Gastrointestinal Complications after Cardiac Surgery: Incidence, Predictors, and Impact on Outcomes

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Abstract

Background: The purpose of this study was to investigate the incidence, predictors, and long-term impact of gastrointestinal (GI) complications following adult cardiac surgery. Methods: Index Society of Thoracic Surgeons (STS) adult cardiac operations performed between January 2010 and February 2018 at a single institution were included. Patients were stratified by the occurrence of postoperative GI complications. Outcomes included early and late survival as well as other associated major postoperative complications. A sub-analysis of propensity score matched patients was also performed. Results: 10,285 patients were included, and the overall rate of GI complications was 2.4% (n=246). Predictors of GI complications included dialysis dependency, intra-aortic balloon pump, congestive heart failure, chronic obstructive pulmonary disease, and longer aortic cross-clamp times. Thirty-day (2.6% vs 24.8%), one- (6.3% vs 41.9%), and three-year (11.1% vs 48.4%) mortality were substantially higher in patients who experienced GI complications (all P<0.001). GI complication was associated with a three-fold increased hazard for mortality (HR 3.1, 95% CI 2.6-3.7) after risk adjustment, and there was an association between the occurrence of GI complications and increased rates of renal failure (39.4% vs 2.5%), new dialysis dependency (31.3% vs 1.5%), multisystem organ failure (21.5% vs 1.0%), and deep sternal wound infections (2.6% vs 0.2%)(all P<0.001). These results persisted in propensity-matched analysis. Conclusions: GI complications are infrequent but have a profound impact on early and late survival, and often occur in association with other major complications. Risk factor modification, heightened awareness, and early detection and management of GI complications appears warranted.

Introduction

Gastrointestinal (GI) complications are an uncommon, but potentially highly morbid events following cardiac surgery procedures[1]. The reported incidence of these events are between 0.5%-4.5% of cardiac cases, but the in-hospital mortality associated with GI complications is around 30%-40%, with some series reporting higher rates of mortality[2–8]. Previous series have identified several risk factors such as increasing age and comorbidity, as well as and prolonged operation times as risk factors for development of GI complications[3,4,7]. While the postoperative increase in mortality has been well described, the long-term ramifications of the GI complications after cardiac surgery are less clear as are the impacts of the individual type of GI complication on outcomes. In this study, we aim to identify the incidence, risk-factors, and long-term outcomes of GI complications following adult cardiac surgery procedures at our institution.

Materials and Methods

Study Population

This was a retrospective single institutional analysis that included adults (18 years or older) that underwent STS-indexed cardiac operations at a multi-hospital health system between January 2010 and February 2018.

Patients were stratified based on whether or not they experienced a GI complication in the initial 30-day postoperative period. GI complications included cholecystitis requiring operative cholecystectomy or percutaneous drainage, GI bleeding requiring transfusion, mesenteric ischemia requiring operative exploration, hepatic failure, prolonged ileus, pancreatitis and/or clostridium difficile infection. This study was approved by the Institutional Review Board at the University of Pittsburgh.

Outcomes

The primary outcomes of this study were early and late survival. Other outcomes investigated were non-GI associated major postoperative complications and readmission. We also modeled predictors of GI complications, mortality, and readmission.

Statistical Analysis

Continuous data are presented as mean ± standard deviation for Gaussian variables or median [interquartile range (IQR)] for non-gaussian variables and all categorical data as number (percentage). Normality was assessed using the Kolmogorov-Smirnov test. Normally distributed continuous data and categorical data were compared with Pearson's Chi-squared test or Fisher's exact test when 25% of available data points had expected values <5. Non-Gaussian distributions were evaluated using Mann-Whitney U test.

Multivariable Cox Proportional Hazards modeling was used to identify predictors for mortality. Competing risk methods by Fine and Grey modeling was used to model all-cause readmission. Multivariable logistic regression was used to identify risk-adjusted predictors for GI complications. Co-variables were first assessed by univariable model with a threshold of P<0.2 for inclusion into the multivariable model.

Propensity score matching on a 1:1 basis using nearest neighbor matching without replacement and caliper setting of 0.2 of the standard deviation of the logit propensity score. Patients were matched on preoperative demographics, comorbidities, and operative characteristics. This resulted in 224 cases, 112 with and 112 without postoperative GI complications.

Results

Baseline Preoperative Characteristics and Operative Details

A total of 10,285 patients were included in this study: 6,441 (63%) isolated coronary artery bypass grafting (CABG), 2,290 (22%) isolated valves, and 1,554 (15%) combined CABG and valve procedures. Of these, 10,039 (97.6%) patients did not experience a postoperative GI complication, whereas 246 (2.4%) of patients did. In comparison to those without GI complications, patients with these complications were older and had higher incidence of preoperative comorbidities such as atrial fibrillation, congestive heart failure, chronic obstructive pulmonary disease, prior myocardial infarction, history of immunosuppression, liver disease, peripheral vascular disease, and/or cerebrovascular disease. Mean preoperative total bilirubin (0.76 ± 0.46 vs 0.69 ± 0.39, P=0.012), Model for End-Stage Liver Disease (MELD) score (11.15 ± 4.45 vs 8.83 ± 3.12, P<0.001), and serum creatinine (1.48 ± 1.32 vs 1.16 ± 1.01, P<0.001) were also higher in patients that had GI complications (**Table 1**).

Preoperative Society of Thoracic Surgeons predicted risk of mortality was higher in patients with GI complications (7.41% ± 8.54% vs 3.10% ± 4.88%, P<0.001). Patients who experienced GI complications were more commonly bridged to surgical therapy with intravenous inotropes and/or intra-aortic balloon pump counter pulsation. In both cohorts, the most common procedure performed was coronary artery bypass grafting (51.6% vs 62.9%, P<0.001). Mean aortic cross-clamp time was longer in patients who experienced GI complications (93.04 ± 40.69 minutes vs 82.15 ± 35.54 minutes, P<0.001)(**Table 1**).

Postoperative Complications and Readmission

In an unmatched comparison, patients who experienced postoperative GI complications also experienced higher rates of reoperation (50.9% vs 14.3%), concurrent multi-system organ failure (27.7% vs 1.3%), renal failure (44.6% vs 8.9%), and new dialysis dependency (41.1% vs 5.4%) (all, P<0.001). Rates of stroke, cardiac

tamponade, and deep sternal wound infections were similar. Median hospital length of stay was longer in patients with GI complications (20 days [IQR 10 to 32] vs 10 days [IQR 7 to 17], P<0.001) (**Table 2**).

Median follow-up was 4.14 years (IQR 2.39 to 6.18). Long-term freedom from all-cause readmission was similar between cohorts (54.88% vs 52.36%, P=0.43). There were no differences in the rates of cardiac specific and heart failure readmission. Competing risk modeling was performed to identify risk-adjusted predictors for all-cause readmission. In this model, postoperative GI complications were associated with decreased hazards for all-cause readmission (HR 0.73, 95% CI 0.59 to 0.91, P=0.005), which may reflect the higher mortality rates in this group. Other significant predictors for all-cause readmission including increasing age (HR 1.01, 95% CI 1.00 to 1.01, P=0.002), female gender (HR 1.16, 95% CI 1.09 to 1.23, P<0.001), black race (HR 1.32, 95% CI 1.16 to 1.51, P<0.001), diabetes mellitus (HR 1.13, 95% CI 1.07 to 1.21, P<0.001), chronic obstructive pulmonary disease (HR 1.28, 95% CI 1.20 to 1.37, P<0.001), peripheral vascular disease (HR 1.27, 95% CI 1.18 to 1.36, P<0.001), immunosuppression (HR 1.34, 95% CI 1.19 to 1.51, P<0.001) and previous history of heart failure (HR 1.14, 95% CI 1.06 to 1.24, P=0.001). Other risk factors identified included history of hypertension, cerebrovascular disease, and increasing serum creatinine level. Factors associated with decreased risk of readmission included increasing serum albumin level, and cardiac presentation of NSTEMI or STEMI. These factors are shown in**Supplemental Table 1** .

Gastrointestinal Complications

The most common GI complication was Clostridium difficile infection experienced in 69 patients (28.0%), followed by hepatic failure (54 [21.9%]) and GI bleeding requiring blood transfusion (48 [19.5%]). Thirty-nine (15.9%) patients experienced more than one GI complication. Within one year, 103 (41.9%) of patients that experienced a GI complication died. Of these, 33 (28.0%) of these patients experienced a GI bleeding event requiring a transfusion and 32 (27.1%) had postoperative hepatic failure. Twenty-three (19.5%) patients that died within the first postoperative year experienced a Clostridium difficile intestinal infection **(Table 3).**

Table 4 displays risk-adjusted predictors for postoperative GI complication identified in a multivariable model. In this model, factors such as increasing age, chronic obstructive pulmonary disease, congestive heart failure, increasing serum creatinine and increasing aortic cross-clamp time were associated with increased hazards. History of preoperative dialysis dependency (HR 2.33, 95% CI 1.15 to 4.72, P=0.018) and preoperative intra-aortic balloon pump (HR 2.04, 95% CI 1.16 to 3.61, P=0.014) were associated with the highest hazards for GI complications.

Postoperative Survival

Thirty-day (75.2% vs 97.3%), one-year (58.1% vs 93.7%) and three-year (51.6% vs 88.9%) survival was significantly lower in patients with GI complications (all P<0.001) (**Figure 1A**). Of all significant predictors, experiencing a postoperative GI complication portended the highest risk-adjusted hazards for mortality in multivariable modeling (HR 3.12, 95%CI 2.61 to 3.72, P<0.001). Other risk factors included increasing age, female gender, diabetes mellitus, dialysis dependency, and preoperative New York Heart Association Class III or IV symptoms. Urgent or emergent procedures were associated with increased hazards for mortality, as well as combined CABG and either aortic or mitral valve replacement (**Table 5**).

Propensity-Matched Sub-Analysis

Propensity matching was performed to create well-balanced cohorts with respect to baseline variables. This matching resulted in an analysis of 224 patients, 112 (50.0%) with and 112 (50.0%) without GI complications. In this comparison, rates of reoperation, concurrent multi-system organ failure, renal failure, and dialysis dependency remained higher in patients that experienced GI complications. Rates of stroke, reoperation, cardiac tamponade, and deep sternal wound infection remained similar (**Table 6**). After propensity matching, 30-day (69.6% vs 94.6%) one-year (55.4% vs 79.5%), and three-year (52.7% vs 74.1%) survival remained lower in the GI complication group (all P[?]0.001) (**Figure 1B**).

Discussion

A principal finding of this study was that GI complications occur with relative infrequency following index adult cardiac surgical procedures, occurring only in 2.4% of our study cohort. These complications tended to occur more commonly in patients who were elderly with an increased comorbidity burden. Other risk-adjusted predictors of developing GI complications included pre-existing impaired renal function, especially those who were dialysis dependent preoperatively, chronic obstructive pulmonary disease, congestive heart failure, use of intra-aortic balloon pumps, and prolonged aortic cross clamp times. Patients who experienced postoperative GI complications had reduced short- and long-term survival, and also experienced higher rates of other concurrent complications including renal failure, multi-system organ failure, and deep sternal wound infections. After propensity-matching patients based on preoperative comorbidities, the occurrence of GI complications was still associated with significantly higher mortality as well as other major complications.

The incidence of GI complications in our cohort was 2.4%, which is comparable to prior series, in which the occurrence of GI complications ranged from 0.5 to 4.5%[2–6]. Several risk factors such as advanced age, chronic obstructive pulmonary disease, heart failure, and worsening preoperative renal function, were identified to be associated with increased risk for development of GI complications. While these risk-factors typically portend worse prognoses in cardiac surgical patients due to their affiliation with a declining preoperative clinical status, they also serve as surrogates for important physiological events that proceed GI complications as well as concomitant non-GI complications[2,3,9,10]. For instance, elderly patients and those with chronic obstructive pulmonary disease from smoking may have a higher vascular calcific burden placing them at risk of gastrointestinal ischemia from ischemic events. This may manifest as thrombembolism from a calcified aorta during cross-clamping, or hypoperfusion of abdominal organs during a low flow state in the postoperative period.

Additionally, those requiring intra-aortic balloon counterpulsation had a two-fold increase in the hazard for GI complications. This finding has also been described by Hashemzadeh *et al* who found several risk factors for GI complications in their series including advanced age (>65 years), preexisting renal disease, intra-aortic balloon pump, and prolonged aortic cross-clamp times[3]. It is unclear of the etiology of these GI complications result directly from the devices themselves, for instance from thrombus formation on the balloon that is dislodged upon removal or malpositioned balloon pumps leading to intestinal and hepatic ischemia[11–15]. The use of intra-aortic balloon pump may also represent a surrogate for the critically ill patient with higher likelihood of hemodynamic instability and end-organ malperfusion. We also found increasing aortic cross-clamp time to be correlated with risk of GI complications. Longer case time was also demonstrated by Marsoner and colleagues who found increasing cardiopulmonary pump times to be associated with higher odds of GI complication (OR 1.006, 95% CI 1.001 to 1.011, P=0.026)[7]. Longer cross-clamp times may subject the patient to longer cardiopulmonary bypass runs, embolic phenomena during bypass, and increased risk of postoperative vasoplegia, all of which may contribute to end-organ malperfusion and/or ischemia. Such events may explain increased propensity for GI complications following longer procedures.

The most common GI complication in our series was Clostridium difficile intestinal infection, but GI bleeding was most prevalent in patients that died within the first postoperative year. In prior series, postoperative GI bleeding has been associated with an 8.8% 30-day mortality, and risk factors included advanced age, congestive heart failure, cerebrovascular disease, and chronic kidney disease. The etiology of the majority of these bleeding events (71%) were from duodenal ulceration[16]. Unlike other GI complications such as Clostridium difficile infection, acute cholangitis, or prolonged ileus which have the potential for cure with appropriate antibiotic management, surgery, and/or expectant management, GI bleeding may be a recurrent phenomenon outside of the postoperative window and possibly exacerbated by newly-prescribed anticoagulation therapies following cardiac surgery. As such, GI bleeding may confer continual long-term morbidity and mortality after cardiac operations.

Several reports have identified GI complications following cardiac surgery to be linked to reduced short-term survival. In hospital mortality has been reported to be exceedingly high ranging between 34-87%[5,17]. In our study, we demonstrate a 30-day mortality of 24.8% in those with GI complications. Rates of other events such as renal failure, new dialysis dependency, and multi-system organ failure were more likely to occur

concurrently with GI complications. This clustering effect persisted after propensity matching illustrating the profound physiologic insult that GI complications impart to other organ systems, or are a result of processes that also portend increased risk to these other organ systems. These clusters of complications reflect an adverse cascade of physiologic insults that often begin with malperfusion from emboli or hypotension that leads to bacterial translocation, more severe hemodynamic compromise and ultimately worsening malperfusion, Additionally, patients with GI bleeds, intestinal ischemia or severe Clostridium difficile colitis may be intravascularly dry requiring extensive volume resuscitation, which may further compromise patients with reduced ejection fractions and also lead to pulmonary dysfunction. It is well appreciated that as more complications are acquired in an individual patient, the odds of mortality increase exponentially[18,19]. Furthermore, additional complications increase intensive care and hospital length of stay time, and often require additional medical, and sometimes surgical, resources for management and treatment of these complications. As a result, it is likely that patients experiencing GI and other concurrent complications often pose a significant resource and financial burden to healthcare systems.

Limitations

The current study has several limitations. This study was retrospective and observational in nature, and as such, may be subject to selection bias. We did find higher rates of preoperative comorbidity and other associated complications in patients that experienced GI complications, which may bias some of the study's findings. In order to account for such possible confounding and selection bias, we did perform multivariable modeling to adjust for such preoperative risk factors, as well as performing propensity-matched sub-analysis to account for the possibility of confounding baseline variables. However, it is possible that there may be some unmeasured confounders that remain despite these measures. The study findings also demonstrate an association between GI complications and higher mortality but do not necessarily translate into causality as the temporal relation of GI and other complications was not evaluated, nor was the ultimate cause of death.

Conclusions

In our analysis of 10,285 adult patients undergoing STS-indexed cardiac surgery procedures, we found GI complications only occurred in 2.4% of cases. Although these complications are quite rare, they portended elevated rates of associated complications as well as profound reductions in early and late survival. Risk factor modification, heightened awareness, and early detection and management of GI complications is therefore important.

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Disclosures

Arman Kilic, MD is on the medical advisory board for Medtronic, Inc. This affiliation does not create direct conflict with the content of this manuscript.

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Table 1. Baseline characteristics and operative details of patients undergoing cardiac surgery procedures

	No GI Complication	**GI Complication**	**P-Value**
	N=10,039	**N=246**	
Age, years, mean (SD)	66.79 (11.22)	71.30 (10.73)	<0.001
Female	3,065 (30.5%)	66 (26.8%)	0.21
Race			
White	9,381 (93.4%)	228 (92.7%)	0.63
Black	446 (4.4%)	13 (5.3%)	0.53
Asian	87 (0.9%)	2 (0.8%)	0.93
Procedure			<0.001
CABG	6314 (62.9%)	127 (51.6%)	
MV repair	489 (4.9%)	11 (4.5%)	
MV replacement	207 (2.1%)	9 (3.7%)	
AV replacement	1544 (15.4%)	30 (12.2%)	
CABG + AV replacement	1066 (10.6%)	43 (17.5%)	
CABG + MV replacement	96 (1.0%)	8 (3.3%)	
CABG + MV repair	323 (3.2%)	18 (7.3%)	
Chronic obstructive pulmonary disease	2,198 (21.9%)	72 (29.3%)	0.006
Dyslipidemia	8,411 (83.8%)	201 (81.7%)	0.38
Hypertension	8,624 (85.9%)	218 (88.6%)	0.23
Atrial fibrillation	1,224 (12.2%)	47 (19.1%)	0.001
Congestive heart failure	2,297 (22.9%)	111 (45.1%)	<0.001
Previous myocardial infarction	5,010 (49.9%)	154 (62.6%)	<0.001
NYHA Class symptoms			
I	69 (2.8%)	3 (2.6%)	0.004
II	513 (20.6%)	11 (9.5%)	
III	1,159 (46.5%)	51 (44.0%)	
IV	694 (27.9%)	49 (42.2%)	
Preoperative anticoagulation	14 (0.1%)	0 (0.0%)	0.56
Intravenous inotropes	192 (1.9%)	14 (5.7%)	<0.001
Number of diseased coronary vessels			
0	1,549 (15.6%)	33 (13.6%)	0.077
1	863 (8.7%)	18 (7.4%)	
2	1,876 (18.9%)	34 (14.0%)	
3	5,653 (56.9%)	158 (65.0%)	
Left main disease	1,007 (21.0%)	39 (28.9%)	0.027
Left ventricular EF, %, mean (SD)	51.51 (12.48)	47.81(15.44)	<0.001
Operative status			
Elective	4,561 (45.4%)	84 (34.1%)	<0.001
Urgent	5,098 (50.8%)	136 (55.3%)	
Emergent	372 (3.7%)	25 (10.2%)	
Emergent salvage	8 (0.1%)	1 (0.4%)	
Cross-clamp time, minutes, mean (SD)	82.15 (35.54)	93.04 (40.69)	<0.001
Preoperative intra-aortic balloon pump	477 (4.8%)	28 (11.4%)	<0.001
Serum creatinine, mg/dL, mean (SD)	1.16 (1.01)	1.48 (1.32)	<0.001
Total albumin, g/dL, mean (SD)	3.64 (0.46)	3.46 (0.51)	<0.001
Immunosuppression	548 (5.5%)	22 (8.9%)	0.018
Liver disease	612 (6.8%)	28 (14.4%)	<0.001
Mediastinal radiation	174 (1.9%)	6 (3.1%)	0.25
History of cancer	613 (6.8%)	22 (11.3%)	0.014
Peripheral vascular disease	1,922 (19.1%)	70 (28.5%)	<0.001
Cerebrovascular disease	2,192 (21.8%)	78 (31.7%)	<0.001

	No GI Complication	GI Complication	P-Value
Prior transient ischemic attack	700 (31.4%)	22 (27.5%)	0.46
Total bilirubin, mg/dL, mean (SD)	0.69 (0.39)	0.76 (0.46)	0.012
MELD score, mean (SD)	8.83 (3.12)	11.15 (4.45)	<0.001
Brain natriuretic peptide, pg/mL, mean (SD)	682 (1,126)	2,602 (10,700)	<0.001
Current smoker	974 (20.9%)	20 (15.5%)	0.14
Prior PCI	3,302 (32.9%)	99 (40.2%)	0.015
Prior CABG	498 (5.0%)	16 (6.5%)	0.27
Prior valve replacement/repair	158 (1.6%)	2 (0.8%)	0.34
STS risk of mortality, mean (SD)	3.10 (4.88)	7.41 (8.54)	<0.001

AV, aortic valve

CABG, coronary artery bypass graft

EF, ejection fraction

GI, gastrointestinal

MELD, Model for End-Stage Liver Disease

MV, mitral valve

NYHA, New York Heart Association

PCI, percutaneous coronary intervention

STS, Society of Thoracic Surgeons

Table 2. Non-GI postoperative complications following cardiac surgery in unmatched cohorts

	No GI Complication	GI Complication	P-Value
	N=10,039	**N=246**	
Stroke	474 (4.7%)	8 (3.3%)	0.28
Reoperation	560 (5.6%)	111 (45.1%)	<0.001
Cardiac tamponade	3 (0.1%)	1 (0.4%)	0.065
Multi-system organ failure	45 (1.0%)	53 (21.5%)	<0.001
Atrial fibrillation	3,395 (72.0%)	142 (57.7%)	<0.001
Renal failure	250 (2.5%)	97 (39.4%)	<0.001
Dialysis	151 (1.5%)	77 (31.3%)	<0.001
Sepsis	11 (0.6%)	0 (0.0%)	0.38
Deep sternal wound infection	20 (0.2%)	6 (2.6%)	<0.001
Mediastinitis	12 (0.1%)	2 (0.8%)	0.65
Hospital LOS, days [IQR]	8 [6-11]	20 [11-32]	<0.001

LOS, length of stay

Table 3. Frequency of GI complications following cardiac surgery and association with mortality at one year

Complications	Frequency	Mortality (%)
GI bleeding requiring transfusion	48 (19.5%)	33 (28.0%)
Pancreatitis	1 (0.4%)	1 (4.0%)

Complications	Frequency	Mortality (%)
Cholecystitis requiring cholecystectomy or drainage	8 (3.3%)	3 (2.5%)
Mesenteric ischemia requiring exploration	30 (12.2%)	19 (16.1%)
Hepatic failure	54 (21.9%)	32 (27.1%)
Prolonged ileus	34 (13.8%)	8 (6.8%)
Clostridium difficile	69 (28.0%)	23 (19.5%)
Unknown	2 (0.8%)	–

GI, gastrointestinal

Table 4. Multivariable logistic regression demonstrating predictors of postoperative GI complications

Independent Predictors	Odds Ratio (95% CI)	P-Value
Age, increasing, per year	1.04 (1.02, 1.06)	<0.001
Chronic obstructive pulmonary disease	1.43 (1.01, 2.04)	0.04
Congestive heart failure	1.62 (1.15, 2.28)	0.005
Cross-clamp time increasing, per minute	1.01 (1.00, 1.01)	0.001
Preoperative intra-aortic balloon pump	2.04 (1.16, 3.61)	0.014
Creatinine, increasing, per mg/dL*	1.12 (1.08, 1.16)	<0.001
Preoperative dialysis	2.33 (1.15, 4.72)	0.018
Serum albumin, increasing, per mg/dL	0.57 (0.43, 0.76)	<0.001

*Adjusted for dialysis dependence

Table 5. Multivariable Cox Proportional Hazard modeling for mortality

	Univariate HR	95% CI	P-Value
Postoperative GI complication	4.62	3.89, 5.49	<0.001
	Multivariate HR	**95% CI**	**P-Value**
Postoperative GI complication	3.12	2.61, 3.72	<0.001
Female	1.17	1.07, 1.29	0.001
Diabetes mellitus	1.39	1.27, 1.54	<0.001
Dyslipidemia	0.82	0.73, 0.93	0.001
Dialysis dependency	2.13	1.60, 2.82	<0.001
Chronic obstructive pulmonary disease	1.53	1.39, 1.69	<0.001
Immunosuppression	1.65	1.41, 1.93	<0.001
Peripheral vascular disease	1.51	1.37, 1.67	<0.001
Cerebrovascular disease	1.29	1.17, 1.43	<0.001
Previous CABG	1.38	1.17, 1.62	0.001
Previous myocardial infarction	1.15	1.02, 1.29	0.02
Preoperative cardiac arrhythmia	1.38	1.24, 1.53	<0.001
Prior heart failure	1.16	1.03, 1.31	0.02
Operative status			
Elective	Reference	Reference	Reference
Urgent	1.16	1.03, 1.32	0.01
Emergent or emergent salvage	1.62	1.28, 2.05	<0.001
NYHA Class symptoms			
I	Reference	Reference	Reference
II	1.07	0.87, 1.33	0.51

	Univariate HR	**95% CI**	**P-Value**
III	1.25	1.08, 1.44	0.003
IV	1.45	1.23, 1.71	<0.001
Procedure			
Isolated CABG	Reference	Reference	Reference
Isolated MV Repair	1.24	0.77, 1.99	0.37
Isolated MV Replacement	0.98	0.61, 1.59	0.93
CABG + MV Repair	1.11	0.83, 1.50	0.47
CABG + MV Replacement	1.16	1.15, 2.43	0.007
CABG + AV Replacement	1.48	1.15, 1.91	0.002
Cardiac presentation			
Stable angina	Reference	Reference	Reference
Unstable angina	0.71	0.60, 0.84	<0.001
NSTEMI	0.74	0.61, 0.89	0.002
STEMI	0.58	0.44, 0.77	0.001
Anticoagulant within 5 days before surgery	1.16	1.03, 1.30	0.02
Antiplatelet within 5 days before surgery	0.82	0.72, 0.93	0.003
Age, increasing, years	1.04	1.03, 1.05	<0.001
Left ventricular EF, increasing, per 1%	0.99	0.985, 0.993	<0.001
Serum creatinine, increasing, per mg/dL	1.10	1.05, 1.15	<0.001

*Variables included but not significant in the model: operative status, previous valve operation, race, hypertension, preoperative intra-aortic balloon pump, family history of coronary artery disease, prior coronary artery bypass graft procedure, body mass index

AV, aortic valve

CABG, coronary artery bypass graft

EF, ejection fraction

GI, gastrointestinal

MV, mitral valve

NSTEMI, non-ST-elevation myocardial infarction

NYHA, New York Heart Association

STEMI, ST-elevation myocardial infarction

Table 6. Postoperative non-GI complications and outcomes following cardiac surgery in propensity-matched cohorts

	No GI Complication	**GI Complication**	**P-Value**
	112	**112**	
Stroke	5 (4.7%)	1 (0.9%)	0.09
Reoperation	16 (14.3%)	57 (50.9%)	<0.001
Cardiac tamponade	0 (0.0%)	1 (0.9%)	0.41
Multi-system organ failure	1 (1.3%)	31 (27.7%)	<0.001
Atrial fibrillation	47 (62.7%)	65 (58.0%)	0.53
Renal failure	10 (8.9%)	50 (44.6%)	<0.001
Dialysis	6 (5.4%)	46 (41.1%)	<0.001
Deep sternal wound infection	0 (0.0%)	2 (1.8%)	0.16

	No GI Complication	GI Complication	P-Value
Hospital LOS, days [IQR]	10 [7,17]	20 [10, 32]	<0.001
Mortality			
30-day	6 (5.4%)	34 (30.4%)	<0.001
1-year	23 (20.5%)	50 (44.6%)	<0.001
5-years	30 (26.8%)	54 (48.2%)	0.001

LOS, length of stay

Figure Legend

Figure 1. Kaplan Meier survival analysis between patients with and without postoperative GI complications in A) unmatched and B) propensity-matched cohorts.