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Quality Improvement: Arterial Grafting Redux, 2010:2019

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Background. **The evidence base favoring utilization of multiple arterial conduits in coronary artery bypass grafting has strengthened in recent years. Nevertheless, utilization of arterial conduits in the US lags behind that of many European peers. We describe a statewide collaborative based approach to improving utilization.**

Methods. **Four metrics of arterial revascularization were devised. These were displayed and discussed at quarterly statewide quality collaborative meetings from January 2016 onwards, integrated with an educational program regarding attendant benefits. We undertook retrospective review of isolated coronary artery bypass grafting statewide from 2012-2019 to assess impact.**

Results. **A total of 38,523 cases met inclusion/exclusion criteria. Statewide incidence of multiple arterial grafting increased from 7.4% at baseline to 21.7% in 2019 ($P < .001$), implementation across hospitals varied widely, ranging from 67.6% to 0.0%. Utilization of total arterial revascularization increased 1.9% to 4.4% ($P < .001$) between time frames. Utilization of both radial artery and bilateral internal thoracic artery conduit increased significantly from 5.3% to 13.2% ($P < .001$) and 2.1% to 8.5% ($P < .001$), respectively; radial artery utilization was significantly higher than bilateral internal thoracic artery for each year ($P < .001$ for all comparisons).**

Conclusions. **Our statewide quality improvement initiative improved rates of utilization of multiple arterial grafting by all metrics. Barriers to current utilization were identified to guide future quality improvement efforts. This reproducible approach is readily transferable to improve quality of care in other domains and geographical areas.**

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The evidence favoring utilization of multiple arterial conduits in appropriate patients undergoing coronary artery bypass grafting (CABG) has strengthened in recent years. The patient-level meta-analysis by Gaudino and associates[1] of 1036 patients enrolled in trials comparing radial artery grafting vs saphenous vein grafting to supplement the use of the left internal thoracic artery (LITA) demonstrates significantly lower incidence of the composite primary outcome of death, myocardial infarction (MI), or repeat revascularization (hazard ratio 0.67, 95% confidence interval 0.49-0.90, $P = .01$), in patients receiving radial artery grafts. Several large meta-analyses of observational studies,[2,3] assessing outcomes of more than 86,000 patients, demonstrate significant survival benefit to utilization of bilateral internal thoracic arteries (BITA) compared with single internal thoracic arteries (SITA). However, utilization of arterial conduits in the US lags behind many European countries on all metrics. In

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Abbreviations and Acronyms

ART	= Arterial Revascularization Trial
BITA	= bilateral internal thoracic artery
CABG	= coronary artery bypass grafting
LITA	= left internal thoracic artery
MAG	= multiple arterial grafting
MI	= myocardial infarction
MSTCVS-QC	= Michigan Society of Thoracic and Cardiovascular Surgeons Quality Collaborative
QI	= quality improvement initiative
STS	= The Society of Thoracic Surgeons
TAR	= total arterial revascularization

the SYNTAX (Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery) trial, rates of total arterial revascularization (TAR), BITA, and radial artery utilization during CABG in the US were 6.9%, 13.0%, and 7.8%, respectively, compared with 48.0%, 60.6%, and 29.0%, respectively in France.[4]

The Michigan Society of Thoracic and Cardiovascular Surgeons Quality Collaborative (MSTCVS-QC) confronted a similar problem previously. In 2005, the MSTCVS-QC identified hospitals within the state where LITA utilization during isolated CABG was statistically lower than the US national average from The Society of Thoracic Surgeons (STS) data. Recognizing that LITA usage benefits patient outcome, the MSTCVS-QC made increasing utilization a statewide quality improvement initiative (QI). By 2008 the rate of LITA usage in Michigan significantly exceeded the STS national rate.[5]

In January 2016, compelled by the growing body of evidence supporting use of arterial conduits, the MSTCVS-QC once again focused on conduit selection. With LITA usage remaining consistently high throughout the state, focus switched to utilization of multiple arterial conduits. We describe the systems implemented to improve this and consequent results.

Patients and Methods

Study Design

The MSTCVS-QC implemented a statewide QI to increase arterial conduit utilization, commencing January 1, 2016. A retrospective observational study examining utilization of arterial conduits during CABG was designed from January 1, 2012, to December 31, 2019. STS and MSTCVS data are harvested from all 33 cardiac surgical hospitals in Michigan by trained data experts and submitted simultaneously to the Duke Clinical Research Institute and the MSTCVS-QC. Sites are audited biannually for data validity and data managers have quarterly training sessions. The University of Michigan institutional review board categorized this as a quality improvement activity, not requiring ethical approval.

Population

The MSTCVS database was interrogated for all patients aged 18 years and older undergoing isolated CABG. Cases were excluded if meeting any STS internal thoracic artery exclusion criteria: emergent/salvage procedure, subclavian artery stenosis, absence of left anterior descending artery disease, previous cardiac or thoracic surgery, or previous mediastinal irradiation. Data were extracted for patient demographics, preoperative patient characteristics, and conduits utilized. These data were analyzed taking the years prior to implementation of the initiative, 2012-2015, as a control arm and 2016-2019 as the intervention arm. National data on utilization of BITA and radial artery conduit for patients meeting the same inclusion and exclusion criteria were obtained from STS data. Additionally, we examined variation in utilization across Michigan's 33 adult cardiac surgery hospitals.

Quality Improvement Process

Four performance metrics for analysis were devised: (1) multiple arterial grafting (MAG), defined as utilization of greater than 1 arterial conduit (LITA, right internal thoracic artery, or radial artery); (2) utilization of BITA; (3) utilization of a radial artery conduit; and (4) total arterial revascularization, defined as exclusive arterial conduit use. The primary outcome was a statistically significant increase in proportion of isolated CABG patients receiving arterial conduits by all of these metrics following institution of the QI. Further comparison was made between these metrics and STS national rates.

All MSTCVS-QC statewide QIs utilize a set of core operational principles, those specific to this included: (1) identification of a surgeon champion for the QI at each site (2) reporting and robust discussion of each metric of MAG in isolated CABG cases for each site at each quarterly meeting; and (3) lectures by surgeons eminent in the field of arterial revascularization regarding benefits of arterial revascularization and techniques to implement it at the quarterly meetings. Together these measures focused the minds of Michigan's surgeons on the initiative, providing continuous feedback on progress and encouraging further gains.

Statistical Analysis

Discrete data are summarized by counts and continuous data are summarized using percentile means (SDs). Data analysis was conducted and outputs generated using SAS/STAT software, Version 9.4 of the SAS System for Windows (IBM, Armonk, NY). Categorical variables were compared with the χ^2 test or Fisher's exact test as appropriate. Continuous variables were compared with the 2-tailed Student's t test. No adjustment was made for multiple comparisons. An alpha value of 0.05 was considered significant.

Results

During the study period (January 1, 2012 to December 31, 2019), 38,523 patients meeting inclusion and exclusion criteria were identified in Michigan's statewide database. Additionally, 1,162,968 patients meeting criteria were identified nationally in the STS database and include Michigan's data.

Significant differences are observed across many preoperative variables, the majority of which would be

Table 1. Baseline Demographics of Intervention and Control Groups Across Michigan

Characteristic	Michigan Isolated CABG		
	2012-2015 Control (n = 18,937)	2016-2019 Intervention (n = 19,586)	*P* Value
Age, y	65.4 ± 10.2	65.9 ± 9.8	<.001
Ethnicity			
White	89.9	89.1	<.001
Black	7.4	7.1	
Other	2.7	3.9	
Female sex	25.1	23.6	<.001
Diabetes			
No	54.7	51.2	<.001
Diabetes control			
None	5.5	5.5	
Diet controlled	1.0	2.7	
Oral agents	20.6	20.8	
Insulin	18.0	19.0	
Hypertension			
Smoking status	90.1	91.4	<.001
Current	22.9	22.5	<.001
Former	21.3	43.6	
Never	55.7	33.9	
Chronic obstructive pulmonary disease			
Nil	68.2	69.7	<.001
Mild	18.0	15.6	
Moderate	6.3	4.8	
Severe	6.1	4.3	
Preoperative dialysis	2.4	2.5	.460
Peripheral vascular disease	15.8	15.2	.111
Previous myocardial infarction	51.7	55.9	<.001
Previous percutaneous coronary intervention	29.5	30.7	.009
Congestive cardiac failure	11.8	16.4	<.001
Unstable angina	39.8	40.5	.231
Cardiogenic shock	0.61	0.91	<.001
Left main disease	38.8	52.7	<.001
Triple vessel disease	78.4	80.2	<.001
LV ejection fraction			
>50%	69.8	71.5	<.001
30%-49%	24.6	23.5	
<30%	5.6	5.0	
Operative status			
Elective	37.9	38.7	.085
Urgent	62.1	61.3	

Values are presented as mean ± SD or percent.

CABG, coronary artery bypass grafting; LV, left ventricle.

expected to discourage utilization of multiple arterial grafts in the intervention cohort (Table 1). The statistically significant exceptions to this trend are a lower proportion of female patients, lower incidences of severe chronic obstructive pulmonary disease, and left ventricular ejection fraction less than 30% in the intervention cohort.

Utilization of Multiple Arterial Conduits

In the control period (2012-2015 inclusive), MAG incidence during isolated CABG surgery statewide was 7.4% (range, 6.8%-7.7%), without significant variation across years ($P = .29$). Within the first year of the QI, MAG incidence increased 3.9% ($P < .001$), reaching 21.7% in 2019. The trendline of this metric approximates an exponential growth curve.

TAR during the control period was 2.1% (range, 1.8%-2.1%) without statistically significant variation across years ($P = .72$). The statewide proportion of isolated CABG cases receiving TAR rose in 2016 after QI initiation. This increase was an order of magnitude less than that of multiple arterial grafting, mean 0.63% per year (range, 0.3%-1.0%), reaching 4.4% in 2019 ($P < .001$) (Figure 1).

Radial Artery and BITA Utilization

Increased utilization of MAG was underpinned by significant increases in utilization of radial arteries and BITA. Radial artery utilization was significantly higher than BITA utilization throughout all individual years. During the control period radial artery conduits were used in 5.3% (range, 4.6%-5.7%) of cases and BITA in 2.1% (range, 1.8%-2.3%), neither varied significantly between years during this period ($P = .10$ and $P = .39$, respectively). In 2016, utilization of radial artery conduits increased significantly from the baseline period, 5.3% vs 7.1% ($P < .001$), reaching 13.2% of cases in 2019, absolute increase 7.9%. BITA utilization also increased significantly in 2016, to 4.2% ($P < .001$), reaching 8.5% by 2019, absolute increase 6.4% (Figures 2, 3).

During the control period, BITA utilization in Michigan was significantly lower than the STS mean, 2.1% vs 4.7% ($P < .001$). BITA utilization became numerically higher than the STS mean in 2018 and statistically significantly so in 2019 (8.5% vs 5.7%, $P < .001$) (Figure 2). Radial artery utilization was significantly higher than the STS mean during the control period, 5.3% vs 4.6% ($P < .001$), increasing further upon commencing the QI, reaching 6.3% higher than the STS mean in 2019 (Figure 3).

Arterial Grafting Strategies by Hospital

In 2019, 32 of 33 of Michigan's hospitals performed cases of MAG. Thirteen hospitals utilized this strategy more frequently than the Michigan mean of 21.7% of cases and 21 hospitals more frequently than the STS mean of 11.1%; the most prolific hospital utilized this approach in 67.6% of cases. The proportion of patients receiving MAG did not correlate with hospital case volume (Figure 4). Twenty-five of the 33 institutions significantly increased utilization of MAG in comparison with the control period; no hospital significantly regressed (Figure 5; Appendix 1).

TAR was used by 29 of Michigan's 33 hospitals in 2019, in 0.8% to 16.9% of cases. Fifteen hospitals undertook TAR more frequently than the Michigan mean of 4.4% of cases—4 significantly so (Figure 6). The change of utilization of TAR between 2019 and the control period varied

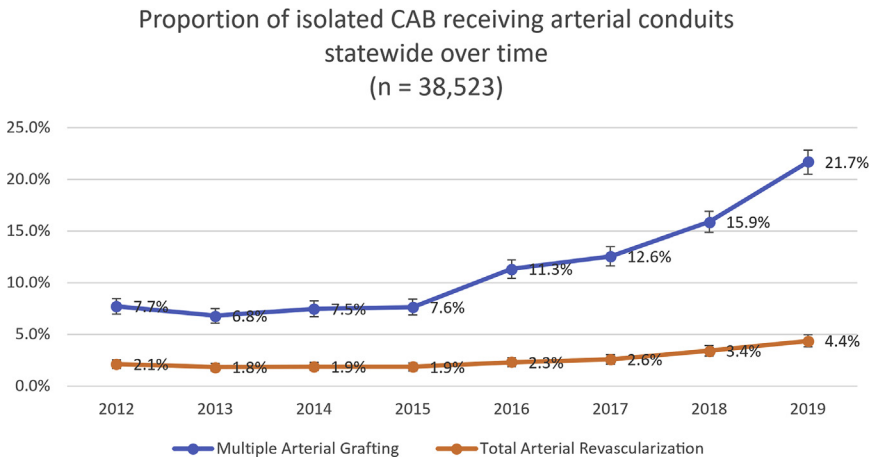

Figure 1. Rate of multiple arterial grafting total arterial revascularization across Michigan, 2012-2019. (CAB, coronary artery bypass grafting.)

more widely at the center level than observed with MAG. Sixteen centers significantly increased the proportion of cases receiving TAR, the greatest increase in utilization was 9.5%. One center significantly decreased TAR utilization by 14.5% (Figure 7; Appendix 1).

Eighteen hospitals significantly increased rate of BITA utilization and 20 significantly increased utilization of radial artery; none significantly decreased utilization of either conduit. Institutional level utilization of either radial artery conduit or BITA is almost binary among hospitals with high rates of arterial conduit utilization (Figure 8). Of the 13 hospitals utilizing radial artery conduit more frequently than the Michigan mean in 2019, and 9 which did so for BITA, only 2 hospitals were statistical outliers for high usage of both conduits.

Comment

Statement of Key Findings

By applying the MSTCVS-QC's standardized approach to developing collaborative learning through unblinded review of institutional-level metrics, statewide education, and peer support, the proportion of cases statewide receiving multiple arterial grafting increased threefold during the intervention period to over 1 in 5 patients. The consequence of this is that in 2019 we project an additional 695 patients statewide received the attendant benefits of multiple arterial grafting than would have been expected in accordance with the control period rate.

It is notable that baseline rates of radial artery utilization during the control period were significantly higher than those of BITA utilization. During the control period no randomized evidence existed demonstrating improved clinical outcomes for either radial artery or BITA use, yet both had comparable evidence of significant benefit in meta-analyses of retrospective studies.[2,3,6,7] Factors that may explain this baseline difference include surgeons' perceived difference in technical demand of internal thoracic artery grafting, increased operative time required for bilateral sequential internal thoracic artery harvesting, influence of prior training/experience in utilizing radial artery as conduit, and perceived increased

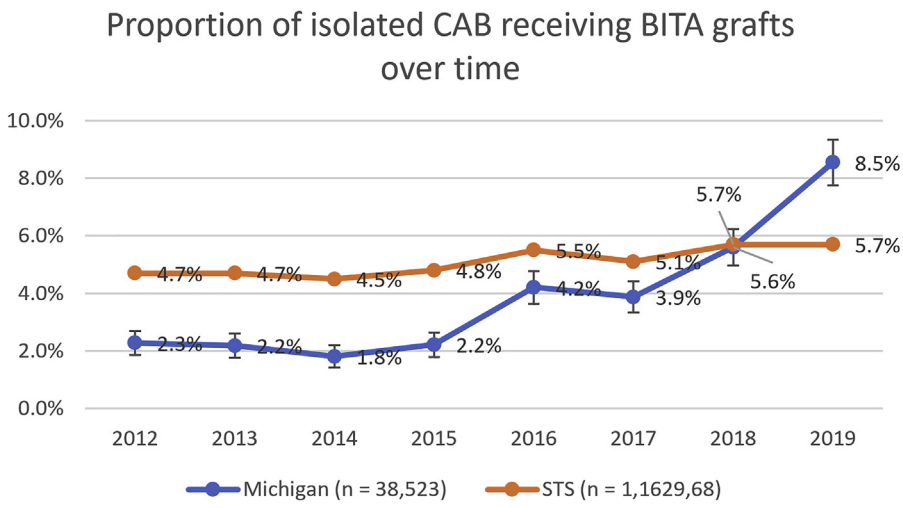

Figure 2. Rate of utilization of bilateral internal thoracic artery (BITA) grafts across Michigan and nationally, 2012-2019. (CAB, coronary artery bypass grafting; STS, The Society of Thoracic Surgeons.)

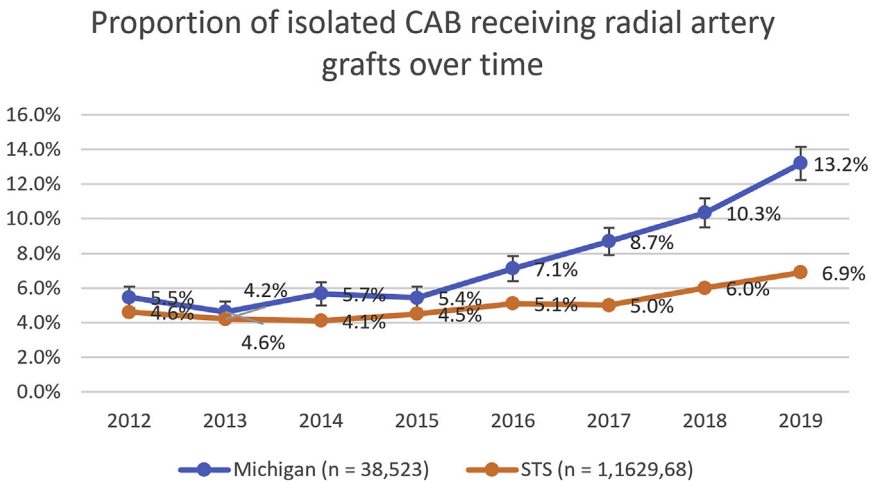

Figure 3. Rate of utilization of radial artery conduit across the state of Michigan and nationally, 2012-2019. (CAB, coronary artery bypass grafting; STS, The Society of Thoracic Surgeons.)

risk of deep sternal wound infection with BITA. With respect to this, we did not observe an association between BITA grafting and deep sternal wound infection incidence during this study: incidence 0.53% (n = 7) of patients undergoing BITA grafting vs 0.30% (n = 91) without BITA grafts ($P = .141$).

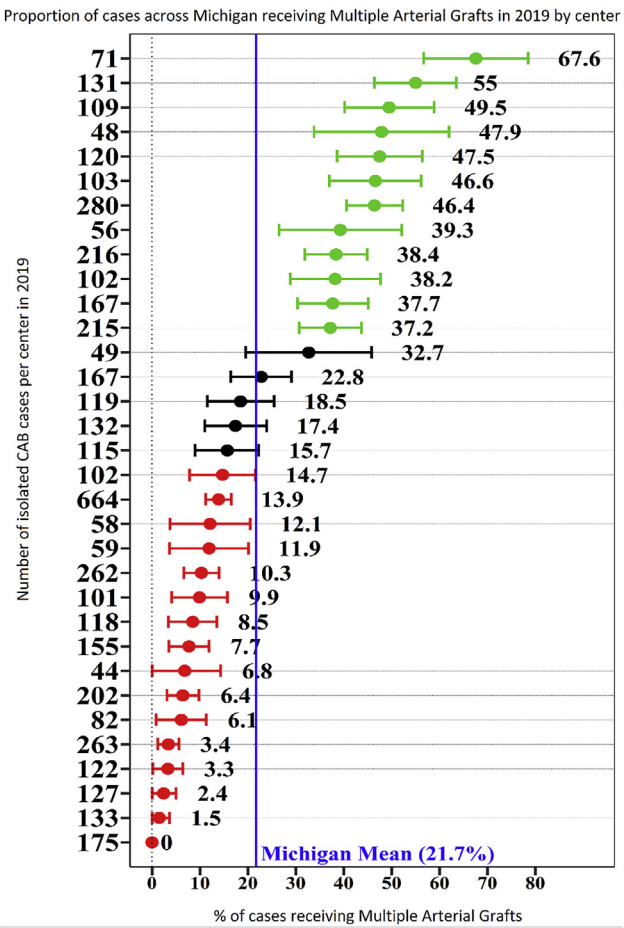

Figure 4. Utilization of multiple arterial conduits during bypass grafting across Michigan, 2019. Green bars denote hospital outliers significantly higher than Michigan mean, red significantly lower. (CAB, coronary artery bypass grafting.)

In addition to higher baseline utilization, the absolute increase in utilization of radial artery during the QI was significantly higher than that of BITA, 7.9% vs 6.4%, respectively ($P < .001$). The trend curves observed for BITA and radial artery utilization over time also differ. Radial artery usage during the QI period rose steadily by ~1.6% for the first 3 years before a step increase of 2.9% in 2019. This increase may have been stimulated by publication of Gaudino and colleagues'[1] meta-analysis in 2018 demonstrating reduction in the composite endpoint of death, MI, or repeat revascularization associated with utilization of radial artery conduit. The curve of BITA utilization shows an initial increase in the first year of the improvement program, reduced utilization in 2017, and subsequently 2 years of increasing increments. The reduction in BITA utilization correlates with publication of interim 5-year outcomes of the Arterial Revascularization Trial (ART),[8] which did not show reduction in mortality or the composite endpoint of mortality, MI, or stroke with BITA grafting, but did demonstrate significantly increased deep sternal wound infection incidence and sternal reconstruction. However, when 10-year outcomes of the ART[9] were published in January 2019 showing no benefit, there was no negative impact on rate of BITA utilization. Commentary regarding the crossover rate of 14% from BITA to single internal thoracic arteries and 4% in the reverse order observed in the ART, along with statistically significant 19% reduction in hazard of death with BITA grafting at 10 years observed in the as-treated analysis may have contributed to varying interpretation by surgeons over time.

Additionally, wide variation was observed across hospitals in utilization of MAG, TAR, BITA, and radial artery conduits. These observations underline the reality that factors other than the "evidence base" markedly influence surgeon decisions for conduit selection in CABG surgery. These factors must be considered when implementing a quality improvement program directed

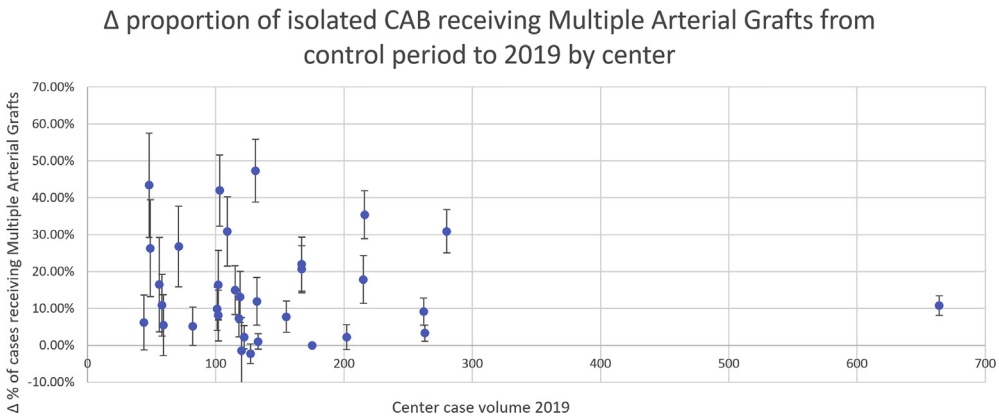

Figure 5. Change in utilization of multiple arterial bypass grafting across Michigan 2019 compared with 2012-2015. (CAB, coronary artery bypass grafting.)

at changing this behavior. It is established that in absence of class I evidence, surgeon-level factors become increasingly important in the decision-making process.[10]

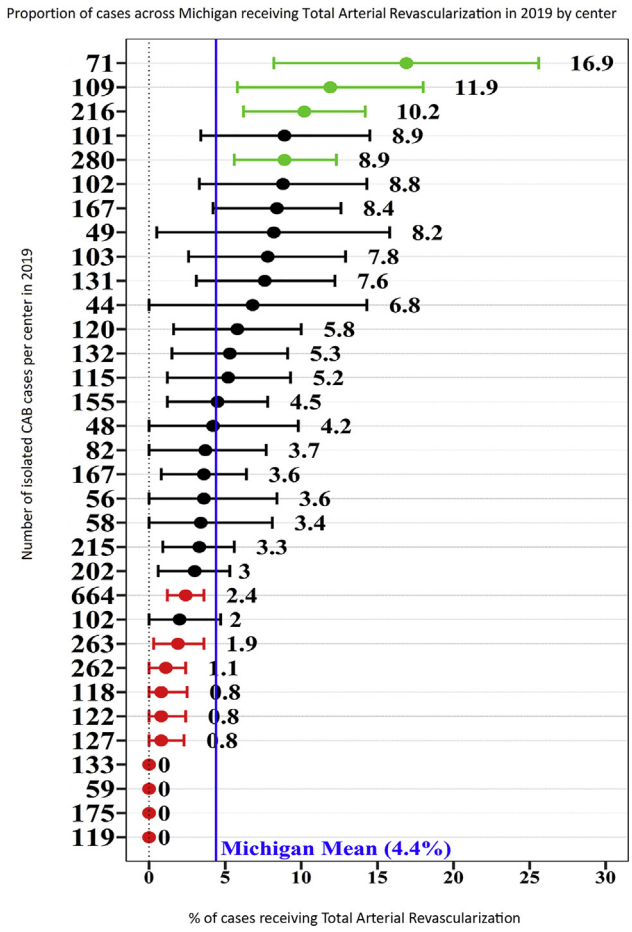

Figure 6. Utilization of total arterial revascularization across Michigan 2019. Green bars denote hospital outliers significantly higher than Michigan mean, red significantly lower. (CAB, coronary artery bypass grafting.)

The experience of the MSTCVS-QC is that the barriers to surgeons and hospitals adopting new therapies or standards of care fall into 4 categories: (1) absence of benchmarking to understand current levels of utilization relative to peers; (2) lack of understanding of the evidence base; (3) technical or procedural gap between understanding the importance of the therapy / standard of care and how to implement it in clinical practice; and (4) extrinsic pressures favoring not adopting the new therapy / standard of care (eg, increased operating room time requirement) outstripping its intrinsic benefit and other extrinsic factors favoring its use. QIs must address all of these factors.

Our approach includes collecting the STS data set for Michigan quarterly and creating analytical metrics to quantify and benchmark statewide practice, over time and across institutions. Metrics must be simple to understand, insightful, and pertinent. Highly interactive quarterly meetings are attended by at least 1 surgeon representative, usually the "surgeon champion". The metrics are collectively reviewed and discussed so key information is disseminated to each hospital. Attendance is mandatory, although our experience is that surgeons do so willingly due to subsequent benefit to patient care. At meetings, metrics demonstrate progress made, positively reenforcing this behavior; where progress is absent this focuses further effort. Metrics are presented with reference to recent high-quality literature, providing an aspirational marker and external frame reference for the state and its institutions. This prevents a culture of acceptance of status quo. Displaying unblinded hospital-level data develops a system of peer review and support. The homogeneity of Michigan's population across its geography prevents the human tendency towards confirmation bias, namely, erroneous belief that hospitals "elsewhere" achieving more impressive results are treating populations with markedly different characteristics, are significantly differently resourced, or are presenting selective data. This approach facilitates a culture of peer learning. Hospitals performing well in specific metrics offer their insights regarding how their results are achieved. Institutions demonstrating

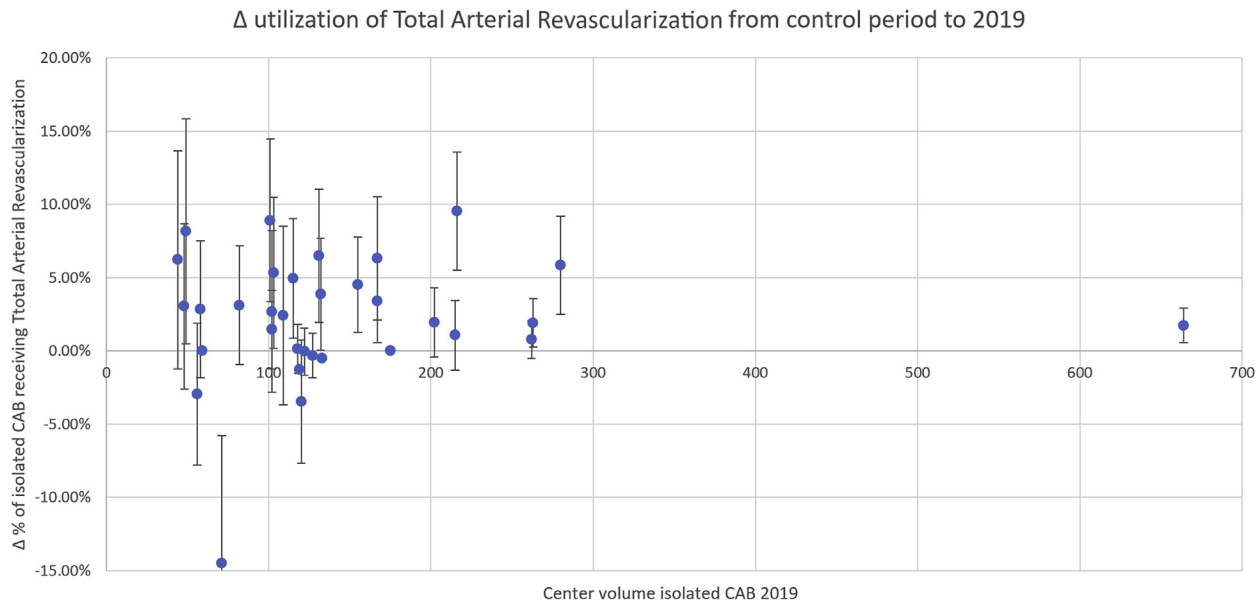

Figure 7. Change in utilization of total arterial revascularization across Michigan 2019 compared with 2012-2015. (CAB, coronary artery bypass grafting.)

less-desirable performance are invited to offer analysis of the barriers they believe they face and are offered solutions by peers who have encountered similar barriers previously. This process of shared learning flourishes in an open, de-anonymized, and non-confrontational environment. Subsequent to meetings, data slides are electronically distributed to all surgeons within the state. This is supported within institutions by the surgeon champion who leads the QI at each site, chairing monthly team meetings, among other responsibilities (Appendix 2).

With respect to this QI, each metric offers specific benefits. The MAG metric drives change via "audit feedback" methodology that is demonstrably efficacious when implemented in this manner.[11] Its high sensitivity to the desired behavioral change readily provides positive reinforcement. As the most holistic metric, it has the broadest support from the existent evidence base, thus is least likely to conflict with surgeons' originally held ideas. In short, it is simple, responsive, and noncontroversial. Radial artery and BITA utilization metrics allow specific insight to practice patterns. This facilitates identification of high- and low-performing hospitals in these areas of practice, thereby directing transfer of knowledge and skills from those who have them to those who may benefit. Finally, TAR offers an aspirational marker by demonstrating the state's performance relative to that of surgeons eminent in arterial revascularization, preventing complacency as progress is made. Argument could be made for the exclusion of BITA as a metric in light of the 10-year ART results. Nonetheless, the ART is not definitive proof that BITA is non-beneficial to an as-yet-undefined patient population. To no longer encourage its implementation in this setting would detract from the clear goal of this QI, sending an unclear message to the state's surgeons and conflicting with currently held beliefs of some. Metrics of higher complexity, for instance, analyzing specifics regarding target vessels and utility of sequential grafts, would obscure the focus of the initiative thus far. As practice in Michigan develops and we look towards more marginal gains, these may become appropriate.

Recognizing that active surgeons are challenged by the number of journal articles published, the MSTCVS-QC references key publications in quarterly meeting slides, summarizing key messages, strengths, and caveats to help surgeons incorporate them into practice. Key publications are distributed for reference with data slides from meetings. This process helps keep Michigan's surgeons abreast of the current evidence base. To address gaps between understanding of the importance of a therapy / standard of care and how to implement this in clinical practice, we invite outstanding speakers accomplished in their relevant field to address our quarterly meetings, explaining how they achieve their results. This offers practical advice that surgeons may implement, demonstrates what is possible, and provides inspiration to attaining such standards of care.

Finally, Blue Cross Blue Shield of Michigan partially supports the MSTCVS-QC by funding a portion of the salary for each site's data management as well as collaborative administrative staff. A portion of this money funds payments to hospitals for achievement of specific QI targets, although such payment for performance incentives was not linked to this QI. No funds are directed to surgeons.

Collectively, these systems address the generic barriers to QI and are a system of collaborative learning. This process actively identifies the specific barriers to improvement within each domain as the initiative is in

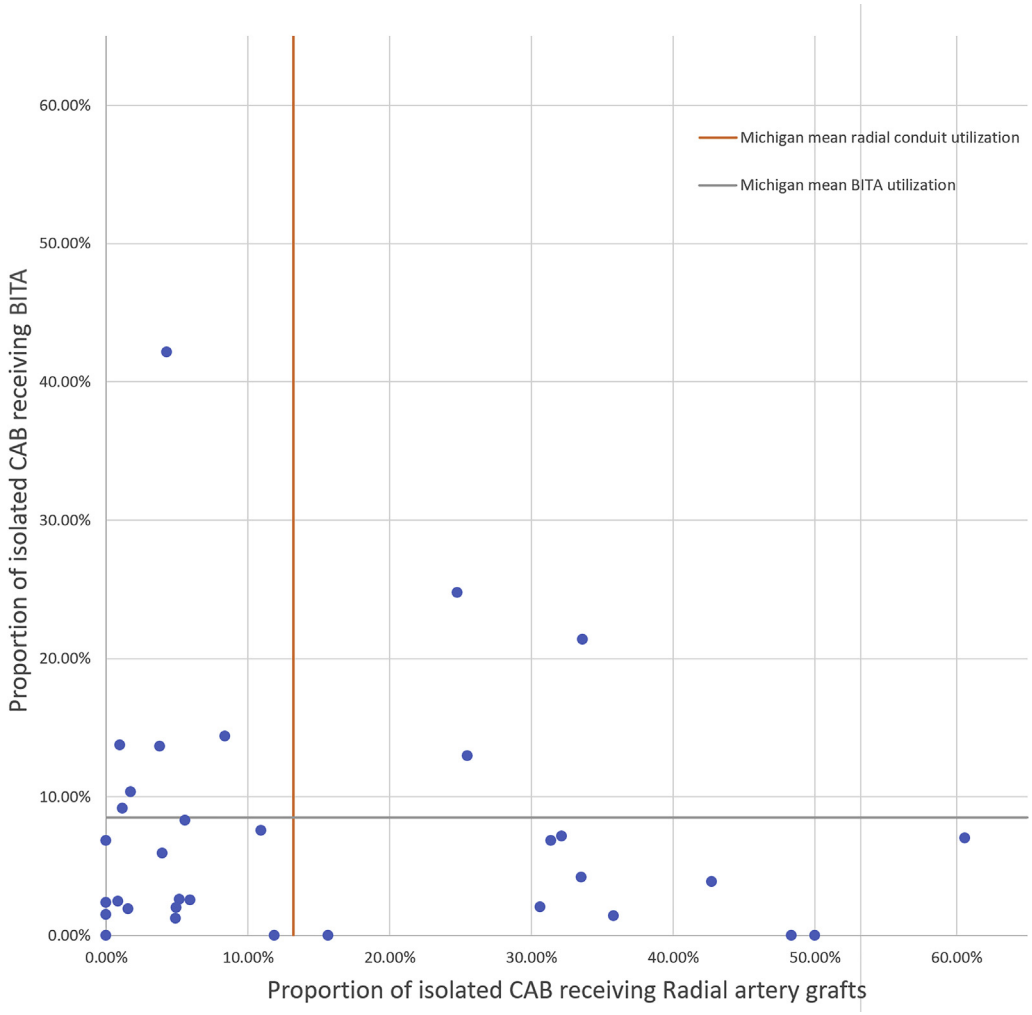

Figure 8. Utilization of bilateral internal thoracic artery (BITA) grafts and radial conduits across the state of Michigan, 2019. (CAB, coronary artery bypass grafting.)

progress allowing these to be addressed. A more comprehensive overview of these systems has been published previously.[12]

Limitations of This Study

This study is retrospective and nonrandomized. It is possible that unobserved confounders underpin the marked increase in utilization of MAG in Michigan rather than the QI. This seems unlikely given the strong temporal relationship between the QI and observed change, along with absence of a similar trend in STS national data over the same time period. Potential confounders include literature that surgeons may have read, interaction with peers outside of the QI setting, and turnover of surgeons during the QI. With respect to this, 93 surgeons operated statewide in 2012. During the ensuing control years 2013-2015, 19 ceased practicing and 12 surgeons commenced practice. This compares to 16 ceasing practice and 13 commencing during the equivalent time duration of the intervention period, 2016-2018.

Further Work

Despite improvements in provision of MAG in Michigan since 2015, accelerating above the benchmark of the US nationally, a gulf remains between our practice and that of some Canadian, European, and Australian peers[4,13,14] Optimum patient selection criteria for those who would benefit from MAG are not yet defined, preventing us from factoring this into analysis. However, the baseline characteristics of the radial cohort in Gaudino and coworkers'[1] meta-analysis (mean age, 66.6 ± 9.28 years; 29.6% female; 33.9% diabetic; 30.7% previous MI; 4.7% LVEF <35%) who did derive a benefit, are not atypical for US practice. This, taken with the signal of exponential growth of MAG in Michigan, yet wide center-level disparity in its implementation and utilization of BITA and radial artery conduits, suggests we are currently in the "early majority" phase of Rogers'[15] innovation-adoption lifecycle (Figure 9). Surgeon survey data during our August 2019 meeting supports this. Only 33% of 26 surgeons reported feeling their residency / fellowship

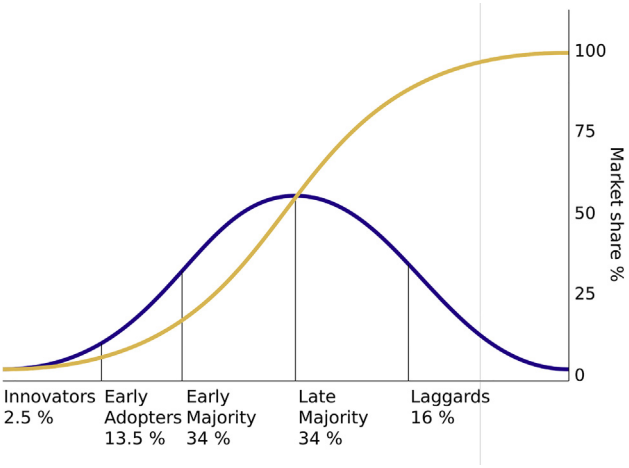

Figure 9. Rogers' innovation-adoption life cycle. Rate of adoption (blue) follows a normal distribution. Market share of the innovation (yellow) follows a sigmoid curve.

trained them to a level of satisfactory competency in MAG, 23% reported they would benefit from further training and mentoring in its practice at this stage in their attending career. Fifty-six percent of Michigan's surgeons reported their preferred second choice arterial conduit, in addition to LITA, was right internal thoracic artery. Finally, when asked to imagine that they are a 59 year-old, nondiabetic, nonsmoker with a body mass index of 22 kg/m^2 and no other past medical history, presenting with stable angina Canadian Cardiovascular Society grade III, a coronary angiography demonstrating a 70% stenosis in all 3 coronary territories including the proximal left anterior descending artery, unremarkable echocardiogram with ejection fraction 70% and no concerns regarding conduit, how would they wish to be revascularized? Sixty percent reported that they would choose to undergo total arterial revascularization, yet our statewide rate of this is 4.4%. Together, these data strongly suggest that Michigan's surgeons believe that MAG, increasing rates of BITA utilization, and TAR are of benefit to patients—but significant practical barriers remain. It is therefore incumbent upon us as a quality collaborative to continue to support our state's surgeons in this endeavor.

Concluding Points

We demonstrate a marked improvement in the rate of multiple arterial revascularization during isolated coronary artery bypass surgery within the state of Michigan resulting from utilization of the MSTCVS-QCs standardized, reproducible QI methodology, noting that there remains residual surgeon discomfort in pursuing these techniques which must be addressed to drive further progress. The quality improvement approaches we have described to achieve our progress are readily implementable elsewhere.

The authors wish to acknowledge the work of all of Michigan's cardiac surgeons whom these data reflect.

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