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Interhospital Failure to Rescue After Coronary Artery Bypass Grafting

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Abstract

Objective: We evaluated whether interhospital variation in mortality rates for coronary artery bypass grafting (CABG) was driven by complications and failure to rescue.

Methods: An observational study was conducted among 83,747 patients undergoing isolated CABG between July 2011 to June 2017 across 90 hospitals. Failure to rescue (FTR) was defined as operative mortality among patients developing complications. Complications included the Society of Thoracic Surgeons (STS) five major (stroke, surgical re-exploration, deep sternal wound infection, renal failure, prolonged intubation) and a broader set of 19 overall complications. After creating terciles of hospital performance (based on observed:expected "O:E" mortality), each tercile was compared based on crude rates of: (i) major and overall complications, (ii) operative mortality and (iii) FTR (among major and overall complications). The correlation between hospital observed and expected (to address confounding) FTR rates was assessed.

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Membership of the IMPROVE Network is provided in the Supplemental material.

Conflicts of Interest: None

Results: Median STS predicted mortality risk was similar across hospital O:E mortality terciles (p=0.831). Mortality rates significantly increased across terciles (low: 1.4%, high: 2.8%). While small in magnitude, rates of major (low: 11.1%, high: 12.2%) and overall complications (low: 36.6%, 35.3%) significantly differed across terciles. Nonetheless, FTR rates increased substantially across terciles among patients with major (low: 9.2%, high: 14.3%) and overall complications (low: 3.3%, high: 6.8%). Hospital observed and expected FTR rates were positively correlated among patients with major (R-squared=0.14) and overall (R-squared=0.51) complications.

Conclusions: The reported interhospital variability in successful rescue following CABG supports the importance of identifying best practices at high-performing hospitals, including early recognition and management of complications.

Keywords

coronary artery bypass grafting; mortality; complications

INTRODUCTION

National efforts exist to advance hospital quality and safety. The Centers for Medicare and Medicaid Services now publicly reports hospital performance related to both recommended practices and clinical outcomes for surgical and non-surgical conditions[1]. While the Society of Thoracic Surgeons (STS) provides cardiac surgeons with benchmarking reports to support hospital-specific quality activities[2], interhospital variability in mortality rates[3].

Failure to rescue (FTR), defined as death following a complication, has been identified as an important contributor to interhospital variability in mortality. Reddy and colleagues, analyzing 45,904 coronary artery bypass grafting (CABG) and/or valve operations (2006 – 2010), reported that relative to low mortality tercile hospitals, high tercile hospitals had worse FTR rates (low tercile: 6.6%, high tercile: 13.5%, p<0.001). Overall complications, including 17 events, varied between 19.1% in the low mortality tercile and 22.9% in the high mortality tercile, p<0.001. A national analysis of isolated CABG (2010 – 2014) revealed a 4.3 percentage-point higher complication rate (including four major events) at high mortality tercile hospitals (low: 11.4%, high: 15.7%), although a 7.1 percentage-point higher FTR rate (6.8% versus 13.9%)[4]. Contemporary evaluations of interhospital FTR are warranted, based on both a broad and narrowly defined set of complications.

Among six cardiac surgical collaboratives, increasing hospital observed-to-expected (O:E) mortality terciles were compared in terms of their complication (broadly and narrowly defined) and FTR rates after isolated CABG.

METHODS

The University of Michigan IRB (HUM00127073) provided a Notice of Not Regulated Determination on 3/8/2017.

This study included 83,747 isolated CABG procedures (July 2011 to June 2017) from 90 hospitals participating in any of six quality collaboratives that in turn are members of the IMPROVE Network, eText 1.

Outcomes

Mortality included deaths within the hospitalization or after discharge but within 30-days of the surgical procedure[5].

Failure to rescue (FTR) was defined as mortality among patients developing a postoperative complication.

A narrowly defined measure included STS major complications (stroke, surgical re-exploration, deep sternal wound infection, renal failure, prolonged intubation). A broader "overall complications" measure included STS major complications, sepsis, surgical site infection, coma, pneumonia, pulmonary embolism, renal dialysis, dysrhythmia requiring a permanent pacemaker, cardiac arrest, anticoagulation event, tamponade, gastrointestinal event, multi-organ system failure, atrial fibrillation, aortic dissection.

Two FTR measures were calculated: major complications (68.3% of all deaths); overall complications (87.9% of all deaths).

Statistical Analyses

The STS' approach for addressing missing values was applied, eMethods[5].

Hospital-level observed mortality was calculated by summing each hospital's observed mortality. Hospital-level expected mortality was calculated by summing each hospital's mortality probability, estimated from logistic regression using STS published preoperative mortality risk model variables[5]. Hospitals were divided into performance terciles based on their O:E mortality[3].

Patients characteristics, risk factors and complication conditions were stratified by hospital O:E mortality terciles, which were used for descriptive statistics. Continuous variables were summarized as median (interquartile range) and compared using Wilcoxon rank-sum tests. Categorical variables were summarized as n (%) and compared using Chi-squared tests. Cochran-Armitage Trend tests were used to test the trend of mortality, complication and FTR rates across hospital O:E mortality terciles.

Generalized linear mixed-effects models were used to develop FTR models (for major and overall complications). To address confounding, expected FTR rates were calculated by summing the patient's probability of FTR within hospitals [accounting for significant preoperative mortality predictors and complication types], assuming an average hospital effect from the FTR models. R-squared was used to associate observed and expected hospital FTR rates. The C-statistic was used to evaluate the addition of cardiopulmonary bypass and crossclamp duration on improving FTR prediction.

Secondarily, Pearson correlation coefficients (r) were used to associate hospital procedural volume with observed and expected FTR (for major and overall complications).

Analyses were performed using SAS version 9.4 and R version 3.5.2.

RESULTS

Figure 1A–E displays the distribution of hospital-level rates for complications (min:max. major: 5.7%−34.7%; overall: 21.6%−54.2%), mortality (0.6%−5.4%) and FTR (major: 3.5% −32.3%; overall: 1.5%−14.3%).

Median STS predicted mortality risk was similar across O:E mortality terciles (p=0.831), Table 1. Patients at high (versus low) O:E mortality tercile hospitals more likely underwent urgent operations, $p<0.001$. Differences across O:E mortality terciles for many characteristics were small in absolute magnitude, while statistically significant. Relative to low O:E mortality tercile hospitals, patients in the high tercile hospitals were more likely to experience prolonged ventilation, cardiac arrest and operative mortality, $p<0.001$.

Figure 2 displays the differences in complication rates, operative mortality and unadjusted FTR by hospital O:E mortality terciles. Relative to the low hospital O:E mortality tercile, rates of major complications in the high tercile were 1.1 percentage-points greater (12.% versus 11.1%, *ptrend*<0.0001), overall complications 1.3 percentage-points lower (35.3% versus 36.6%, *ptrend*=0.002) and mortality 1.4 percentage-points higher (2.8% versus 1.4%, *ptrend*<0.0001). In contrast, and relative to the low hospital O:E mortality tercile, FTR rates were higher at high tercile hospitals, including 5.2 percentage-points higher for major complications (14.3% versus 9.1%, *ptrend*<0.0001) and 3.5 percentage-points higher for overall complications (6.8% versus 3.3%, *ptrend*<0.0001). The FTR rates were highest for cardiac arrest (48.9%), although varied by 15.8 percentage-points across O:E mortality terciles (high: 56.1%, low: 40.3%, p<0.001), Table 2.

Multivariable modeling estimates are presented for major and overall FTR outcomes in eTable 1. Bypass duration significantly predicted FTR (major complications: p=0.0003; overall: p<0.0001); however, crossclamp duration did not (major complications: p=0.39; overall: p=0.78). The addition of bypass and crossclamp duration did not change the C-statistic for the FTR major complication (0.78) or the overall complication (0.93) models.

Hospital observed and expected FTR rates were less strongly correlated for patients with major (Figure 3A, R-squared=0.14) than overall complications (Figure 3B, R-squared=0.51).

Hospital procedural volume was not significantly associated with observed ($r=-0.13$, $p=0.21$) and expected ($r=-0.022$, $p=0.84$) FTR rates for major complications. Hospital procedural volume was negatively correlated with observed ($r=-0.32$, $p=0.0023$) and expected ($r=-0.36$, $p=0.0005$) FTR rates for overall complications.

DISCUSSION

This study yields four distinct findings that establish the importance of identifying and disseminating optimal CABG rescue strategies. First, observed FTR rates varied 28.8 percentage-points across hospitals for major complications and 12.8 percentage-points for a broad set of complications. Second, FTR rates, both for major and overall complications, were greater at high relative to low O:E mortality tercile hospitals. When compared across terciles, there was: (i) no difference in median predicted mortality risk, (ii) small differences in major and overall complications, and (iii) a two-fold increased mortality risk at high versus low O:E mortality tercile hospitals. Third, complication-specific FTR rates varied within and across O:E mortality hospital terciles. Fourth, observed and expected hospital FTR rates were positively correlated although weaker for major complications.

Investigators have evaluated the role of FTR within adult[3,4,6] and congenital[7] cardiac surgical populations. Ghaferi and colleagues, analyzing national Medicare claims for CABG[6], reported 1.1-fold variability in complication rates across mortality quintile hospitals (low: 21.1% versus high quintile: 24.2%) although 3.1-fold (6.2% versus 18.9%) FTR. These findings suggest that interhospital variation in mortality is driven by how a hospital manages complications rather than complication rates themselves.

Reddy and colleagues evaluated interhospital variability in rates of complications, mortality and FTR across terciles of O:E mortality[3]. In the Reddy study, despite similar complication rates across terciles, mortality rates were 2.1 percentage points higher (3.6% versus 1.5%) and FTR rates 6.9 percentage-points higher (13.5% versus 6.6%) at high versus low tercile hospitals.

Edwards and colleagues compared rates of complications and FTR across terciles of hospital mortality rates among 604,154 patients undergoing isolated CABG[4]. Complication rates, defined narrowly (stroke, renal failure, reoperation or prolonged ventilation), varied 4.3 percentage-points (high tercile: 15.7%, low tercile: 11.4%) while FTR rates varied 7.1 percentage-points (13.9% versus 6.8%)[4]. Reddy and Edwards had noteworthy differences in their study sample (e.g., time periods, evaluated surgical procedures) and set of morbid events included within their complication measures.

In our current study, hospital observed and expected FTR rates were weakly correlated, especially among patients developing major complications. Further work is required to identify important organizational and unit-level determinants of hospital FTR. Hospital procedural volume was negatively associated with observed FTR rates for patients developing overall complications although not for major complications. While Gonzalez and colleagues reported a significant 16% increased relative odds of FTR after CABG at low-versus high-volume quintile hospitals[8], Edwards and colleagues did not find a significant relationship between volume and FTR[4].

Since Silber's original report[9], a number of patient-level risk factors for FTR have been documented[10]. Potentially modifiable determinants have also been reported (e.g., early recognition of patient deterioration[11] and nurse staffing and educational levels[12]), with many confirmed across a variety of surgical cohorts[13,14] and data sources[4,6,8,15]. Reported interhospital variability in FTR rates has contributed to current public reporting of hospital FTR rates.

Prior reports have identified potential unit- (nurse:patient ratios[12,16,17]) and hospital (rapid response teams[18,19]) FTR targets. Ward and colleagues merged survey data reflecting microsystem-level practices with registry data representing general surgery operations at

54 hospitals[20]. Relative to high FTR tercile hospitals, low tercile hospitals were more likely to have: (i) closed intensive care units, (ii) hospitalists, residents or board-certified intensivists, (iii) advanced practice providers, (iv) overnight coverage and (v) rapid response teams. Our findings of a weak positive correlation between a hospital's observed and expected FTR rate for major complications suggest the need to identify how institutional resources and practices are differentially employed at high performing hospitals. Reductions in interhospital variability in FTR may result from leveraging collaborative learning[21] to reveal currently unexplained modifiable unit- and hospital-level FTR determinants[22].

This study has several limitations. First, while not all complications were evaluated, this study focused on both a narrow set of STS-defined and publicly reported major complications[23] as well as a broader that are tracked by the STS[24]. Second, while unmeasured confounding persists, this study accounted for pre-operative factors included in the STS' risk models[5]. While the inclusion of cardiopulmonary bypass and crossclamp duration did not appreciably improve our FTR prediction model's discrimination, we cannot rule out the influence of other intraoperative confounding. Third, while the present findings may not be universally generalizable, our study includes hospitals across the U.S. and low and high-volume hospitals.

CONCLUSIONS

Considerable variation in FTR rates existed across O:E mortality terciles (Figure 4) after isolated CABG despite similar STS predicted mortality risk and small differences in complication rates. Given that existing clinical registry data are limited in their ability to predict observed hospital FTR rates, important modifiable FTR targets may be identified through benchmarking visits to high-performing hospitals.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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This study was reviewed by the University of Michigan Institutional Review Board (HUM00127073) and provided a Notice of Not Regulated Determination on 3/8/2017.

GLOSSARY OF ABBREVIATIONS

CABG	Coronary Artery Bypass Grafting
FTR	Failure to Rescue
STS	Society of Thoracic Surgeons

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CENTRAL MESSAGE

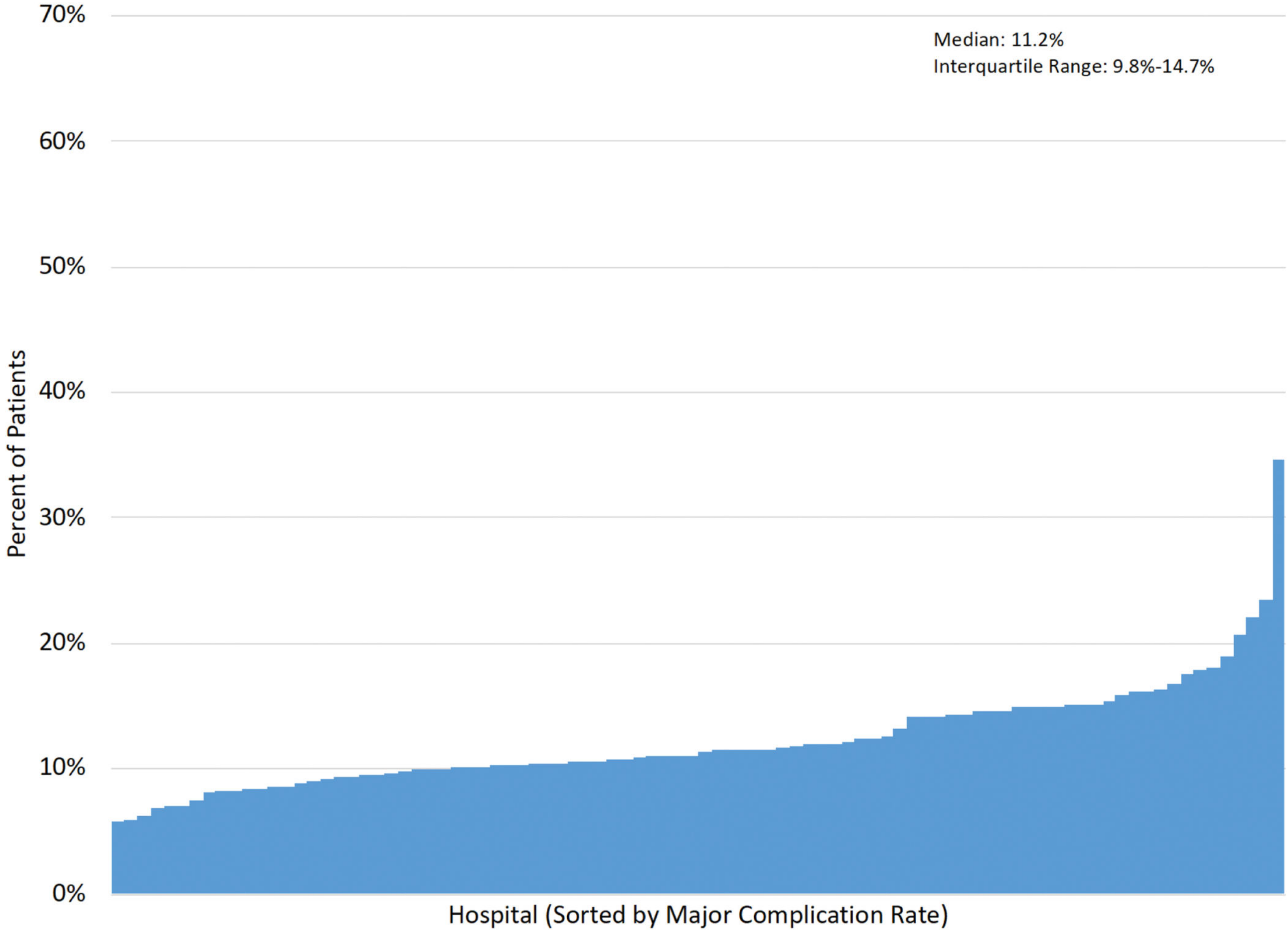
Rescue strategies should be identified and prioritized given interhospital variation in mortality after coronary artery bypass grafting is driven principally by a hospital's failure to rescue rate.

PERSPECTIVE STATEMENT

In this multi-collaborative cohort of 83,747 isolated coronary artery bypass procedures, significant interhospital variation in mortality rates was driven principally by failure to rescue rates rather than complication rates. Efforts to reduce mortality should focus on identifying and implementing optimal rescue strategies.

CENTRAL PICTURE

Variability in mortality is driven by differences in failure to rescue, not complications.


70%
60%
50%
40%
30%
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10%
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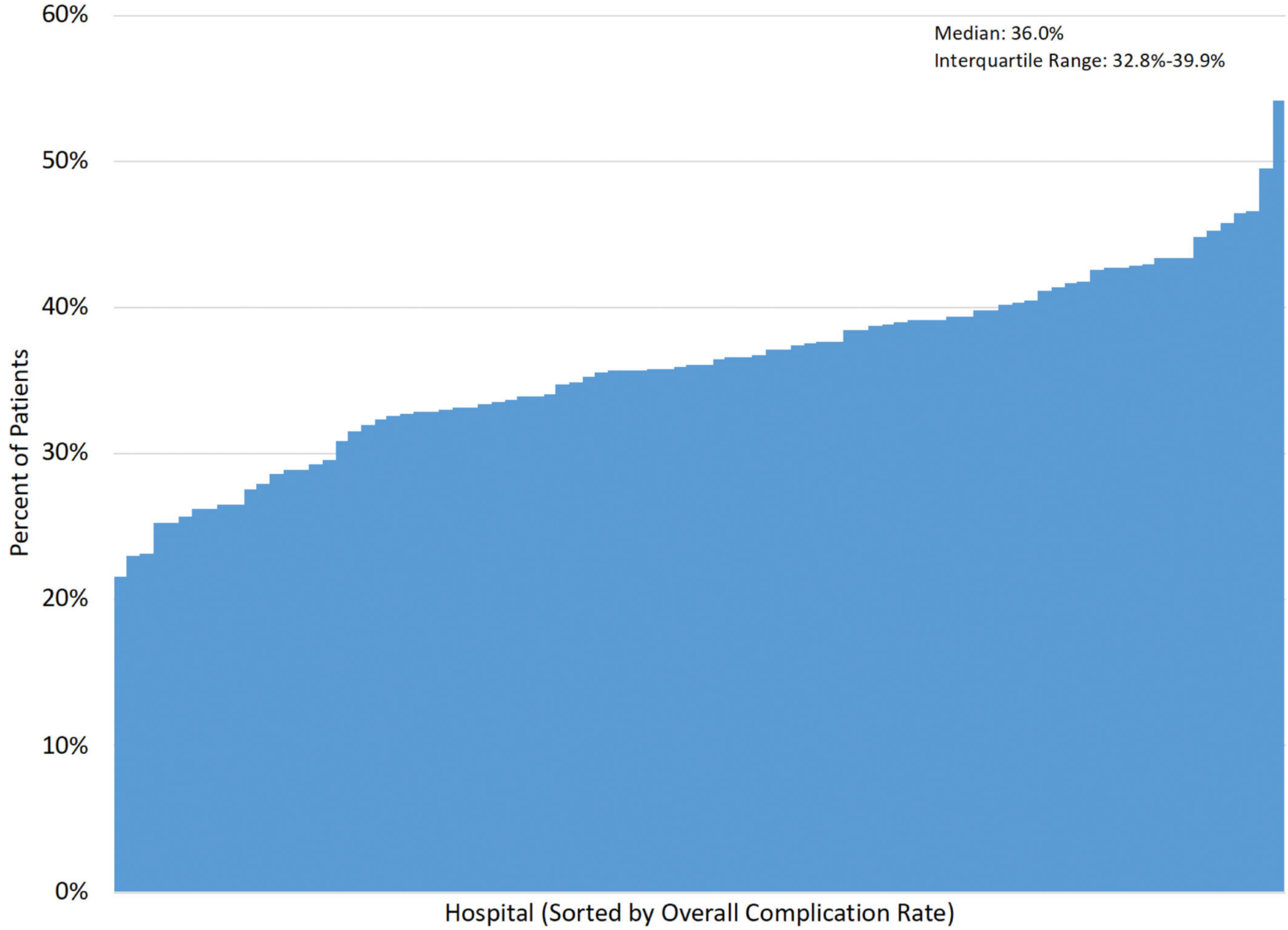
Percent of Patients
Median: 11.2%
Interquartile Range: 9.8%-14.7%
Hospital (Sorted by Major Complication Rate)


Median: 36.0%
Interquartile Range: 32.8%-39.9%
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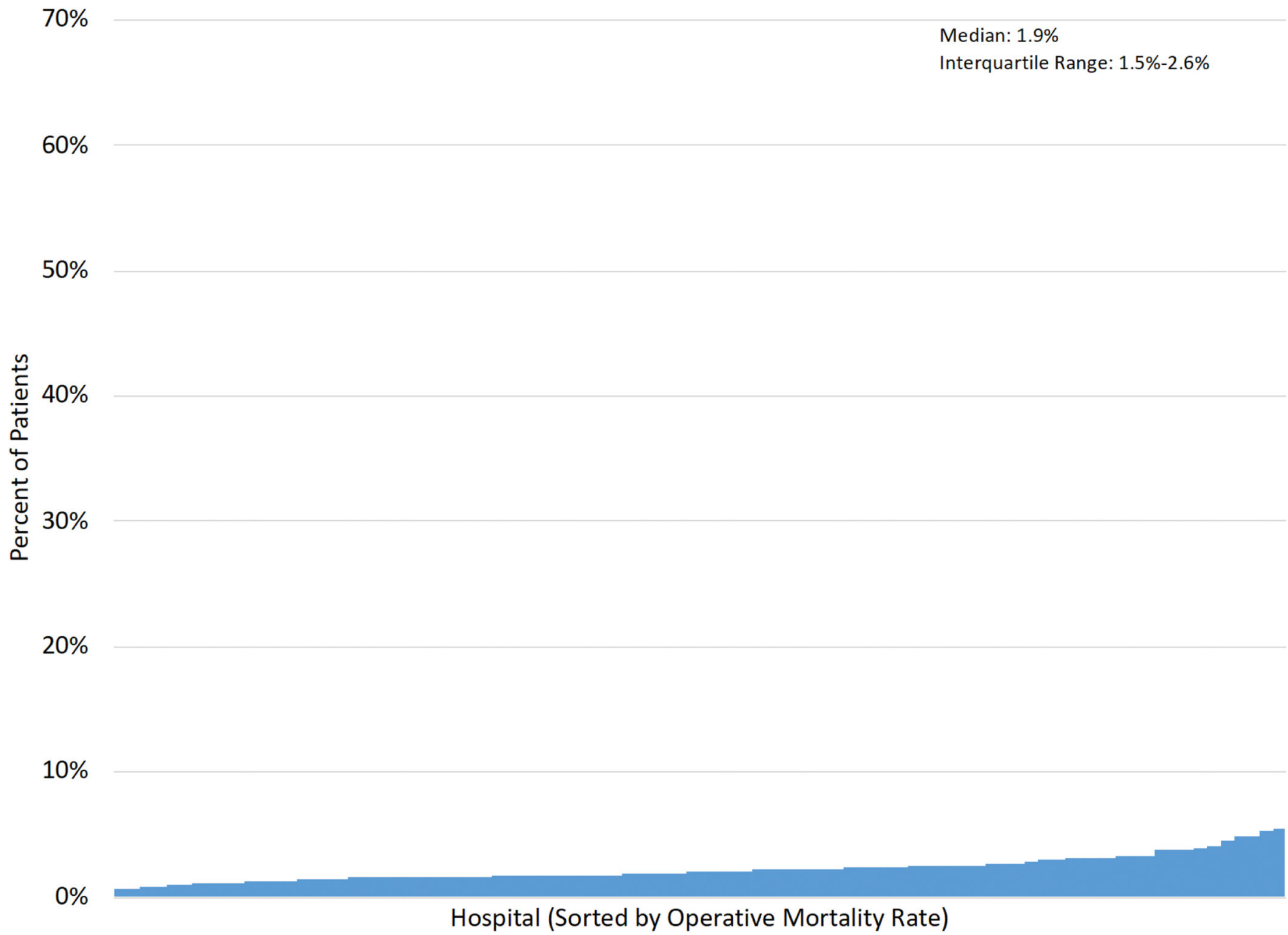
Percent of Patients
Hospital (Sorted by Overall Complication Rate)


70%
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40%
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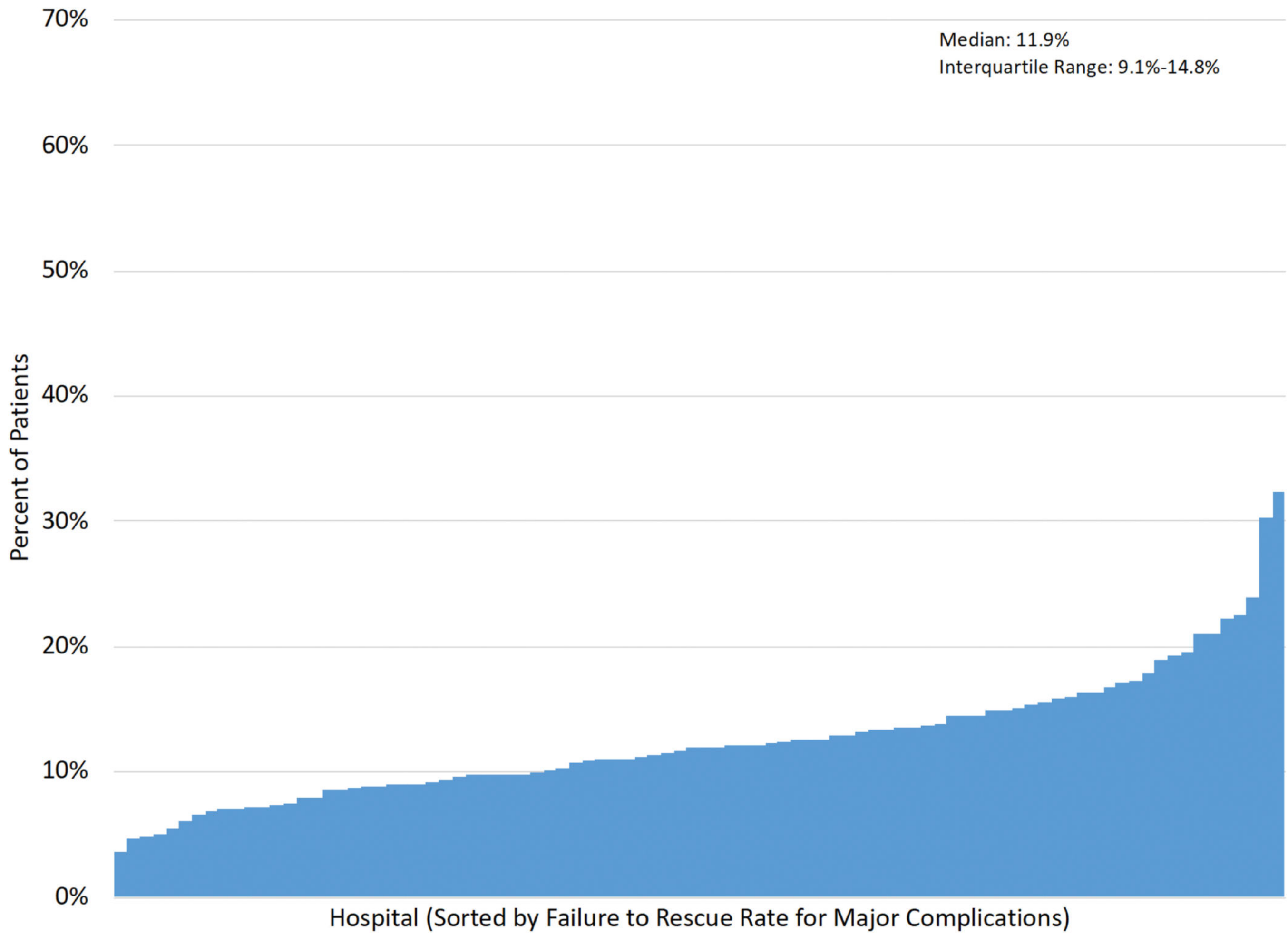
0%
Percent of Patients
Median: 1.9%
Interquartile Range: 1.5%-2.6%
Hospital (Sorted by Operative Mortality Rate)


70%
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0%
Median: 11.9%
Interquartile Range: 9.1%-14.8%
Percent of Patients
Hospital (Sorted by Failure to Rescue Rate for Major Complications)

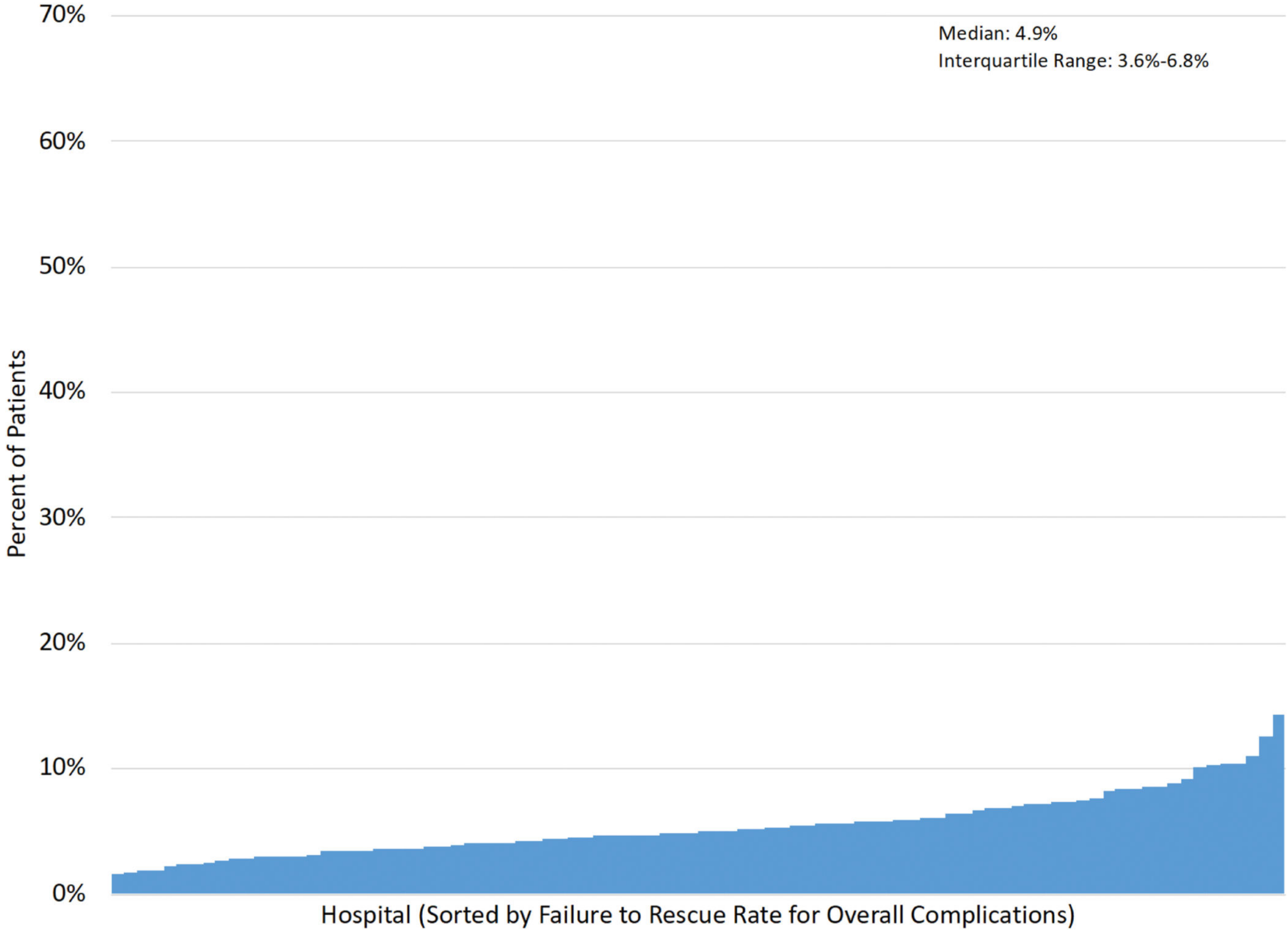


Figure 1 (A-E): Histograms of Interhospital Variability in Complication, Mortality and Failure to Rescue Rates

Each figure is separately sorted by hospital.

A: Major complications; B: Overall complications; C: Operative mortality; D: FTR among major complications; E: FTR among overall complications.

Major complications included five STS-defined major morbidities.

Overall complications included the STS major and 14 additional morbidities.

Failure to Rescue (FTR): death among patients developing a complication.

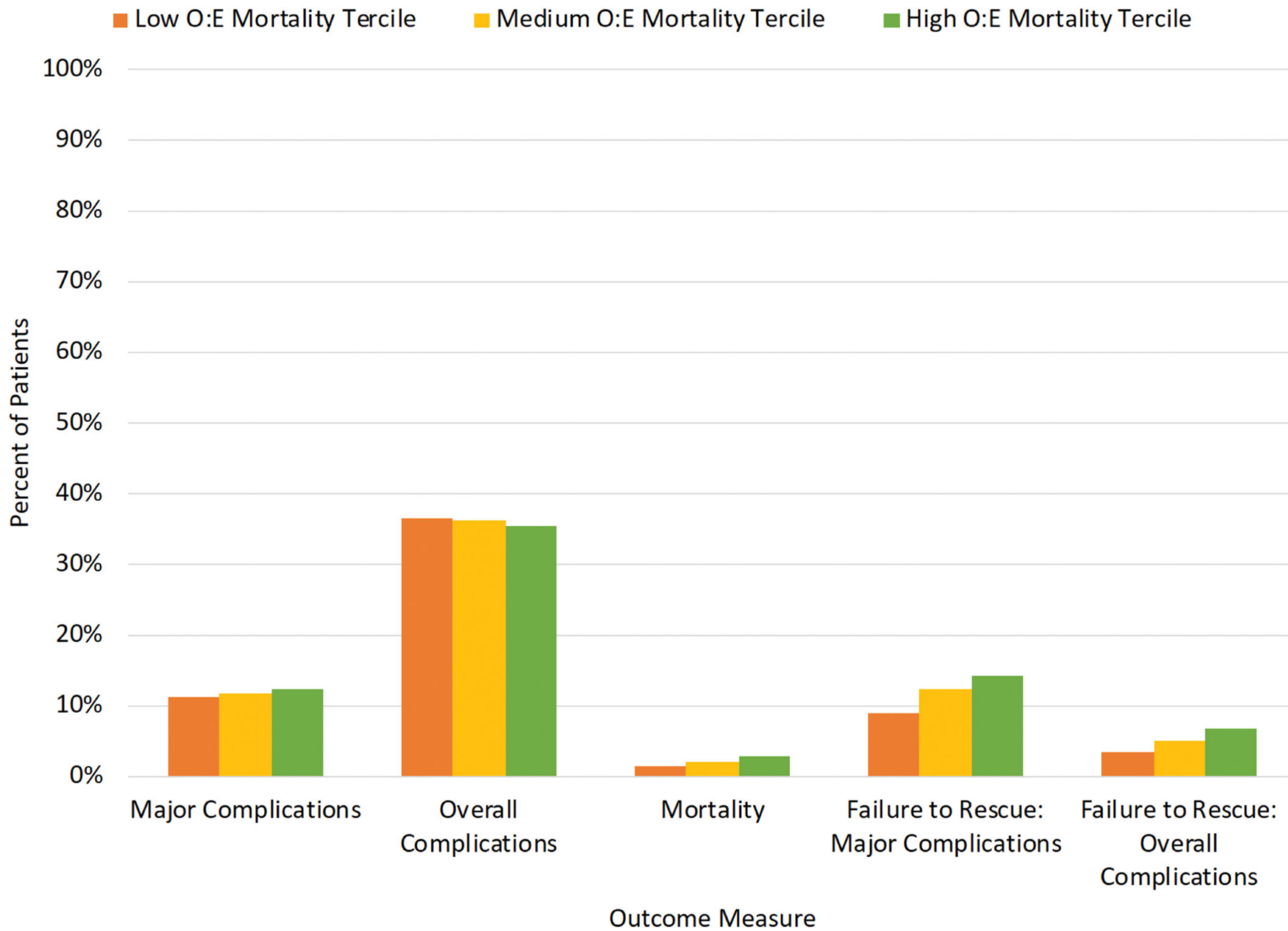


Figure 2: Complication, Mortality and Failure to Rescue Rates by Hospital Observed:Expected Mortality Tercile<

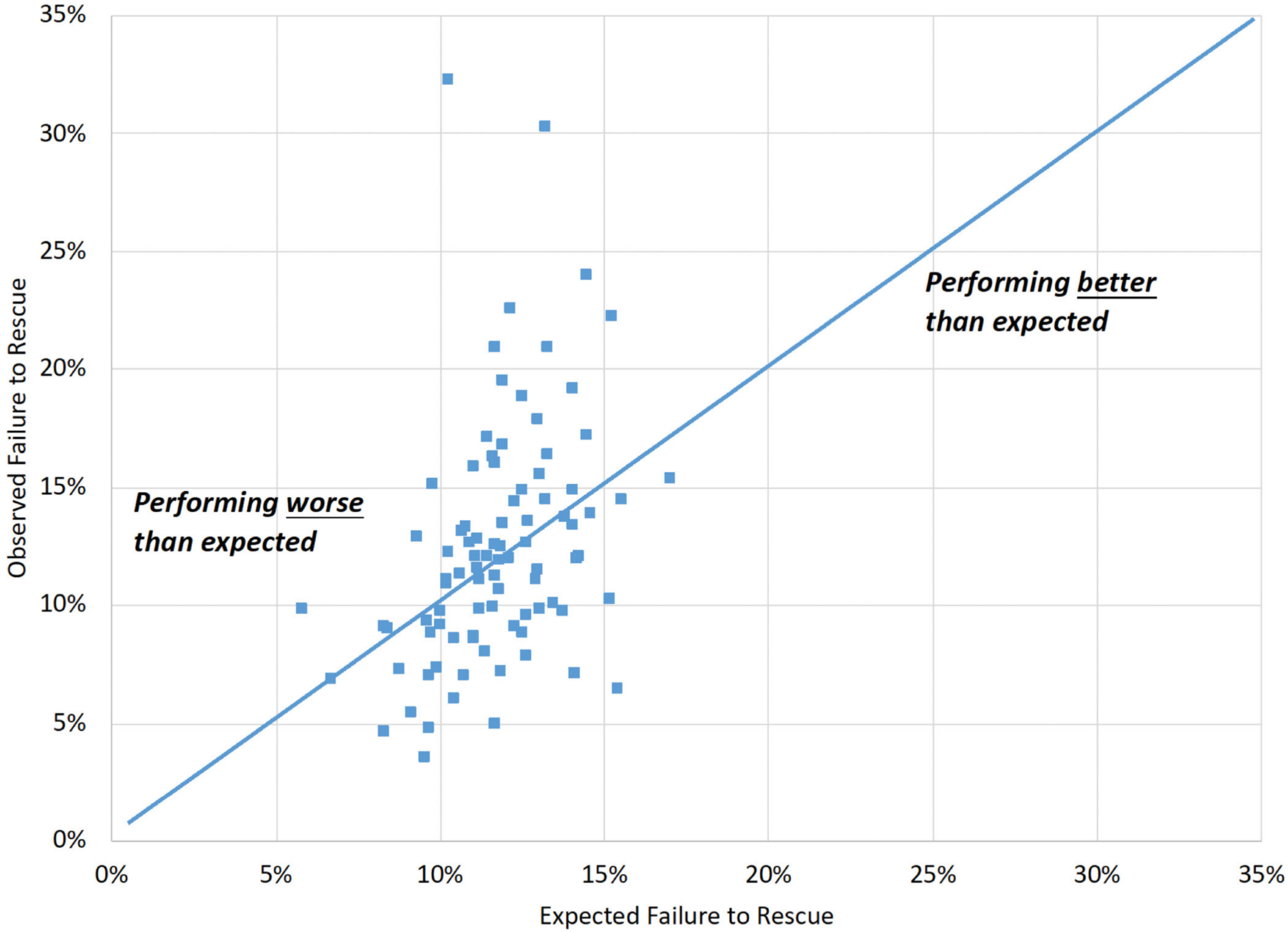
Major complications included five STS-defined major morbidities.

Overall complications included the STS major and 14 additional morbidities.

Failure to Rescue: death among patients developing a complication.

Expected mortality rates were calculated based on the STS mortality models.

O:E -> observed:expected hospital mortality tercile


35%
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10%
5%
0%
Observed Failure to Rescue
0%
5%
10%
15%
20%
25%
30%
35%
Expected Failure to Rescue
Performing better than expected
Performing worse than expected

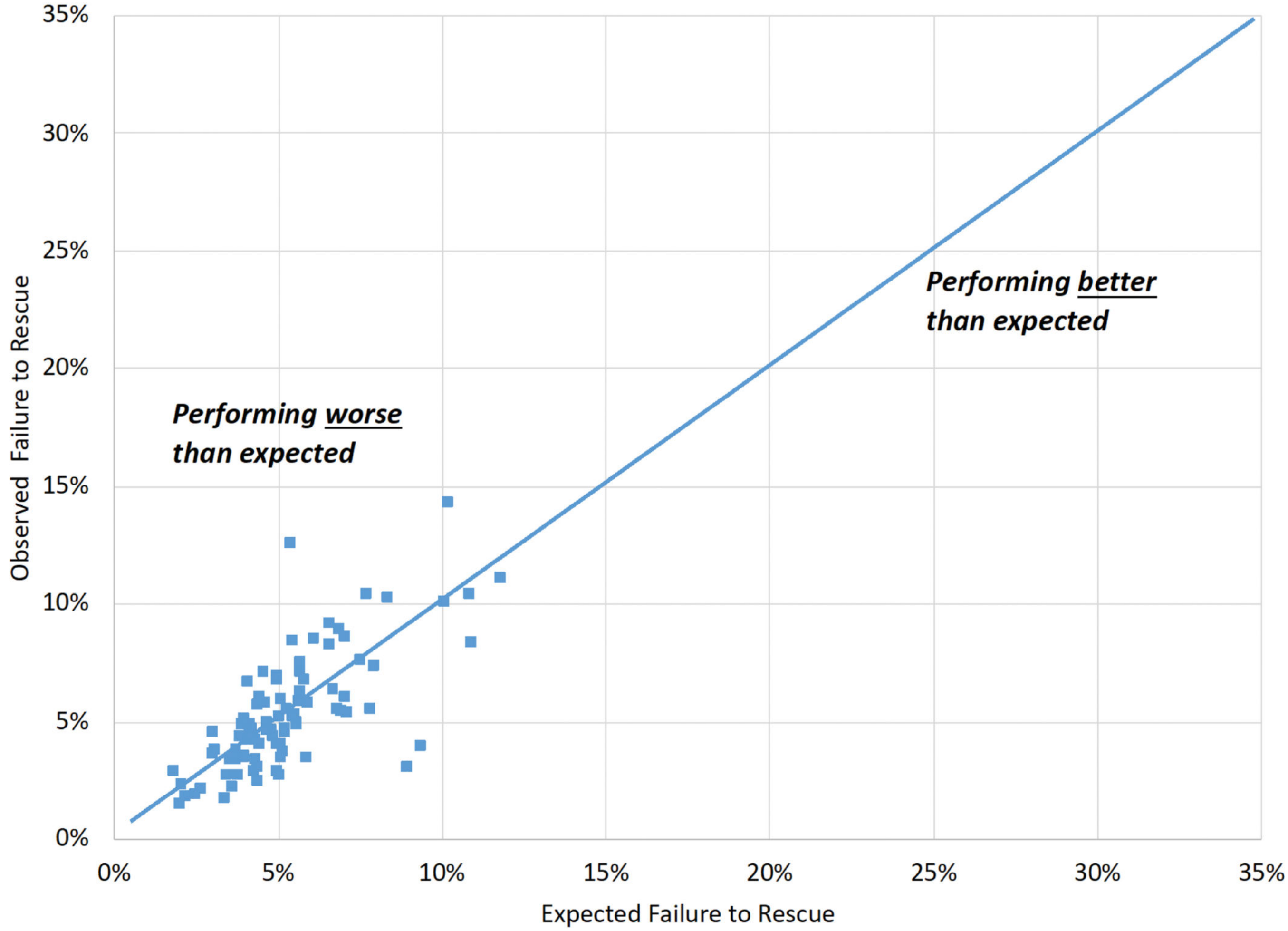

Figure 3 (A-B). Variability in Observed and Expected Failure to Rescue by Hospital:

A: Failure to rescue among major complications (five STS-defined major morbidities).

B: Failure to rescue among overall complications (STS major and 14 additional morbidities).

Expected values, derived from multivariable regression models, represent the expected hospital failure to rescue rate.

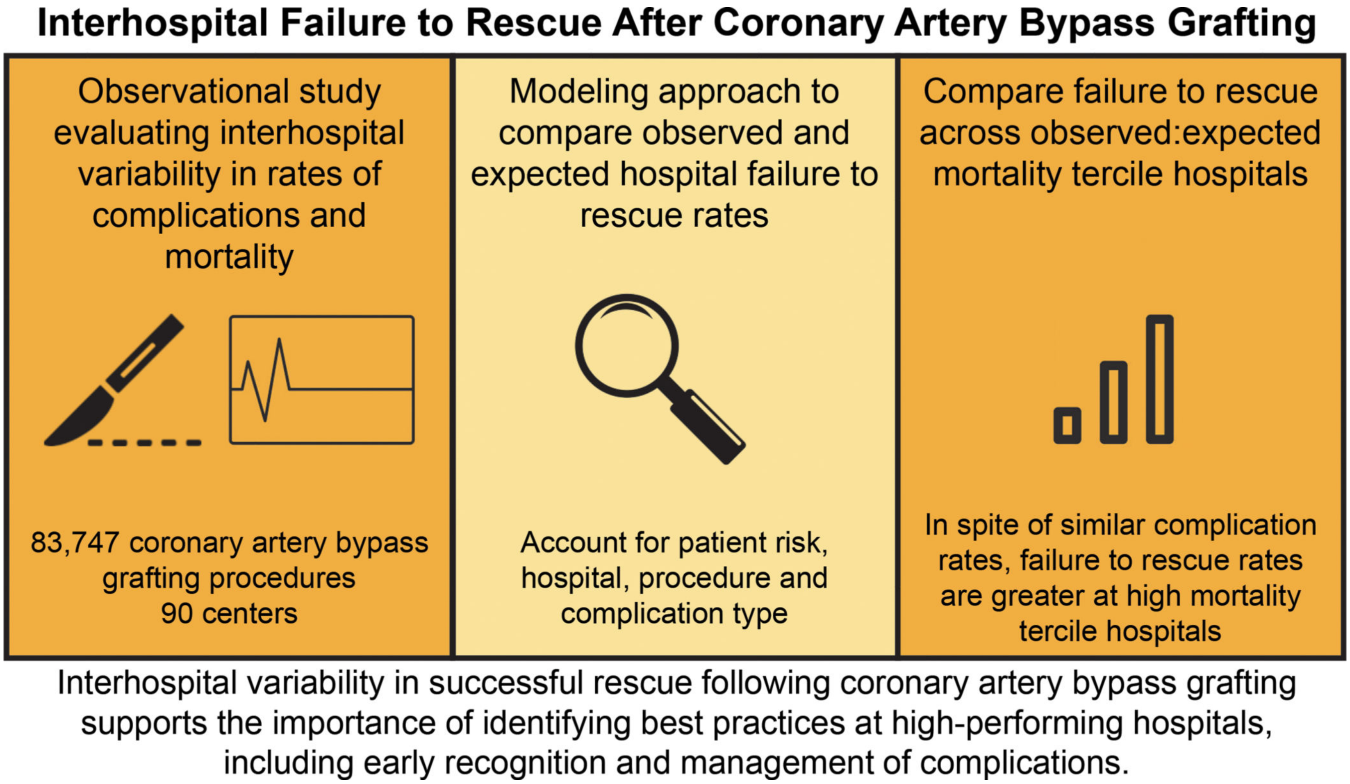

Figure 4:
Interhospital variability in mortality was attributed to failure to rescue (FTR). FTR rates were higher for patients in high observed:expected (O:E) mortality tercile hospitals. Successful rescue differed by complication type and across O:E terciles. Hospital observed and expected FTR rates were correlated although weaker for major complications.

Table 1.

Overall Cohort by Hospital Observed:Expected Mortality Terciles

Characteristic	Overall	Low O:E Mortality Tercile	Middle O:E Mortality Tercile	High O:E Mortality Tercile	p-value
Observations	83747	33984	27864	21899	
Preoperative Risk					
STS PROM (%)	1.05 (0.58, 2.11)	1.05 (0.58, 2.13)	1.05 (0.58, 2.12)	1.04 (0.58, 2.07)	0.831
Demographics					
Age (years)	66.00 [58.00, 73.00]	66.00 [59.00, 73.00]	66.00 [58.00, 73.00]	65.00 [58.00, 72.00]	<0.001
Female	20424 (24.4)	7984 (23.5)	6876 (24.7)	5564 (25.4)	<0.001
BSA	2.05 [1.89, 2.23]	2.06 [1.89, 2.23]	2.05 [1.89, 2.23]	2.05 [1.89, 2.23]	0.079
Caucasian	71352 (85.2)	30163 (88.8)	23046 (82.7)	18143 (82.8)	<0.001
Cardiac History					
Angina	20516 (24.5)	7697 (22.6)	7223 (25.9)	5596 (25.6)	<0.001
Hypertension	74199 (88.6)	29890 (88.0)	24645 (88.4)	19664 (89.8)	<0.001
PVD	12386 (14.8)	5164 (15.2)	4103 (14.7)	3119 (14.2)	0.008
Cerebrovascular Disease					<0.001
Cerebrovascular Disease Alone	9229 (11.0)	4174 (12.3)	2940 (10.6)	2115 (9.7)	
Cerebrovascular Disease and Stroke	6449 (7.7)	2456 (7.2)	2121 (7.6)	1872 (8.5)	
Myocardial Infarction					<0.001
<=6Hrs	907 (1.1)	401 (1.2)	282 (1.0)	224 (1.0)	
>6Hrs but <24Hrs	1730 (2.1)	625 (1.8)	622 (2.2)	483 (2.2)	
1– 21days	26594 (31.8)	10393 (30.6)	8614 (30.9)	7587 (34.6)	
Arrhythmia	11841 (14.1)	4901 (14.4)	3916 (14.1)	3024 (13.8)	0.113
Congestive Heart Failure and NYHA Class					<0.001
had CHF, less than Class IV NYHA	8244 (9.8)	3969 (11.7)	2653 (9.5)	1622 (7.4)	
Class IV NYHA	2979 (3.6)	1340 (3.9)	837 (3.0)	802 (3.7)	
Prior Cardiovascular Intervention	2202 (2.6)	924 (2.7)	782 (2.8)	496 (2.3)	<0.001
Diseased Vessels, Number					<0.001
Two	16339 (19.5)	6943 (20.4)	5536 (19.9)	3860 (17.6)	
Three	63906 (76.3)	25623 (75.4)	21073 (75.6)	17210 (78.6)	
Risk Factors					
Ejection Fraction	55.00 [45.00, 60.00]	55.00 [45.00, 60.00]	55.00 [45.00, 60.00]	55.00 [45.00, 60.00]	<0.001
<40	12673 (15.1)	5075 (14.9)	4158 (14.9)	3440 (15.7)	<0.001
40–50	13130 (15.7)	5372 (15.8)	4250 (15.3)	3508 (16.0)	
50–60	26880 (32.1)	11066 (32.6)	8718 (31.3)	7096 (32.4)	
Diabetes Control					<0.001

Characteristic	Overall	Low O:E Mortality Tercile	Middle O:E Mortality Tercile	High O:E Mortality Tercile	p-value
Insulin Control	14553 (17.4)	5684 (16.7)	4918 (17.7)	3951 (18.0)	
Diabetes with Other Control	24308 (29.0)	9929 (29.2)	7920 (28.4)	6459 (29.5)	
Dyslipidemia	74945 (89.5)	30884 (90.9)	24315 (87.3)	19746 (90.2)	<0.001
Dialysis	2259 (2.7)	841 (2.5)	764 (2.7)	654 (3.0)	0.001
Chronic Lung Disease					<0.001
Mild	12690 (15.2)	4901 (14.4)	4512 (16.2)	3277 (15.0)	
Moderate	3730 (4.5)	1396 (4.1)	1342 (4.8)	992 (4.5)	
Severe	3045 (3.6)	1255 (3.7)	1186 (4.3)	604 (2.8)	
Immunosuppression	2877 (3.4)	1231 (3.6)	929 (3.3)	717 (3.3)	0.046
Cardiogenic Shock on Admission	1493 (1.8)	653 (1.9)	513 (1.8)	327 (1.5)	0.001
Intra-aortic Balloon Pump	6125 (5.4)	2440 (5.0)	1888 (5.7)	1797 (5.8)	<0.001
Left Main Disease	28280 (33.8)	11459 (33.7)	9291 (33.3)	7530 (34.4)	0.05
Laboratory Values					
Preoperative Creatinine (mg/dL)	1.00 [0.80, 1.20]	1.00 [0.83, 1.20]	1.00 [0.80, 1.20]	1.00 [0.80, 1.20]	<0.001
0.8–1.0	26482 (31.6)	10575 (31.1)	8834 (31.7)	7073 (32.3)	
1.0–1.2	21976 (26.2)	9234 (27.2)	7128 (25.6)	5614 (25.6)	
>=1.2	22192 (26.5)	9170 (27.0)	7222 (25.9)	5800 (26.5)	
Acuity					<0.001
Urgent	48858 (58.3)	19123 (56.3)	16018 (57.5)	13717 (62.6)	
Emergent	2878 (3.4)	1258 (3.7)	917 (3.3)	703 (3.2)	
Emergent /Salvage	91 (0.1)	34 (0.1)	43 (0.2)	14 (0.1)	
Complication					
Major	9697 (11.6)	3779 (11.1)	3245 (11.6)	2673 (12.2)	<0.001
Overall	30265 (36.1)	12442 (36.6)	10094 (36.2)	7729 (35.3)	0.006
Stroke	1045 (1.2)	413 (1.2)	323 (1.2)	309 (1.4)	0.033
Sepsis	697 (0.8)	266 (0.8)	225 (0.8)	206 (0.9)	0.114
Surgical Site Infection	1237 (1.5)	514 (1.5)	419 (1.5)	304 (1.4)	0.445
Deep Sternal Wound Infection	288 (0.3)	104 (0.3)	103 (0.4)	81 (0.4)	0.302
Re-operation					
Overall	2880 (3.4)	1123 (3.3)	1007 (3.6)	750 (3.4)	0.109
For Bleeding	1380 (1.6)	532 (1.6)	484 (1.7)	364 (1.7)	0.244
For Valve Dysfunction	8 (0.0)	4 (0.0)	2 (0.0)	2 (0.0)	0.842
For Graft Occlusion	163 (0.2)	55 (0.2)	62 (0.2)	46 (0.2)	0.196
For Other Cardiac Indication	333 (0.4)	142 (0.4)	122 (0.4)	69 (0.3)	0.072
For Other Non-Cardiac Indication	1281 (1.5)	512 (1.5)	440 (1.6)	329 (1.5)	0.712
Coma	1993 (2.4)	793 (2.3)	636 (2.3)	564 (2.6)	0.08
Prolonged Ventilation	6882 (8.2)	2658 (7.8)	2295 (8.2)	1929 (8.8)	<0.001
Pneumonia	2027 (2.4)	750 (2.2)	704 (2.5)	573 (2.6)	0.003

Characteristic	Overall	Low O:E Mortality Tercile	Middle O:E Mortality Tercile	High O:E Mortality Tercile	p-value
Pulmonary Embolism	139 (0.2)	52 (0.2)	52 (0.2)	35 (0.2)	0.574
Renal Failure	1681 (2.0)	617 (1.8)	587 (2.1)	477 (2.2)	0.004
Renal Dialysis	1001 (1.2)	377 (1.1)	348 (1.2)	276 (1.3)	0.166
Dysrhythmia requiring permanent pacemaker	1032 (1.2)	396 (1.2)	398 (1.4)	238 (1.1)	0.001
Cardiac Arrest	1523 (1.8)	491 (1.4)	515 (1.8)	517 (2.4)	<0.001
Anticoagulation Event	400 (0.5)	144 (0.4)	173 (0.6)	83 (0.4)	<0.001
Tamponade	21 (0.0)	6 (0.0)	10 (0.0)	5 (0.0)	0.352
Gastrointenstinal Event	1924 (2.3)	889 (2.6)	617 (2.2)	418 (1.9)	<0.001
Multiorgan system failure	456 (0.5)	144 (0.4)	145 (0.5)	167 (0.8)	<0.001
Atrial Fibrillation	21536 (25.7)	9110 (26.8)	7044 (25.3)	5382 (24.6)	<0.001
Aortic Dissection	36 (0.0)	11 (0.0)	18 (0.1)	7 (0.0)	0.103
Mortality	1648 (2.0)	459 (1.4)	573 (2.1)	616 (2.8)	<0.001

Value is the “n (%)” for categorical data and the median [interquartile] for continuous data.

Abbreviations: NYHA: New York Heart Association Class; CABG: Coronary artery bypass grafting; BSA: Body Surface Area; STS PROM: Society of Thoracic Surgeons Predicted Risk of Mortality

Table 2.

Unadjusted Failure to Rescue Rates by Complication Type and Stratified by Hospital O:E Mortality Terciles

	Mortality (n)	Complication (n)	Failure to Rescue (FTR) Rates by Hospital O:E Mortality Terciles*					
Complication Type			**Overall**	**Low Tercile**	**Middle Tercile**	**High Tercile**	**Absolute Difference (High versus Low Tercile)**	**Cochran-Armitage Trend Test**
Major	1126	9697	11.6	9.1	12.4	14.3	5.2	<.0001
Overall	1448	30265	4.8	3.3	5.1	6.8	3.5	<.0001
Stroke	174	1045	16.7	15.5	15.5	19.4	3.9	0.18
Sepsis	199	697	28.5	26.3	28.9	31.1	4.8	0.25
Surgical Site Infection	38	1237	3.1	2.5	3.6	3.3	0.8	0.47
Deep Sternal Wound Infection	22	288	7.6	6.7	10.7	4.9	−1.8	0.73
Re-operation								
Overall	430	2880	14.9	14.4	15	15.6	1.2	0.48
For Bleeding	146	1380	10.6	9.8	11.4	10.7	0.9	0.59
For Valve Dysfunction	3	8	37.5	25	50	50	25.0	0.51
For Graft Occlusion	30	163	18.4	16.4	20.9	17.4	1.0	0.87
For Other Cardiac Indication	116	333	34.8	40.9	31.2	28.9	−12.0	0.059
For Other Non-Cardiac Indication	216	1281	16.9	15.6	16.4	19.5	3.9	0.16
Coma	263	1993	13.2	10.5	13.5	16.7	6.2	0.0008
Prolonged Ventilation	978	6882	14.2	11.3	15.3	16.9	5.6	<.0001
Pneumonia	250	2027	12.3	11.5	11.8	14.1	2.6	0.16
Pulmonary Embolism	13	139	9.4	7.7	3.9	20	12.3	0.087
Renal Failure	427	1681	25.4	19.3	27.9	30.2	10.9	<.0001
Renal Dialysis	328	1001	32.8	24.7	36.2	39.5	14.8	<.0001
Dysrhythmia requiring permanent pacemaker	39	1032	3.8	3.3	4.0	4.2	0.9	0.53
Cardiac Arrest	745	1523	48.9	40.3	49.9	56.1	15.8	<.0001
Anticoagulation Event	99	400	24.8	27.8	21.9	25.3	−2.5	0.54
Tamponade	6	21	28.6	16.7	20.0	60.0	43.3	0.13
Gastrointenstinal Event	249	1924	12.9	10.4	14.1	16.8	6.4	0.0008
Multiorgan system failure	353	456	77.4	75	77.9	79.0	4.0	0.40
Atrial Fibrillation	543	21536	2.5	1.6	2.9	3.4	1.8	<.0001
Aortic Dissection	4	36	11.1	0.0	11.1	28.6	28.6	0.06

Values represent frequency unless noted.

*represent percentage

Major complications include five STS-defined events.

Abbreviation: FTR: Failure to Rescue.