




ORIGINAL RESEARCH

A Failed Cardiac Surgery Program in an Underserved Minority Population County Reimagined: The Power of Partnership

James M. Brown , MD; M. J. Hajjar-Nejad , MD; Guerda Dominique, PAC; Malinda Gillespie, RN; Imran Siddiqi, MD, MBA; Heather Romine, BS; Patrick Odonkor , MD; Murtaza Dawood, MD; James S. Gammie, MD

BACKGROUND: Prince George's County Maryland, historically a medically underserved region, has a population of 909 327 and a high incidence of cardiometabolic syndrome and hypertension. Application of level I evidence practices in such areas requires the availability of highly advanced cardiovascular interventions. Donabedian principles of quality of care were applied to a failing cardiac surgery program. We hypothesized that a multidisciplinary application of this model supported by partnership with a university hospital system could result in improved quality care outcomes.

METHODS AND RESULTS: A 6-month assessment and planning process commenced in July 2014. Preoperative, intraoperative, and postoperative protocols were developed before program restart. Staff education and training was conducted via team simulation and rehearsal sessions. A total of 425 patients underwent cardiac surgical procedures. Quality tracking of key performance measures was conducted, and 323 isolated coronary artery bypass grafting procedures were performed from July 2014 to December 2019. Key risk factors in our patient demographic were higher than the Society of Thoracic Surgeons national mean. Risk-adjusted outcome data yielded a mortality rate of 0.3% versus 2.2% nationally. The overall major complication rate was lower than expected at 7.1% compared with 11.5% nationally. Readmission rate was less than the Society of Thoracic Surgeons mean for isolated coronary artery bypass grafting (4.0% versus 10.1%, $P < 0.0001$). Significant differences in 6 key performance outcomes were noted, leading to a 3-star Society of Thoracic Surgeons designation in 7 of 8 tracking periods.

CONCLUSIONS: Excellent outcomes in cardiac surgery are attainable following program renovation in an underserved region in the setting of low volume. The principles and processes applied have potential broad application for any quality improvement effort.

Key Words: coronary artery bypass grafting ■ Donabedian triad ■ health disparities ■ health outcomes ■ quality improvement ■ partnership model ■ patient-centric process maps

See Editorial by Lazar

Fifty years ago, Donabedian described the triad of structure, process, and outcome in relation to quality in health care.¹⁻⁴ Structure was defined as the hospital facility, equipment, qualifications of personnel, administrative structure, operation of programs, and fiscal organization.^{1-3,5,6} Process was defined as all aspects of the interaction of the structure

with the patient during an episode of care.^{1,2,5} Outcome under this model was given license to include all aspects of the result, especially the patient's short- and long-term health. Outcome measures or metrics could be chosen to evaluate outcomes and thereby monitor quality of care provided. This might include health status, delivery of care outcomes, patient well-being/

Correspondence to: James M. Brown, MD, Division of Cardiac Surgery, University of Maryland School of Medicine, 110 South Poca Street, 7th Floor, Baltimore, MD 21201. E-mail: jmbrown@som.umaryland.edu

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CLINICAL PERSPECTIVE

What Is New?

- A simplified yet focused approach may be undertaken to develop a highly successful cardiac surgery program.
- Developing a key partnership with a major medical system allows for provision of highly advanced care with appropriate support systems in place.
- The methodology employed focused on simple tenets of health care and optimized structure, process, and outcome dynamics to achieve goals.

What Are the Clinical Implications?

- Our approach resulted in excellent outcomes and a top-tier rating from the Society of Thoracic Surgeons.
- By providing highly advanced cardiac surgical care in an underserved community, healthcare disparities were decreased.
- Prior volume outcome assertions were not applicable as low volumes did not exclude excellent performance, and this experience may be replicated by existing cardiac surgery programs in need of quality improvement or may serve as a roadmap for newly forming programs.

Nonstandard Abbreviations and Acronyms

AATS	American Association for Thoracic Surgery
ACSD	Adult Cardiac Surgery Database
STS	Society of Thoracic Surgeons
STSNDB	Society of Thoracic Surgeons National Database
UMMC	University of Maryland Medical Center
UMMS	University of Maryland Medical System
UMCRH	University of Maryland Capital Region Health

satisfaction, and optimal utilization of resources.^{3,6} Now, the National Quality Forum, National Committee for Quality Assurance, and Medicare scrutinize process and outcome measures. Cardiothoracic surgery outcomes in the United States are analyzed using the Society of Thoracic Surgeons (STS) National Database (STSNDB), which provides an evidence-based quality tool and in-depth modeling to provide accurate risk-adjusted outcome measures.

These fundamental Donabedian principles of quality were applied to a failed urban cardiac surgery

program in an underserved county of 909 327 people with a large cardiovascular disease burden, high death rates, high rates of cardiometabolic syndrome, and poor access to health care (Figure 1). Specifically, the program had a volume of <20 procedures per year with high mortality, poor quality measures, lack of equipment, and absence of systematically integrated personnel to perform advanced cardiac surgery.

The University of Maryland's School of Public Health Impact study (2012) reported that 20% of the county's eligible population had no health insurance as of 2005. A total of 62% of the county's population are Black. More than 12 million years of life are lost annually in this patient group in the United States from cardiometabolic diseases.⁷ Chiefly, in embarking on this journey, it was critical for us to address the lack of access to care (ie, cardiac surgery) and to help eradicate healthcare disparities in the region. For the first goal, we focused on reorganizing the cardiac surgery program to increase access to the appropriate level of complex care with high value.

Our hypothesis was that a simplified yet rigorous multidisciplinary application of the Donabedian triad could result in quality care at the newly restructured University of Maryland Capital Region Health (UMCRH) Cardiac Surgery program as measured by standard outcome measures established by the STSNDB, widely accepted as one of the most reliable clinical databases in the world. The heart of Donabedian's work essentially conveys the importance of evaluating the entire healthcare delivery process in assessing the quality of patient care. It is the fidelity and precision with which protocols and interventions are implemented, or proper use of infrastructure, which generates optimal outcomes for patients while embracing patient safety simultaneously.³ The STS Adult Cardiac Surgery Database (ACSD) is a tool that permits dynamic "real-time" assessment of interventions and allows for continuous quality improvement. It contains more than 6.9 million cardiac surgery procedure records and has 3800 participating physicians.⁸ The STS has developed a rating system for the quality of coronary artery bypass grafting (CAB) surgery among hospitals nationally. Approximately 12% to 15% of hospitals receive a 3-star rating, which denotes the highest category of quality. The overall aim of this endeavor was to reduce surgical healthcare disparities for patients by developing a comprehensive patient-centric cardiac care program starting with a focus on the cardiac surgery program. To accomplish this task, proper planning, teamwork, and collaboration were utilized in a systematic manner. Coordinated, patient-centered, and culturally competent systems of care starting with policy-making were implemented.⁹ The process was orchestrated from a top-down

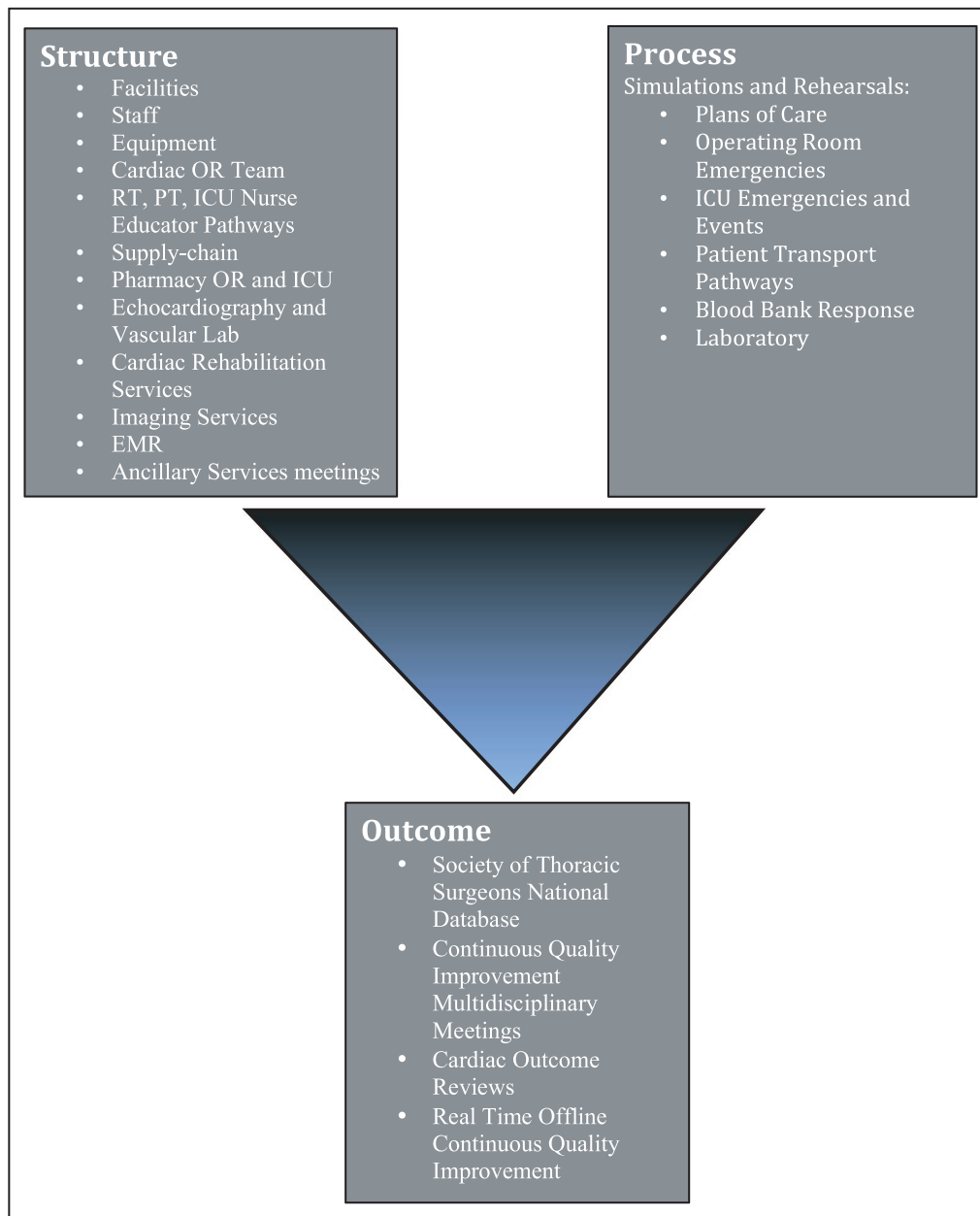


Figure 1. Donabedian triad applied to the cardiac surgery program at the University of Maryland Capital Region Health.

EMR indicates electronic medical record; ICU, intensive care unit; OR, operating room; PT, physical therapy; RT, respiratory therapy and STS, Society of Thoracic Surgeons.

approach by utilizing the expertise of a University of Maryland Medical System (UMMS) and an experienced cardiac surgery team.

METHODS

Program Characteristics

The data that support the findings of this study are available from the corresponding author on reasonable request. The University of Maryland School of

Medicine faculty, UMCRH, and the UMMS performed detailed assessments of the entire process of care for cardiac surgery patients to develop patient-centric process maps in cardiac surgery (Figure 2). Before our involvement with the cardiac surgery program, there was no participation with STS. Notably, the volumes performed in the program were extremely low, at <20 cases per year with a high mortality rate (no predicted risk of mortality models secondary to lack of use of STS ACSD). This information was extracted by individual chart reviews by our cardiac surgery team. All

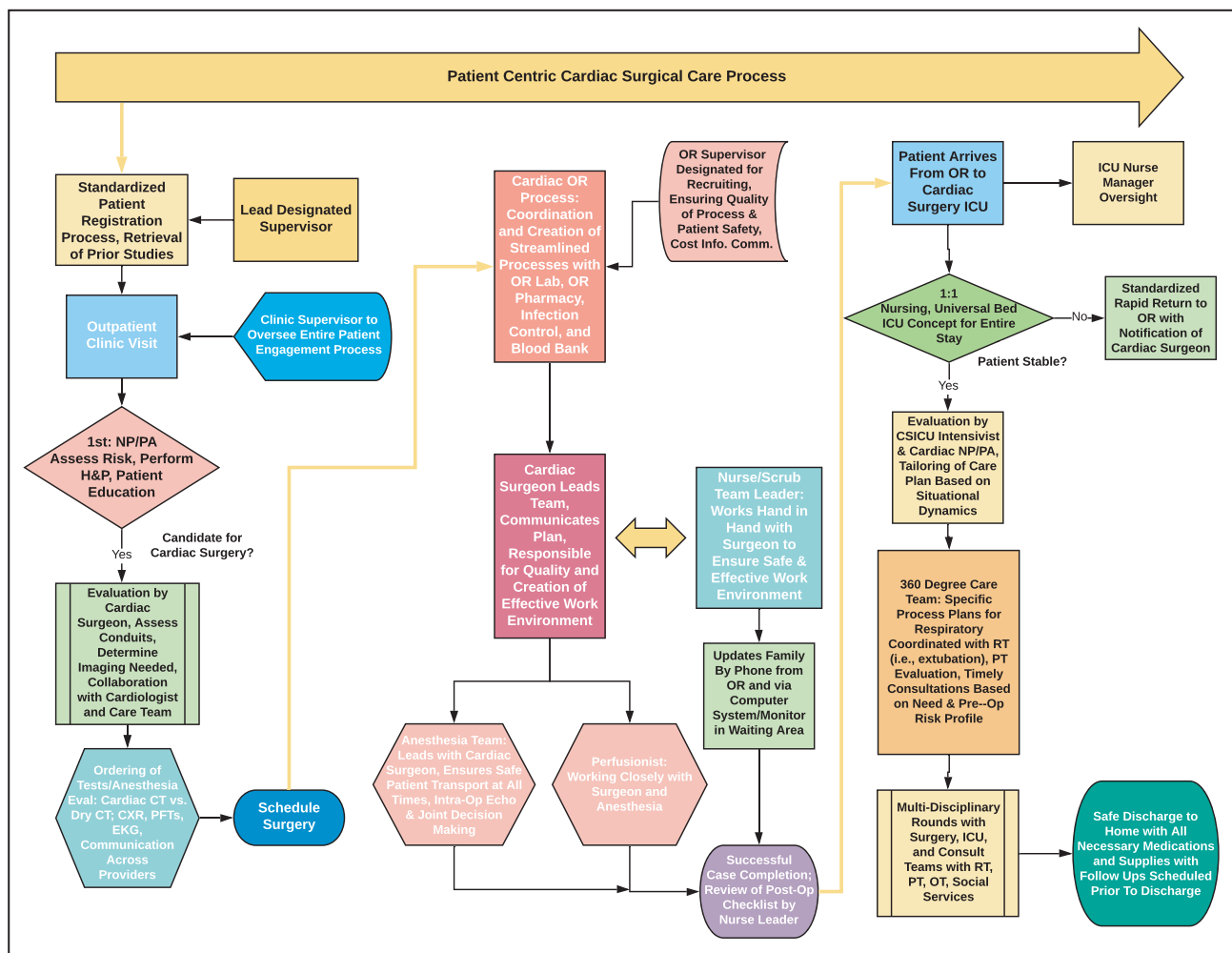


Figure 2. Patient-centric process charts for outpatient, intraoperative, and intensive care unit (ICU) care.

CSICU indicates cardiac surgery intensive care unit; CT, computerized tomography; CXR, chest x-ray; H&P, history and physical; NP, nurse practitioner; OR, operating room; OT, occupational therapy; PA, physician assistant; PFTs, pulmonary function tests; PT, physical therapy; and RT, respiratory therapy.

processes and structure of care including preoperative, intraoperative, and postoperative protocols were recreated and rehearsed before program restart via novel handcrafted process maps. STS guidelines for glycemic control and American Association for Thoracic Surgery (AATS) guidelines for prevention of sternal wound infection were strictly instituted in the cardiac surgery program.^{10,11}

The planning process also included examination of staff, facilities, and equipment. Emphasis was placed on quality, safety, and patient-centric thinking at all times. Staff were educated by training on site or within the UMMS. Further, a cardiac surgery team of nurse practitioners, certified physician assistants, perfusion specialists, and anesthesiologists was hired. Hired staff met the following criteria: (1) a track record of excellence, (2) an interest in the challenging nature of the project, and (3) >10 years of experience. For our advanced practice provider team,

we hired 2 nurse practitioners and 4 physician assistants. Two perfusionists were brought on board and a supporting team of 8 anesthesiologists was utilized from the University of Maryland. As all equipment was outdated, key equipment for high-quality cardiac care was purchased. This included a new heart-lung machine, new cerebral oxymetry monitoring equipment, and new cardiac operating room instruments and supplies. Additionally, we acquired new rotational thromboelastometry laboratory testing equipment for platelet count and function, a new microcardioplegia delivery system, and a new extracorporeal membrane oxygenator machine. For the operating room, we also brought in a new transesophageal echocardiography machine with probes. Overall investments to hire staff, provide training, and purchase new equipment totaled \$3.2 million.

A comprehensive, multimodality, multiphase effort was used to accomplish our goals in setting up this

program. Team simulations and training were also conducted at all phases of patient care. An integrated system of patient care delivery was created between UMCRRH and the University of Maryland Medical Center (UMMC) for advanced care needs such as transplantation, ventricular assist device treatment, or advanced structural heart therapies.

The cardiac surgery program initiated a wide-ranging campaign to bring to the attention of the medical community its presence and the availability of advanced cardiac surgical services in Prince George's County. This was accomplished by holding numerous seminars, meetings, and talks with groups of primary care physicians, cardiologists, and other specialists in the region. Our regional outreach efforts included cardiac symposia inviting primary care physicians and specialists from the region, in order to provide coordinated care and ensure that any patient who has cardiovascular disease is appropriately screened, diagnosed, and referred appropriately. Through working with the medical center, we conducted Internet marketing, revamped our hospital and program website, and ran advertisements on TV and radio regularly to increase awareness in the community. Significant community outreach was also accomplished through our Heart Disease Campaign, organized community gatherings, and special events within the hospital. Along with this, we host an Annual Heart & Health Bike Tour in support of cardiac surgery services at UMCRRH.

Postoperative intensive care unit care was performed in a closed unit designated for cardiac surgery patients only. We utilized a Universal Bed Model, wherein patients stayed in the same bed from operation to discharge. Intensive care unit care was orchestrated by a 3-way collaboration with a designated intensive care unit cardiac surgery intensivist, a cardiac surgeon, and an advanced practice provider. Our advanced practice provider team would provide overnight coverage working in conjunction with the cardiac surgeon on call. The study was reviewed by the University of Maryland's institutional review board and received exemption, as it did not use protected health information.

UMCRRH Patient Study Group

The study group comprised 425 total patients who underwent cardiac surgical procedures from July 2014 to December 2019. Of those, 323 patients underwent CAB, 48 underwent isolated valve procedures, 13 underwent combined procedures, and 33 underwent other procedures, such as atrial fibrillation correction surgery and aortic aneurysm repair. Off-pump CAB was used as needed.¹² A heart team approach to determine suitability for CAB grafting (CABG) was used.

The STS Short-Term Risk Calculator was used in all decision-making algorithms.

Operative Techniques

Operative techniques were standard and included general anesthesia, a median sternotomy approach, central venous cannulation, arterial line and pulmonary artery catheter monitoring, mild systemic cooling, aortic cross-clamping, and cold blood cardioplegic cardiac arrest. Of note, an epiaortic ultrasound of the ascending aorta was performed in all cases before planning cannulation and cross-clamping.¹² For severe atherosclerosis of the ascending aorta characterized by large or mobile atheroma, an off-pump, but no-touch, technique was used, with T grafts off the internal thoracic artery when necessary.¹² For lesser degrees of atherosclerosis of the ascending aorta and arch, the approach was modified to include a single-clamp technique in the on-pump group and altered proximal placement in the off-pump group.

Statistical Analysis

Data were collected and submitted to STSNDB on a quarterly basis. Results are all displayed below in tabulation format. Key terms or variables are in line with those used by the STS report. *P* values for all measures were calculated via MedCalc's N-1 chi-square test (MedCalc Software Ltd) as recommended by Campbell¹³ and Richardson¹⁴ to independently establish significance in all examined variables. The data had already been analyzed by the STS via odds ratios, ratio of observed deaths to expected deaths, and risk-adjusted rates to stratify performance among hospital programs. A *P*<0.05 was considered statistically significant.

RESULTS

A total of 425 total cardiac procedures were performed. Of those, 323 were CABs (isolated CABG). Preoperative variables are shown in Table 1, operative variables in Table 2, and patient outcomes in Table 3.

Several risk factors in our patient cohort were more common than the STS national mean (Table 1). Family history of coronary artery disease grafting and current/recent cigarette smoking were present in a larger proportion of our patient population (39.3% versus 18.7% [*P*<0.0001] and 61.6% versus 21.1% [*P*<0.0001], respectively). Chronic lung diseases were present in 35.9% of our patient population undergoing isolated CAB, as compared with 26.6% of patients in the STS database (*P*=0.0002). Additionally, 36.2% of our patients had peripheral artery disease versus 13.3% nationally (*P*<0.0001). The groups

Table 1. Preoperative Characteristics and Risk Factors of the Study Patients Versus STS Isolated CAB

Variable	UMCRH All Cases (07/17/14–12/31/19)		UMCRH Isolated CAB (07/17/14–12/31/19)		STS Isolated CAB (01/01/19–09/30/19)		UMCRH vs STS Isolated CAB, P Value
	n=425		n=323		n=170 304		
Age, y	63.2±11.1		63.7±9.8		65.8		
Women	132 (31.1%)		91 (28.2%)		23.7%		0.0575
Race							
White	131 (30.8%)		78 (24.1%)		81.9%		<0.0001
Black	236 (55.5%)		200 (61.9%)		7.5%		<0.0001
Asian	16 (3.8%)		15 (4.6%)		3.7%		0.3921
Native American	2 (0.5%)		2 (0.6%)		0.7%		0.8295
Hispanic or Latino	24 (5.6%)		14 (4.3%)		8.0%		0.0143
Other	14 (3.3%)		14 (4.3%)		4.3%		1.0000
BMI, kg/m ²							
Normal (BMI 18.5–24.9)	84/425	19.8%	63/323	19.5%	17.6%	0.3704	
Overweight (BMI 25.0–29.9)	146/425	34.4%	124/323	38.4%	36.8%	0.5514	
Obese I (BMI 30.0–34.9)	105/425	24.7%	72/323	22.3%	27.0%	0.0573	
Obese II (BMI 35.0–39.9)	65/425	15.3%	51/323	15.8%	11.8%	0.0260	
Morbid obesity (BMI 40.0+)	25/425	5.9%	19/323	5.9%	6.0%	0.9397	
Risk factors							
Hypertension	370/425	87.1%	292/323	90.4%	90.6%	0.9021	
Diabetes mellitus	233/425	54.8%	188/323	58.2%	50.5%	0.0057	
HbA _{1c}	7.8±1.9		8.0±1.9				...
HbA _{1c} among insulin-dependent population	8.5±2.1		8.6±2.0				...
HbA _{1c} among a non-insulin-dependent population	7.5±1.6		7.7±1.7				...
Preoperative creatinine	1.3±1.5		1.3±1.5		1.2		
Dyslipidemia	374/425	88.0%	299/323	92.6%	90.8%	0.2634	
Family history of CAD	161/425	37.9%	127/323	39.3%	18.7%	<0.0001	
Current/recent cigarette smoker	243/425	57.2%	199/323	61.6%	21.1%	<0.0001	
Chronic lung disease	156/425	36.7%	116/323	35.9%	26.6%	0.0002	
Congestive heart failure	45/425	10.6%	39/323	12.1%	14.7%	0.1873	
Peripheral arterial disease	137/425	32.2%	117/323	36.2%	13.3%	<0.0001	
Renal failure, dialysis-dependent	19/425	4.5%	15/323	4.6%	3.1%	0.1204	
Cardiac pressure on admission							
No symptoms or angina	124/425	29.2%	43/323	13.3%	6.9%	<0.0001	
Stable angina	58/425	13.6%	36/323	11.1%	16.1%	0.0146	
Unstable angina	101/425	23.8%	107/323	33.1%	32.6%	0.8481	
NSTEMI	73/425	17.2%	89/323	27.6%	28.5%	0.7204	
STEMI	27/425	6.4%	35/323	10.8%	4.8%	<0.0001	
Angina equivalent	18/425	4.2%	8/323	2.5%	4.4%	0.0961	
No. of diseased coronary vessels							
One	35/425	8.2%	20/323	6.2%	3.7%	0.0175	
Two	80/425	18.8%	68/323	21.1%	18.5%	0.2293	
Three	243/425	57.2%	233/323	72.1%	77.0%	0.0366	
Left main disease (≥50% stenosis)	69/425	16.2%	67/323	20.7%	31.8%	<0.0001	
Status							
Surgery status							
Elective	208/425	48.9%	125/323	38.7%	37.8%	0.7389	

(Continued)

Table 1. Continued

	UMCRH All Cases (07/17/14–12/31/19)		UMCRH Isolated CAB (07/17/14–12/31/19)		STS Isolated CAB (01/01/19–09/30/19)	UMCRH vs STS Isolated CAB, P Value
	n=425		n=323		n=170 304	
Urgent	205/425	48.2%	188/323	58.2%	58.6%	0.8841
Emergent	12/425	2.8%	10/323	3.1%	3.4%	0.7663
Emergent salvage	0/425	0%	0/323	0%	0.2%	0.4211
MI	180/425	42.4%	170/323	52.6%	52.9%	0.9141

BMI indicates body mass index; CAB, coronary artery bypass; CAD, coronary artery disease; HbA_{1c}, glycated hemoglobin; MI, myocardial infarction; NSTEMI, non-ST-segment-elevation myocardial infarction; STEMI, ST-segment-elevation myocardial infarction; STS, Society of Thoracic Surgeons; and UMCRH, University of Maryland Capital Region Health.

were also different in the disease category of diabetes mellitus (58.2% versus 50.5%, respectively; $P=0.0057$). However, there was no difference between groups for dialysis-dependent patients with renal failure (4.6% versus 3.1%, $P=0.1204$). Cardiac presentation on admission, number of diseased coronary vessels, and surgical status are all also presented in Table 1.

Mean graft number, use of the left internal mammary artery, and percentage of off-pump procedures are all presented in Table 2. A total of 96.3% in the UMCRH study group received a left internal mammary artery ($P=0.0082$). The majority of patients (32.8%) received 3 grafts ($P=0.0075$). A total of 5.9% of 323 cases were done off-pump ($P=0.0040$).

Observed 30-day mortality for the isolated CABG group during the time period under study (July 2014 to December 2019) was 0.3% (expected 2.5%; ratio of observed deaths to expected deaths, 0.1 [$P=0.0199$]). The national observed 30-day mortality from January 2019 to September 2019 was 2.2% in the STS ACSD (Table 3). The overall major complication rate was 7.1% as compared with 11.5% nationally (Table 3, Figure 3; $P=0.0132$). The readmission rate was less than the STS mean for the CABG cohorts (4.0% versus 10.1%, $P<0.0001$) (Table 3).

Stroke (0.9% versus 1.4%, $P=0.4446$) and deep sternal wound infection were the same (0% versus 0.3%, $P=0.3242$) in both groups. Renal failure (0% versus 2.2% [$P=0.0070$]), reoperation for any reason (0.9% versus 3.7% [$P=0.0077$]), postoperative atrial

fibrillation (4.6% versus 25.9% [$P<0.0001$]), and degree of prolonged ventilation (1.24% versus 7.2% [$P<0.0001$]) were less than the STS mean, as shown in Table 3. Extubation by 6 hours was greater than the STS mean (86.7% versus 59.1%, $P<0.0001$).

The total length of stay (LOS) was defined by STS as the number of days from the date of admission to the date of discharge. The median LOS in our program of 4 days was 48 hours shorter than the national average of 6 days, as shown in Table 3. The overall average trend of our LOS since program inception to present (2014–2020) has decreased from 6 to 3 days.

Approximately 10% of patients were transferred to UMMC for advanced levels of care. These transfers occurred to UMMC for 3 main reasons: (1) patients who were not a surgical candidate and required potential supported (eg, Impella [ABIOMED]) high-risk angioplasty, (2) severely reduced left ventricular function necessitating ventricular assist device backup, and (3) requirement for advanced extracorporeal membrane oxygenation support. The STS predicted risk of mortality for operative patients was 1.743% (mean predicted risk of mortality). The 30-day mortality and median LOS (from surgery to discharge) for these patients was 0% and 5 days, respectively.

In the current analysis of national data covering the period from January 1, 2019, to September 30, 2019, the CAB surgery performance (isolated CAB only) of our hospital was found to be in the highest quality tier,

Table 2. Operative Data Versus STS Isolated CAB

Variable	UMCRH All Cases (07/17/14–12/31/19)	UMCRH Isolated CAB (07/17/14–12/31/19)	STS Isolated CAB (01/01/19–09/30/19)	UMCRH vs STS Isolated CAB, P Value
	n=425	n=323	n=170 304	
Mean graft no.	2.83±0.99	2.89±0.97		
Internal mammary artery used				
Left	332/425 (78.1%)	311/323 (96.3%)	92.4%	0.0082
Off-pump procedure (% off-pump)	19/425 (4.5%)	19/323 (5.9%)	10.9%	0.0040

CAB indicates coronary artery bypass grafting; STS, Society of Thoracic Surgeons; and UMCRH, University of Maryland Capital Region Health.

Table 3. Operative Outcomes Versus STS Isolated CAB

Variable	UMCRH All Cases (07/17/14–12/31/19)		UMCRH Isolated CAB (07/17/14–12/31/19)		STS Isolated CAB (01/01/19–09/30/19)	Isolated CAB UMCRH vs STS Isolated CAB, P Value
	n=425		n=323		n=170 304	
Mortality						
Observed mortality, %	3/425 (0.7%)		1/323 (0.3%)		2.2%	0.0199
Expected mortality, %	2.6		2.5		...	
O:E ratio	0.3		0.1		1.00	
30-d mortality	3/425 (0.7%)		1/323 (0.3%)			
Readmission rate	19/425 (4.5%)		13/323 (4.0%)		10.1%	<0.0001
Any major complication or death	37/425	8.7%	23/323	7.1%	11.5%	0.0132
Permanent stroke	3/425	0.7%	3/323	0.9%	1.4%	0.4446
Renal failure	19/425	4.5%	0/323	0%	2.2%	0.0070
Prolonged ventilation	8/425	1.9%	4/323	1.24%	7.2%	<0.0001
Deep sternal wound infection	0/425	0%	0/323	0%	0.3%	0.3242
Reoperation for any reason	8/425	1.9%	3/323	0.9%	3.7%	0.0077
Postoperative atrial fibrillation	23/425	5.4%	15/323	4.6%	25.9%	<0.0001
Median LOS	4.0		4.0		6.0	-
Extubated by 6 h	360/425	84.7%	280/323	86.7%	59.1%	<0.0001

CAB indicates coronary artery bypass; LOS, length of stay; O:E ratio, ratio of observed deaths to expected deaths; STS, Society of Thoracic Surgeons; and UMCRH, University of Maryland Capital Region Health.

thereby receiving an STS 3-star rating. Our program has earned a 3-star rating in 7 of 8 total rating periods since inception 6 years ago.

projected to rise to \$749 billion by 2035.¹⁶ Prevalent in the Prince George’s County population (>62% Black) are extremely high rates of cardiometabolic syndrome, hypertension, and cardiovascular death.¹⁷ Per the Centers for Disease Control and Prevention, 72.6 preventable deaths per 100 000 population occur from stroke and heart disease in Prince George’s County yearly.¹⁸ Chu et al¹⁹ studied cardiovascular risk reduction in underserved populations and found that they have greater levels of metabolic and inflammatory risk than adequately served counterparts at baseline and over 2 years.

DISCUSSION

A total of 2150 Americans die per day from cardiovascular disease at 1 death every 40 seconds.¹⁵ The annual direct and indirect cost of cardiovascular disease in the United States is an estimated \$351.3 billion.¹⁶ Total direct medical costs of cardiovascular disease are

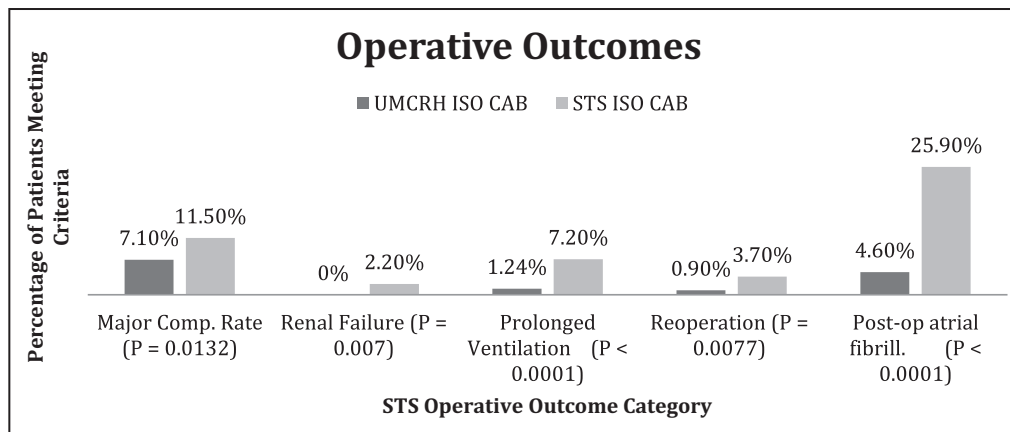


Figure 3. Outcomes in patient group compared with Society of Thoracic Surgeons (STS) average outcome measures.

CAB indicates coronary artery bypass; and UMCRH, University of Maryland Capital Region Health.

Through undergoing a comprehensive improvement process, we were able to provide high-quality cardiac surgery care, with high efficiency and strong performance outcomes. Among the cardiac procedures performed at our cardiac program, CABG has lifesaving import by level I evidence in patients with diabetes mellitus and multivessel coronary artery disease.²⁰ By example, the Freedom Trial (n=1900), the largest trial comparing CABG with drug-eluting stents in patients with diabetes mellitus, substantiated that, in a good candidate for surgery, CABG was favored over percutaneous coronary intervention, prevented death, showed cost-effectiveness, and helped prevent heart failure.²¹ Thus, CAB is an essential service for a region with a large at-risk population to ensure better healthcare access and to help alleviate the expanding costs of care associated with heart failure estimated at a total cost of care of \$32 to \$60 billion that will double by 2030.²²

Comparison of our preoperative data with STS data shows a far greater Black population (61.9% versus 7.5%, $P<0.0001$). Additionally, risk factors for coronary artery disease, chronic lung disease, and peripheral artery disease were present in greater proportions (Table 1). Therefore, the risk profile was greater but also the opportunity to make an impact on a population health level more significant. Observed mortality was also less than the STS average (0.3% versus 2.2%, respectively; $P=0.0199$). The overall major complication rate of 7.1% was far below the national average of 11.5% nationally. Our 30-day mortality of 0.3% over the study period for isolated CAB was notable. While there were no differences in rates of stroke and deep sternal wound infection between our study population and the STS group, significant strides were made in key operative outcomes. Attaining no cases of deep sternal wound infection may be attributed to strict application of STS guidelines for glycemic control and precisely following the AATS guidelines for sternal wound infection prevention.^{10,11}

Chiefly, renal failure, reoperation for any reason, postoperative atrial fibrillation, and degree of prolonged ventilation was less than the STS mean. We surmise that our extremely low incidence of atrial fibrillation was secondary to a multitude of factors. This included prophylaxis with amiodarone if no contraindications, ensuring presence of a β -blocker, standardization of care, and strict implementing of cardiac process pathways and protocols. With that said, we are unable to explain this surprisingly low rate unequivocally. Extubation by 6 hours was better in our study group as compared with the STS (86.7% versus 59.1%, $P<0.0001$). Thus, we were able to achieve fewer complications and improved outcomes, which we believe may be attributed to our priorities, focus, and methods for renovation and rebuilding of the cardiac surgery program.²³

LOS may also be viewed as a helpful cost surrogate in analyzing the efficiency of a program. In the beginning, our LOS started at 6 days in 2014, comparable to the national average. However, over time, our LOS continued to decrease, to 4 days in 2017, and down to 3 days in 2019. Again, this reduction in LOS may be attributed to strict application of a patient care model (ie, Donabedian model) to optimize patient outcomes and overall quality of care.^{1-3,6} Furthermore, other pertinent factors contributing to our short LOS may include crafting of standardized patient care pathways, tailoring of said pathways based on patient idiosyncrasies secondary to experience, and particular attention to the basic tenets of care (ie, pulmonary toilet and ambulation) engrained in order sets, processes, and pathways. Importantly, the readmission rate of 4.0% was far below the national average of 10.0%. This was significant because LOS and readmission rates are in part dependent outcome measures. Aggressive lowering of LOS performed inappropriately can lead to increased readmission rates. The opposite was true in our series, as we were able to improve on the STS average in both outcome measures. Patients were discharged earlier and readmitted less often.

Given the model implemented, we were able to obtain high-quality results at lower-than-expected volumes for cardiac centers as this was a newly rejuvenated program. Generally, the volume of CABG performed in a hospital is inversely related to mortality.²⁴

Importantly, Shahian et al²⁵ were able to show that a volume-performance association holds true for CAB. Yet, there was considerable outcome variability not explained by hospital volume alone. Low volumes per se did not exclude excellent performance. Systemwide application of care processes in coronary artery surgery may explain the excellent results attained by lower-volume CAB programs in the United States and Japan.²⁵ We were able to demonstrate that by using a patient-centric model, orchestrated through a multidisciplinary approach, excellent results can be obtained at low volumes consistently and improved over time through continuous quality improvement processes.

This newly reimagined cardiac surgery program sought to quintessentially capture all of the above by developing its model of patient care starting with the patient and taking into account everything that they will need to have a successful cardiac surgical procedure. Importantly, the starting point for improving quality and outcomes is the healthcare system's structure. An optimized infrastructure can generate value and aid in cost control.²⁶ In applying Donabedian principles we were able to both keep it simple and at the same time focus on the most important details. We consider this particular characteristic central to program success thus far. Importantly, the STS ACS/DCOP played a pivotal role in tracking our performance outcome measures from

program inception to ensure constant dynamic quality improvement.²⁷ It is unquestionably an invaluable repository on quality and performance improvement that quintessentially captures Donabedian principles at heart.²⁷

Moreover, the collaborative dynamic between all providers laid the foundation for better patient care, created consistency in patient management, and led to higher levels of patient satisfaction.²⁸ We cannot overstate the synergy and impact of teamwork collaboration between all providers—cardiac surgeon, lead intensive care unit physician assistants, operating room nurse practitioners, and operating room physician assistants—in attaining our successful results as well. The strength of partnership in meting out top-notch cardiac care stemmed from a common denominator as best captured by Donabedian: “Ultimately, the secret of quality is love. You have to love your patient, you have to love your profession, you have to love your God.”²⁹

Study Strengths and Limitations

Strengths of this study include the careful vetting, processing, and analyzing of our data through the STSNDB and data harvesting process. We also independently compared performance outcomes between our study group and the STS group to ensure significance. Limitations in our work include that this study was retrospective and nonrandomized and had a small patient group, perhaps decreasing the power of our study. We seek to address this by increasing program volume over time with continuous monitoring, reporting, and publishing of our results. We instituted fast-tracking measures, but predated the formal enhanced recovery after cardiac surgery program.³⁰ We did institute patient care pathways and protocols. In the future, through ongoing quality improvement efforts, we will incorporate enhanced recovery after cardiac surgery principles as they evolve into our cardiac surgery program. The key implication of this study is that by focusing on critical basic elements of health care, combined with developing a relationship with a university hospital system, a highly specialized level of care can be introduced into an underserved region. We hope our endeavor will serve as a template for future initiatives in building specialty programs in partnership with community hospitals across the nation. Also, our experience may have positive implications for established programs to improve existing structure, process, and outcome dynamics to better the quality of their programs.

CONCLUSIONS

A cardiac surgery program can be completely restructured successfully. This success was enhanced

in our experience using a simple Donabedian model applied strictly. Partnership with a major university hospital system allowed for enhanced staff training and continuity over the full spectrum of cardiovascular care, and provided a repository of program staff excellence. Utilization of the STSNDB was central to our efforts and provided direct feedback on performance outcome measures to allow for continuous quality improvement. Focusing on patient-centric cardiac care through specific protocols, rehearsals, and application of models, we were able to achieve significantly better-than-average outcome measures, extubation times, and LOS over a period of years. Prior volume outcome assertions were not applicable in this setting. Top-tier outcome measures were accomplished in light of higher risk factors present in the study group. This experience has potential application in the setting of established cardiac surgery programs, which are in need of improvement in quality or as a roadmap for newly developing cardiac surgery programs aiming to provide the highest quality cardiac surgical care.

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Affiliations

From the University of Maryland School of Medicine and University of Maryland Capital Region Health, Baltimore, MD.

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