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Editorial

Coronary Artery Bypass Grafting in 2024: The Shape of a Subspeciality

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Introduction

Coronary artery bypass grafting represents the first-line treatment for complex and severe coronary artery disease. The immense dedication of countless surgeons and researchers has led operative techniques to evolve dramatically over the past seven decades. However, each tranche of technical innovation demands further training and skill acquisition for coronary surgeons. Thus, some methods have been slowly adopted, even with societal support and guidelines. Subsequently, the use of off-pump coronary bypass grafting has decreased. Multiple arterial grafting is underutilized despite convincing evidence of its benefit. A growing body of research supports using intraoperative patency verification devices, which can improve outcomes if standardized across institutions. The advanced level of technical training necessary to develop the full range of skills in the current age suggests a need to focus resources on coronary bypass surgery by referring to it as a subspecialty.

Background

The burden of coronary artery disease (CAD) worldwide abounds, the leading imposition of our mortality for generations. Coronary artery bypass grafting (CABG) is the gold standard for complex and severe CAD, offering now consistently excellent outcomes at its highest levels. Innovation is the essence of this sanguine forward impulse, with each decade setting the pace for a new output of progress. The mastery of cardiopulmonary bypass and myocardial protection has rendered these amazing technologies routine across all cardiac surgery theatres. Off-pump coronary artery bypass grafting (OPCAB) widely promulgated and mastered by some, offers better outcomes for surgeons committed to trekking up over the learning escarpment. Now we have come within reach of ever higher achievements of patency, survival and morbidity reduction, if surgeons continue to perfect technical skills of multiple arterial grafts, minimal aortic manipulation and composite grafts. Minimally invasive techniques herald greater patient satisfaction and reduced postoperative burden. Momentous achievements in data collection and outcomes reporting cement our Overton windows to the realities on the ground across nations and continents. All of this takes place with a view to the many landmarks in pharmacological and percutaneous therapies, ensuring that surgical cases are pushed further toward the margin of complexity.

Main Text

The current silhouette of progress in CABG surgery takes the familiar form of an asymptote, with each increment of improvement an increasing ratio of investment is required of the surgery team, and especially the surgeon. The latest developments for this burgeoning subspecialty include an array of devices for intraoperative validation of technical success. Following the initial phase of implementation and data collection, transit-time flow measurement (TTFM) and high frequency ultrasound (HFUS) are emerging as practical, reliable, effective and low-cost tools with a relatively superable learning curve [1]. Indeed there are technical nuances, investments of the temporal, spatial and pecuniary kind. Yet the data speak assertively. Di Giammarco *et al*. [2] found HFUS combined with TTFM predicted patency with a positive predictive value of 100%. Lehnert *et al*. [3] showed TTFM predicts graft patency at one year, with a four percent reduction in graft failure per 1 mL/min of better flow in internal mammary artery (IMA) grafts. The ROOBY trial data analysis found better graft patency at one year with TTFM confirmation than in cases without it [4].

The need for intraoperative validation is simple. Perioperative graft failure is 7% and when it occurs acute and long-term outcomes suffer, sometimes acutely fatal [5]. It comes as no surprise that the benefit of these technically parsimonious devices depends on their proper use. The question that begs an answer is whether the findings make a difference. A REQUEST registry study found that in 25% of CABG cases surgeons changed their operation due to TTFM or HFUS and excellent outcomes were achieved [6]. These included changes of the aortic site as well as the distal sites and anastomosis revisions. A systematic review by Thuijs *et al*. [7] found a 4.3% rate of graft revision using TTFM. These findings alone sufficiently merit our attention, and further research has found the trade-off in effort is

very low. A United Kingdom National Institute for Health and Care Excellence (NICE) review of four studies found TTFM reduces overall cost per patient and adds only three minutes of additional operating room time [5]. Rosenfeld *et al*. [8] analyzed REQUEST registry data and found the greatest benefit of TTFM coincides with arterial grafts compared with venous, and inferior wall anastomoses compared to anterior or lateral sites, thus illustrating that the trade-off of technical difficulty for greater clinical benefit can be assuaged by intraoperative verification. All this with far lower risk to the patient or cost when compared with performing an angiogram.

Furthermore these benefits grant a fortuitous complement to the technical complexity of OPCAB. A substantial body of evidence demonstrates that surgeon experience improves OPCAB outcomes significantly and it's easy to understand why [9]. Exposure is more complex, suturing angles more constrained, motion and coronary blood flow are uninterrupted meanwhile elegantly sustaining the patient's life. But once mastery is achieved the benefits of OPCAB in select patients is supported by multiple meta-analyses, small randomized trials and retrospective reviews. Specifically, reduced respiratory, renal and cerebrovascular complications, less atrial fibrillation, fewer blood transfusions and lower mortality [10,11]. In order to attain this next tier of outcome improvements, the anastomoses must be as excellent as the CABG standards set by the Society of Thoracic Surgeons (STS) database. Moreover, sequential and composite grafts enable minimal or no-touch aortic techniques, effectively minimizing stroke risk, thus raising the bar again. Though a slight statistical shift here, nevertheless a highly relevant one to the fortunate patients who could dodge this most fearsome morbidity.

Yet OPCAB utilization rates are declining in our specialty. Intraoperative validation is far from universal, with 30% usage in the United States compared with 80% in Japan [5]. A recent review of Veterans Health Administration data found a precipitous drop in proportion of OPCAB cases from 18% in 2008–2012 down to 9% just six years later [10]. National trends in the United States have also fallen. Even such uncontroversial developments as multiple arterial grafting have met slow adoption. Guidelines are effective tools and will continue to influence the community in this regard to the extent they can. European guidelines contain a Class IIa recommendation for TTFM since 2018. Japanese guidelines recommend OPCAB for high STS risk patients in 2018. American Heart Association 2021 guidelines contain a Class I recommendation for multiple arterial grafts using a radial artery and a Class IIa recommendation for bilateral IMA grafts by experienced operators.

The use of multiple arterial grafts warrants consideration in patients scoring appropriately on the SYNTAX scoring system. This remains the most widely accepted and utilized clinical scoring system in patients to guide the choice of revascularization in individuals with multivessel disease [12]. This may utilize a combination of arterial grafts, including bilateral internal mammary artery (BIMA), which remains under-utilized despite evidence suggestive superior outcomes when compared to single internal mammary artery (SIMA) use in patients with complex multi-vessel coronary disease [13]. Minimally-invasive approaches to CABG began to emerge in the 1990s, and has evolved from early mini-incisions and port placement to current use of robotic technology which facilitates completely endoscopic approaches. A review of over 11,000 patients indicates that the robot afforded a mortality rate of 1.0%, stroke of 0.6%, and wound infection of 1.2% [14]. The robot appears to demonstrate significant promise, mitigating the risks associated with sternotomy while affording appropriately-selected patients comparable revascularization outcomes [14].

Conclusions

The answer that the reader will find here perhaps begging the question, is that our community needs to identify coronary artery bypass surgery a subspecialty. Reasonable minds can disagree on the remedy. CABG remains by far the most commonly performed cardiac surgery. Most cardiac surgeons rely upon these cases for the balance of their clinical volume. However, if we wish to commit our progress in outcomes to the highest standards, the effect must be taken across the board. The solution well may lie in a posture of careerlong learning guided by the leadership of those who can share their expertise at scale. More investment here is to be commended. The most complex cases should be transported to centers with the greatest experience when appropriate. In any case, cardiac surgeons must view CABG as a complex set of specialized skills that require significant focus in skill development in order to achieve mastery. In conclusion, the logarithmic form of the trade-off between greater technical challenge in exchange for increasingly smaller, though crucial, increments of clinical excellence takes the shape of a CABG subspecialty. It remains imminently for the cardiac surgery community as a whole to determine the course.

Abbreviations

CABG, coronary artery bypass grafting; CAD, coronary artery disease; HFUS, high frequency ultrasound; IMA, internal mammary artery; NICE, National Institute for Health and Care Excellence; OPCAB, off-pump coronary artery bypass grafting; STS, Society of Thoracic Surgeons; TTFM, transit-time flow measurement.

Consent for Publication

This manuscript is the original work of the authors. We each give our consent to publish to the Journal of Cardiac Surgery.

Availability of Data and Materials

Referenced data is contained in the medical literature and available to the public.

Author Contributions

CH, JK and GT contributed substantially to the planning, writing and editing of this manuscript. All authors read and approved the final manuscript. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Conflict of Interest

The author declares no conflict of interest. GT is a member of the editorial board of this journal. GT declares that he was not involved in the processing of this article and has no access to information regarding its processing.

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