Dedicated training in advanced coronary surgery: Need and opportunity

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The transition from being a trainee to becoming an autonomous cardiac surgeon is a complex process with many challenges and potential pitfalls. Developing a niche within our specialty, in the sense of being a true expert in the management of patients with a similar set of problems, such as heart failure or aortic diseases, is the result of many years of hard work and experience. As Drs Vardas and Badhwar pointed out in a Thoracic Surgery Residents Association (TSRA) podcast episode that is a “must listen to” for every cardiothoracic trainee, “a niche is the endgame, not the first.”¹ Focused attention and continued dedication to a specific area is key to master all its facets, and it is well known that there is a positive volume-to-outcome (or, more appropriately, expertise-to-outcome) relationship in every field of our profession.

The issue of whether coronary surgery should be considered a well-defined subspecialty within adult cardiac surgery has been a matter of debate, with arguments made on both sides.^{2,3} We believe that state-of-the-art coronary surgery is a technically complex field, and that focused advanced training in such a discipline should be advocated to create true “coronary surgery specialists.” Although in the literature and at scientific meetings this issue has been addressed mainly from the senior surgeon's perspective, we would like to tackle it from the viewpoint of a trainee or young surgeon, for whom we think it would be a great opportunity and a wise choice to seek formal training in advanced coronary surgery. Indeed, one of us (C.M.R.) is about to complete his Cardiothoracic Surgery Fellowship

All-arterial, no-aortic-touch off-pump coronary artery bypass grafting (OPCAB).

CENTRAL MESSAGE

There remains a gap between available evidence and common practice in coronary surgery. Focused training is key to creating the coronary specialists of the future and advancing this discipline.

PERSPECTIVE

Coronary surgery should be considered a well-defined subspecialty within cardiac surgery. It is an extremely impactful discipline, yet its current implementation is below state-of-the-art standards. Expertise is key to performing all aspects, including the most technically challenging components, safely and effectively on a daily basis and to truly tailor the operation to each specific patient.

See Commentaries on pages 2135 and 2136.

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at the University of Michigan and will then be the Advanced Coronary Surgery Fellow at Mount Sinai Morningside (previously St Luke's) in New York under the mentorship of our senior author (J.D.P.), while the other young surgeon among the authors of this editorial (G.T.), after training and practicing with a faculty position at Mount Sinai St Luke's, is now working with the second senior author (H.H.B.) to complete his training in totally endoscopic robotic coronary bypass grafting.

In this *Young Surgeon's Note*, we present both the reasons, in our view and from a trainee's standpoint, to consider such career pathway (“why do it”) and propose a curriculum

of the skills that need to be learned and mastered to become a coronary specialist (“how to do it”).

WHY DO IT: FIVE REASONS TO CONSIDER AND SEEK FOCUSED TRAINING IN ADVANCED CORONARY SURGERY (FIGURE 1)

Widely Unmet Patient Needs

Coronary artery disease (CAD) remains the most common cause of death, and coronary surgery represents the largest component of adult cardiac surgical operations, with 55% of cardiac cases in the United States involving isolated coronary artery bypass grafting (CABG).⁴ Because it is the most commonly performed operation, CABG is often simplistically considered the “bread-and-butter” of cardiac surgery. This is an inappropriate designation, however, and it is against the evidence and the patients' interests to trivialize such an important procedure as a “commodity.” Despite compelling evidence regarding the benefits of several key components of intra-operative and perioperative management including, for instance, multiple arterial grafting (MAG)⁵ and, for high risk patients, no-aortic-touch off-pump techniques,⁶ most CABG operations are still performed using the same approach and strategy for every patient: on-pump, cardioplegic arrest CABG through a sternotomy using the left internal mammary artery (IMA) for one graft and saphenous vein(s) for the remaining graft(s). A second arterial conduit is used in only approximately 11% of CABGs performed in the United States.⁷ Minimization of aortic manipulation, together with aortic assessment with epiaortic ultrasound, is key to minimizing the risk of perioperative stroke. A no-aortic touch off-pump CABG (OPCAB) technique, in particular, dramatically decreases the risk of perioperative mortality (by 50%), stroke (by 78%), renal failure (by 53%), bleeding (by 36%), and atrial fibrillation (by 29%) over conventional on-pump CABG⁶ but yet is used only rarely due to its technical complexity. Moreover, we need to advance the field of CABG by offering less invasive procedures that are capable of providing the positive long-term benefits of MAG and the reduced stroke risk of a no-aortic touch technique together with a truly minimally invasive approach able to reduce postoperative length of stay and enhance overall recovery. In this sense, totally endoscopic CABG (TECAB), performed off-pump, is the most technically demanding procedure and is capable of providing bilateral IMA revascularization with no risk of sternal wound infection and no ascending aorta manipulation through a truly minimally invasive approach. This procedure is rarely performed due to its technical complexity. Implementation of evidence-based practices in coronary surgery would be extremely impactful and beneficial for a large number of patients every year.

Five reasons to get focused training in advanced coronary surgery:
1. Widely unmet patients' needs
2. Experience/expertise are crucial in coronary surgery
3. A true coronary surgery expert will play a key role within the multidisciplinary heart team
4. Coronary operations are beautiful
5. Fascinating research and academic opportunities

FIGURE 1. Why to do it: five reasons to consider and seek focused training in advanced coronary surgery.

Experience and Expertise Are Crucial in Coronary Surgery

Consider the case of OPCAB.⁸ It is still a widely held belief that OPCAB not only provides no benefit, but also is associated with higher rates of incomplete revascularization and inferior graft patency rates. Such a belief is overly simplistic, however, and does not take into consideration the key importance of the surgeon's experience and expertise with OPCAB. It is well documented that by avoiding the deleterious effects (eg, neurologic, respiratory, and renal dysfunction, coagulopathy) of cardiopulmonary bypass, OPCAB disproportionately benefits high-risk patients.⁹ However, OPCAB is not an operation that should be performed occasionally by the occasional OPCAB surgeon in high-risk patients. Reviewing data (Nationwide Inpatient Sample) on more than 2 million patients who underwent CABG between 2003 and 2011, Benedetto et al¹⁰ clearly showed the volume-to-outcomes relationship for OPCAB: at the hospital level, risk-adjusted in-hospital mortality was lower with OPCAB only in those hospitals in the highest-volume quartile (≥ 164 cases/year); at the surgeon level, it was higher than on-pump CABG for those OPCAB surgeons in the 3 lowest quartiles (ie, performing <48 cases/year), and lower (odds ratio, 0.6) for high-OPCAB volume surgeons (≥ 48 cases/year).

The same applies to the results of many randomized clinical trials. For example, it is well known that in the Arterial Revascularization Trial, the intention-to-treat analysis failed to show any benefit of a bilateral IMA grafting strategy over a single IMA strategy. Thus finding is inconsistent with the large body of observational data showing the superiority of bilateral IMA grafting and may be attributed to a high rate of crossover from bilateral to single IMA and a high use of the radial artery as a second arterial conduit in the single IMA arm. However, when considering the number of patients enrolled in the trial by each surgeon (a reasonable proxy of the surgeon's volume and expertise), a benefit of bilateral IMA grafting in terms of mortality and the composite of mortality, stroke, and myocardial infarction was evident for those surgeons who performed ≥ 50 operations in the trial.¹¹

Therefore, when considering evidence derived from both observational studies and randomized clinical trials, surgeon's expertise plays a key role in coronary surgery. "Hot topics" such as MAG and OPCAB should be studied while keeping this in mind. Only those surgeons who can master every aspect and option of coronary revascularization are able to truly tailor the surgical operation to each specific patient. To perform the most technically demanding coronary procedures (such as off-pump no-aortic touch bilateral IMA and robotic TECAB) safely and successfully on a daily basis, commitment and dedication on the part of the surgeon and their entire team is mandatory.

A True Coronary Surgery Expert Plays a Key Role in the Multidisciplinary Heart Team

Complex clinical scenarios (eg, patients with major comorbidities/high risk, diffuse severe CAD, poor targets, multiple previous interventions) should be discussed within and managed by a multidisciplinary team of true coronary experts. A cardiac surgeon with focused interest and expertise in all the aspects of coronary surgery, including the most technically challenging components of the specialty, will be of paramount importance in the collaboration with interventional cardiologists and will be able to offer the best treatment option (eg, hybrid, off-pump, no aortic touch, multiarterial, minimally invasive technique, endarterectomy) for each individual specific patient safely and effectively. Although many CABG operations will still be performed by "generalist" cardiac surgeons, a coronary surgery expert will be the best surgeon to address such complex scenarios and to educate the cardiovascular professional community.

Coronary Operations Are Beautiful

Yes, this is our personal opinion and not a data-supported statement, but we honestly believe that advanced coronary surgery is second to none in terms of beauty of surgical technique. We see different "phenotypes" of adult cardiac surgeons that justify/motivate the decision to pursue a career within a specific subspecialty. The "heart failure/transplant surgeon," for instance, is passionate about the idea of replacing or supporting the function of a very weak ("failed") heart and treating very sick patients with (oftentimes) multisystem organ failure. The "aortic surgeon," as a second example, is excited by performing major macroscopic reconstructive or endovascular procedures that affect not only the central/largest blood vessel in the body but also, consequentially, every other organ system (brain, spinal cord, viscera, extremities), working at a "whole-body" scale. In our view, the phenotype of the "coronary surgeon" is characterized by passion for the most precise, challenging, and elegant surgical technique (true

microsurgery of the heart, where everything must be done perfectly at a <0.1-mm scale, while working efficiently and safely). Technical perfection as a mandatory requirement for eventual success is nowhere exemplified better than in coronary operations. The quality of the surgical technique (eg, depth, distance, harmony, pace and efficiency of every stitch, every gesture, and every step) has long-term consequences for the durability of our revascularization and thus the quantity and quality of life of our patients. The inextricable interrelationship between beauty and function ("what looks beautiful also works better"), which is an eternal theme in art and philosophy, from the *kalós kai agathós* of the ancient Greek through the aesthetic and moral ideals of Michelangelo and the Renaissance to our own days, finds one of its highest embodiments in coronary surgery. If you love to operate and are passionate about surgical technique, there is nothing more beautiful and exciting than coronary surgery.

Fascinating Research and Academic Opportunities

Dealing with the coronary circulation, coronary surgery focuses on studying and understanding the blood flow requirements of the heart and on developing and implementing a strategic plan meant to optimize the energy supply-to-demand balance of the heart. We see exciting endless scientific opportunities within this specialty as it pertains to the pathophysiology of coronary disease, invasive and noninvasive assessment of the coronary circulation, technical steps of the operations, and perioperative management. Coronary surgery is a wonderful choice for a young surgeon who wants to pursue an academic career.

The International Coronary Congress (ICC), an annual 3-day-long meeting that engages the participation of coronary surgery experts from around the world, provides a unique venue in which to learn and discuss the current and emerging topics of the specialty and a great opportunity for trainees. The fifth annual meeting of the ICC was held in New York City on December 6–8, 2019, and the next one is scheduled for December 4–6, 2020, in Tokyo.

HOW TO DO IT: PROPOSED CURRICULUM FOR A FORMAL STRUCTURED TRAINING PATHWAY IN ADVANCED CORONARY SURGERY (FIGURE 2)

From a knowledge and scientific standpoint, a coronary surgery specialist must be able to understand and master all diagnostic and therapeutic aspects of the discipline, work proficiently with cardiologists and all other members of a dedicated multidisciplinary heart team, and be enthusiastically involved in research endeavors and clinical trials.

From a technical standpoint, several components beyond basic cardiothoracic surgery training need to be learned and mastered by a young surgeon who wishes to become a coronary expert. The following list is our proposed progression

FIGURE 2. How to do it: proposed curriculum for a formal structured training pathway in advanced coronary surgery. *IMA*, Internal mammary artery; *OPCAB*, off-pump coronary artery bypass; *MAG*, multiple arterial grafts; *TECAB*, totally endoscopic coronary artery bypass.

(transitioning from easier to more complex) of technical skills to master. Of course, such a curriculum must be adapted to the specific situation and to the specific trainee.

- Routine skeletonization of IMAs. The benefit of skeletonization of IMA over the pedicle technique has been well established to increase conduit length, reduce the risk of sternal wound infection, and facilitate the performance of Y and T anastomoses from IMA conduits. The Harmonic scalpel (Ethicon Endo-Surgery, Minneapolis, Minn) is a user-friendly tool for proficient skeletonization of the IMA. Its use helps minimize trauma to the veins and the soft tissues surrounding the IMA, decreasing the risk of wound infection even further. The pedal activator represents a good opportunity to train young surgeons in the hand/foot coordination that is also required by the current robotic platform for the most advanced coronary revascularization.
- Endoscopic harvest of radial artery. Endoscopic conduit harvest has always been perceived by trainee surgeons as a cardiac surgery skill not required to advance in our profession. One of the most important limiting factors in adopting a second arterial conduit as a standard of care in CABG surgery is the lack of skilled operators capable of harvesting a radial artery with minimally invasive techniques. To establish a center of excellence in coronary surgery, surgeons should be vested in each step of the operation and in the training of the physician assistants or cardiac surgery residents in harvesting radial arteries.
- Routine use of MAG. This is facilitated by skeletonized harvest of bilateral thoracic arteries and endoscopic harvest of radial arteries. MAG should be the routine default operation for surgical coronary revascularization.

- OPCAB through sternotomy. There is abundant evidence indicating that avoiding the potential complications of the heart-lung machine in cardiac surgery is beneficial to patients. Moreover, OPCAB is a key platform that allows the surgeon to minimize or entirely avoid aortic manipulation during surgical coronary revascularization. OPCAB requires a reengineering of the conduct and process of CABG surgery for the whole team and thus cannot be a casual, infrequent occurrence. Given that coronary surgery is an epicardial procedure and given the availability of cardiac stabilizers and positioners as well as a wealth of expertise in performing this procedure successfully, this approach can be perfected by the young coronary surgeon who takes the time to learn from an expert in the field.
- Proximal anastomoses without aortic clamp using, for example, the HeartString device (Heartstring III Proximal Seal System; Getinge, Wayne, NJ) or the single shot PAS-Port device (PAS-Port Proximal Anastomosis System; AesDex/Aesculap, Palo Alto, Calif). The avoidance of aortic clamping has been shown to reduce the dreaded complication of perioperative stroke and should be a routine goal in OPCAB cases.
- Composite Y/T, I, and K grafts, alternative MAG configurations that use available arterial conduits efficiently
- Total arterial no-aortic touch OPCAB, perhaps the gold standard of surgical coronary revascularization via sternotomy
- Coronary endarterectomy and coronary stentectomy. These are difficult procedures suitable for patients with diffuse disease, in-stent restenosis, and/or chronic total occlusion. The indications for these procedures are becoming more common in the era of multiple coronary stenting.

- Robotic harvest of IMA. For sternal-sparing coronary surgery to be successful, surgeons must take advantage of robotic systems that provide 3-dimensional vision and manual dexterity to execute a procedure as complex as coronary bypass. The first step toward this will be the harvesting of one IMA, followed by both IMAs. Skeletonization should be perfected first via sternotomy, however, after which robotic left IMA harvesting can be tackled, and then finally crossing the midline to the right pleural space and performing the exact same maneuvers to successfully harvest the right IMA.
- Minimally invasive direct CABG (MIDCAB) though nonsternotomy approaches (eg, left anterior small thoracotomy)
- On-pump TECAB
- Off-pump TECAB. This we believe is the highest form of coronary surgery, but it will take a significant learning curve in both robotic and coronary surgery to perfect. A dedicated training period will be necessary after mastering OPCAB/MIDCAB and robotic IMA harvesting to begin to handle the full beating heart in an endoscopic environment. Familiarity with endoscopic cardiac stabilization and distal anastomotic devices will also be important, and demonstration of interest in and engagement with this procedure will help secure industry support for future development of these devices.

CONCLUSIONS

In summary, we believe that coronary surgery should be considered a well-defined subspecialty within cardiac surgery. It is an extremely impactful discipline, providing significant survival and quality of life benefits to an immense number of patients. Nonetheless, there remains a considerable gap between available evidence and common practice. This represents an important opportunity to elevate the standard of care in surgical coronary revascularization. Experience and expertise are key, and the most

technically challenging yet beneficial components (such as no-aortic touch MAG OPCAB) should be performed only by coronary experts and not occasionally by inexperienced surgeons for high-risk patients only. Coronary surgery is, in our opinion, the most beautiful surgical specialty from both the technical and research/academic standpoints. A structured, focused advanced training in coronary surgery is the key to creating the coronary specialists of the future and represents a golden opportunity for young surgeons.

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