

Supplemental Online Content

Gaudino M, Chadow D, Rahouma M, et al. Operative outcomes of women undergoing coronary artery bypass surgery in the US, 2011 to 2020. *JAMA Surg*. Published online March 1, 2023. doi:10.1001/jamasurg.2022.8156

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This supplemental material has been provided by the authors to give readers additional information about their work.

eMethods.

Data collection and data quality control in the STS Adult Cardiac Surgery Database

Step 1: Data manager(s), the majority with a nursing background in ICU or CVOR, from each participant in the STS ACSD collect the patient-level data based on the patients' comprehensive medical record (EHR). This is mostly done at the participant's own institution (hospital or surgeon groups), and patient data are entered using ACSD-specific and STS-certified vendor software applications (certification is done with every data version and data specification upgrade). The software application is required to incorporate many robust data quality checks and data validation logic. These checks are particularly robust in case of variables used in outcomes' risk model estimation, key outcomes measures through 30-days after surgery and hospital discharge, demographic data, and critical operative variables and details.

Step 2. The data is submitted/uploaded to the STS ACSD Data Warehouse (DWH: Duke Clinical Research Institute prior to January 1, 2019, or IQVIA, January 1, 2019 and forward, over the study period) where another level of data quality and validation checks is done in addition to flagging of missing data. The results are then resent to participants in the form of a comprehensive all-inclusive data quality reports (DQR) covering every submitted data record. Participants must address all critical flags, correct errors, and complete missing data to the extent the data is available or truly missing.

Step 3. Only data that passes the DWH critical quality checks advance to data analysis. Cases with missing the analyzed outcome information are not analyzed. Outcomes are NOT imputed.

Step 4. Ten percent (10%) of all ACSD sites are audited for data accuracy and completeness every year. These audited sites are randomly selected. Participants identified to have data accuracy issues (very rare) are instructed on corrective measures and they are re-audited within two years. The audit also confirms completeness of cardiac surgery reporting (sites should submit all their cases without exception). Historically the Accuracy rate across all audited data elements has been in the 96-98%.

Step 5. Twice monthly webinars and an annual data manager meeting are held to educate abstractors and answer coding questions. The focus of education is on variables

eTable 1. The Society of Thoracic Surgeons outcomes definitions.

Outcome	Definition
Operative mortality	All-cause death occurring within 30 days postoperatively.
Prolonged hospital stay	Patients who had a postoperative hospitalization longer than 14 days.
Stroke*	Any confirmed neurological deficit of abrupt onset caused by a disturbance in blood supply to the brain that did not resolve within 24 hours.
Prolonged mechanical ventilation*	Patients who required mechanical ventilation/intubation for more than 24 hours.
Renal failure*	Increase in serum creatinine levels 4 mg/dL or greater (176.8 mmol/L), a 50% or greater increase in serum creatinine levels over the baseline preoperative value, or a new requirement for dialysis.
Reoperation*	Any patient who required a return to the operating room for bleeding with or without tamponade, graft occlusion, valve dysfunction, or other cardiac reason.
Deep sternal wound infection	Any patient who developed an infection involving muscle, bone, and/or mediastinum requiring operative intervention within 30 days postoperatively.

* Outcomes assessed during the complete postoperative period up to discharge, even if over 30 days.

eTable 2. Data fields used for risk adjustment (based on the 2018 STS Risk Model)¹.

	Operative mortality	Operative mortality and morbidity
Angiotensin-converting enzyme / angiotensin-receptor blocker usage within 48 hours	✓	
Adenosine diphosphate inhibitor usage / timing of discontinuation	✓	✓
Age	✓	✓
Alcohol consumption (drinks per week)	✓	✓
Aortic insufficiency	✓	✓
Aortic stenosis	✓	
Arrhythmia & type	✓	✓
Beta blockers	✓	
Body mass index	✓	✓
Body surface area	✓	✓
Cancer	✓	
Cardiac presentation	✓	✓
Chronic lung disease	✓	✓
Cardiovascular disease or cerebrovascular accident or transient ischemic attack	✓	✓
Carotid artery stenosis	✓	✓
Diabetes and control method	✓	✓
Ejection fraction	✓	✓
Family history of coronary artery disease	✓	✓
Glycoprotein IIb/IIIa Inhibitor within 24h	✓	✓
Heart failure class and timing	✓	✓
Hematocrit	✓	✓
Home oxygen	✓	✓
Hypertension	✓	✓
Illicit drug use	✓	
Immunosuppressive therapy	✓	✓
Inotrope	✓	✓
Left main disease	✓	✓
Liver disease	✓	✓
Mediastinal radiation	✓	
Mitral insufficiency	✓	✓
Mitral stenosis	✓	
Myocardial infarction history/timing	✓	✓
Number of diseased vessels	✓	✓
Number of previous cardiovascular surgeries	✓	✓
Payor	✓	✓
Percutaneous coronary intervention and timing	✓	✓
Platelet count	✓	✓
Preop intra-aortic balloon pump	✓	✓
Previous any other cardiac intervention	✓	✓
Previous aortic valve procedure		✓
Previous coronary artery bypass surgery	✓	✓
Previous carotid surgery	✓	
Previous implantable cardioverter-defibrillator		✓
Proximal left anterior descending artery	✓	
Peripheral vascular disease	✓	✓
Race & Ethnicity	✓	✓
Recent pneumonia	✓	✓

Recent smoker/timing	✓	✓
Renal function (dialysis/creatinine)	✓	✓
Sex	✓	✓
Shock & extracorporeal-membrane-oxygenation & catheter-based assist device	✓	✓
Sleep apnea	✓	✓
Status	✓	✓
Steroid	✓	✓
Syncope	✓	✓
Time trend		✓
Tricuspid insufficiency	✓	✓
Unresponsive neurologic status	✓	✓
White blood cell count	✓	✓

¹ From: O'Brien SM, Feng L, He X, Xian Y, Jacobs JP, Badhwar V, et al. The Society of Thoracic Surgeons 2018 Adult Cardiac Surgery Risk Models: Part 2—Statistical Methods and Results. The Annals of Thoracic Surgery. 2018 May 1;105(5):1419–28.

eTable 3. Missing data.

Variable	Missing No.	Missing percentage
Age (years)	55	0.004
Caucasian race	25,043	1.93
Body mass index (kg/m ²)	755	0.06
Body surface area (m ²)	2,919	0.23
Family history of coronary disease	47,424	3.66
Hypertension	1,615	0.12
Diabetes	1,830	0.14
Prior myocardial infarction	6,451	0.50
Peripheral vascular disease	4,877	0.38
Cerebrovascular disease	5,761	0.44
Chronic lung disease	22,791	1.76
Obstructive sleep apnea	31,192	2.41
Need for home oxygen	27,868	2.15
Cancer diagnosis within 5 years	33,120	2.55
Mediastinal radiation	24,250	1.87
Recent pneumonia	35,500	2.74
Liver disease	16,086	1.24
Dialysis	2,270	0.18
Endocarditis	2,311	0.18
Illicit drug use	45,596	3.52
Alcohol consumption	47,530	3.66
Preoperative intra-aortic balloon pump	3,070	0.24
Urgent surgery	516	0.04
Steroids within 24 hours	6,804	0.53
Glycoprotein IIb/IIIa inhibitor within 24 hours	5,168	0.40
Inotropes within 48 hours	3,251	0.25
ADP receptor inhibitor usage within 5 days	6,827	0.53
Immunosuppressive therapy within 30 days	4,120	0.32
Cardiogenic shock	1,370	0.11
Number of diseased coronary vessels	7,366	0.57
Left main disease	0	0
Proximal left anterior descending disease	0	0
Ejection fraction (%)	31,848	2.46
Hematocrit (%)	9,456	0.73
White blood cell count (10 ³ /uL)	9,729	0.75
Platelet count (10 ³ /uL)	30,910	2.38

eTable 4. Annual coronary artery bypass grafting procedures by sex.

Year	Overall CABG procedures (n=1,297,204)	Procedures in men (n=979,488)	Procedures in women (n=317,716)	P-value
2011	66,385	48,969 (73.8)	17,416 (26.2)	<0.001
2012	135,668	100,498 (74.1)	35,170 (25.9)	<0.001
2013	137,653	102,809 (74.9)	34,844 (25.1)	<0.001
2014	138,692	104,310 (75.2)	34,382 (24.8)	<0.001
2015	144,829	109,119 (75.3)	35,710 (24.7)	<0.001
2016	150,929	114,349 (75.8)	36,580 (24.2)	<0.001
2017	152,999	116,067 (75.9)	36,932 (24.1)	<0.001
2018	153,003	116,787 (76.3)	36,216 (23.7)	<0.001
2019	154,731	118,404 (76.5)	36,327 (23.4)	<0.001
2020	62,315	48,176 (77.3)	14,139 (22.7)	<0.001

Data are presented as count (%). CABG: coronary artery bypass grafting.

eTable 5. Outcomes by sex stratified by multiple or single arterial grafting and off- or on-pump CABG.

Multiple arterial grafting	Overall (n=155,446)	Men (n=117,358)	Women (n=38,088)	Adjusted OR
• Operative mortality	3,093 (2.0)	2,020 (1.7)	1,073 (2.8)	1.23 (1.09-1.38)
Single arterial grafting	Overall (n=1,084,671)	Men (n=819,174)	Women (n=265,497)	Adjusted OR
• Operative mortality	21,088 (1.9)	13,593 (1.7)	7,495 (2.8)	1.28 (1.23-1.34)
Off-pump CABG	Overall (n=182,735)	Men (n=137,546)	Women (n=45,189)	Adjusted OR
• Operative mortality	3,529 (1.9)	2,248 (1.6)	1,281 (2.8)	1.30 (1.17-1.45)
On-pump CABG	Overall (n=1,114,469)	Men (n=841,942)	Women (n=272,527)	Adjusted OR
• Operative mortality	21,808 (2.0)	14,120 (1.7)	7,688 (2.8)	1.28 (1.22-1.33)

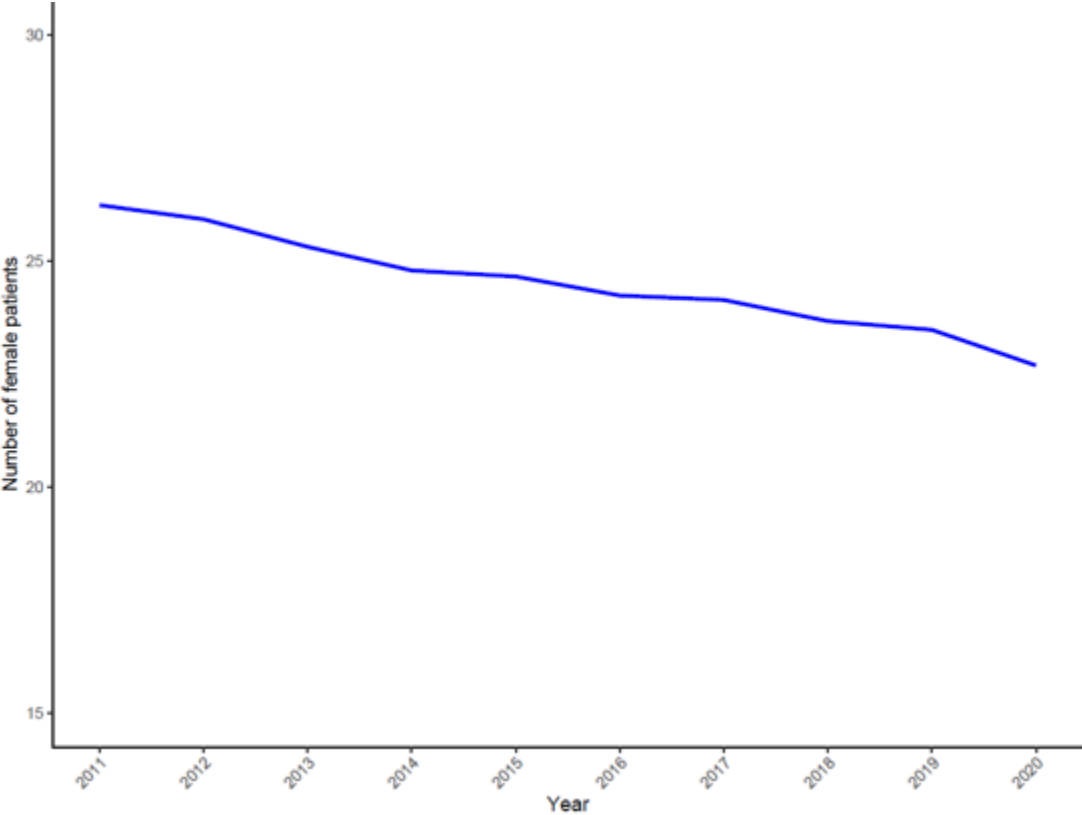
CABG: coronary artery bypass grafting; OR: odds ratio.

eTable 6. Unadjusted primary and secondary outcome by sex and year.

Operative mortality	Men (%)	Women (%)	P-value
2011	667 (1.6)	435 (2.9)	<0.0001
2012	1,389 (1.6)	864 (2.9)	<0.0001
2013	1,408 (1.6)	844 (2.8)	<0.0001
2014	1,658 (1.8)	882 (2.8)	<0.0001
2015	1,964 (1.8)	1,100 (3.2)	<0.0001
2016	2,054 (1.8)	1,037 (2.9)	<0.0001
2017	2,167 (1.9)	1,160 (3.2)	<0.0001
2018	2,061 (1.8)	1,104 (3.1)	<0.0001
2019	2,087 (1.8)	1,077 (3.0)	<0.0001
2020	913 (1.9)	466 (3.3)	<0.0001
Operative mortality and morbidity	Men (%)	Women (%)	P-value
2011	8,299 (19.4)	4,098 (26.4)	<0.0001
2012	16,816 (19.2)	8,000 (25.7)	<0.0001
2013	16,767 (18.6)	7,719 (25.1)	<0.0001
2014	16,687 (17.6)	7,567 (23.9)	<0.0001
2015	18,230 (17.1)	8,100 (23.1)	<0.0001
2016	19,204 (16.9)	8,330 (22.9)	<0.0001
2017	19,577 (16.9)	8,612 (23.4)	<0.0001
2018	20,150 (17.3)	8,356 (23.2)	<0.0001
2019	19,880 (16.9)	8,580 (23.7)	<0.0001
2020	7,891 (16.5)	3,300 (23.5)	<0.0001

Data are presented as count (%).

eFigure 1. Annual percentage of women undergoing coronary artery bypass grafting between 2011 and 2020.



*P for trend <0.001.

eFigure 2. Observed-to-expected (O/E) operative mortality ratios by year for both sexes.

