, 3]. It is also interesting to note that if the assumption is that an error is likely to occur during a handoff, then multiple (2+) handoffs would portend a worse prognosis than one or no handoffs; however, this was not demonstrated in our results.

The complexity of cardiac surgery requires that numerous personnel with different skillsets interact and communicate during the course of a procedure, and the anesthesia handoff process is only one of these important interactions. Future research should be directed at characterizing and quantifying best practices for anesthesia handoff and other interactions and conducting a randomized trial when feasible.

5. Conclusion

In a large single-center experience of a tertiary academic medical center, intraoperative anesthesia handoffs were not associated with deleterious outcomes after cardiac surgery.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request and on IRB approval.

Ethical Approval

This study was approved by the Mass General Brigham Institutional Review Board Protocol #2004P001528, approved 4/27/2021.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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