Cardiac surgery training in Canada: Current state and future perspectives

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As stated by the Hippocratic oath, transmission of knowledge is an important part of a physician's duty: "I will impart a knowledge of the Art to my own sons, and those of my teachers, and to disciples bound by a stipulation and oath according to the law of medicine, but to none others." Historically, training in surgery was based on oral transmission and an "apprenticeship" between a junior trainee and a senior surgeon or mentor. During the training period, surgical residents have to develop the knowledge, technical abilities, surgical intuition, and clinical experience necessary for independent and safe practice. We present here the modalities, objectives, strengths and weaknesses, challenges, and the future of training in cardiac surgery in Canada.

BACKGROUND: DEMOGRAPHY OF CARDIAC SURGERY IN CANADA

Historic Considerations

The Royal College of Physicians and Surgeons of Canada (RCPSC) recognized the specialty of thoracic surgery in 1946 and the specialty of cardiovascular surgery in 1962.¹ The first training program dedicated to cardiovascular surgery in Canada was created in 1958 by Dr Bigelow at the University of Toronto. Before 1984, trainees could obtain a combined fellowship in cardiac, vascular, and thoracic surgery. In 1986, vascular surgery was removed from the combined fellowship and in 1989, thoracic surgery also was removed, as well as the mandate to successfully

complete certification in general surgery. Currently, candidates are only certified in cardiac surgery. Important dates in the evolution of cardiac surgery education in Canada are summarized in [Table 1](#).

Cardiac Surgery Workforce in Canada

The number of major cardiac procedures has been increasing during the last few years and about 30,000 were performed in 2014 with a median annual number of cases per center of 1012 ± 437 (range 400-1900). There are approximately 175 active cardiac surgeons in Canada allocated in 30 cardiac surgery centers across the country (6.2 cardiac surgeons per center). Most Canadian cardiac surgeons work in academic centers (80%) and must balance

Proposed new curriculum for cardiac surgery training programs in Canada.

Central Message

We present here the modalities, the objectives, the strengths and weaknesses, the challenges, and the future of training in cardiac surgery in Canada.

Perspective

The future pathway of cardiac surgery training evolves towards the Competence by Design initiative that should be effective as of 2018 in Canada. The objectives of this competency-based curriculum are to improve training and to focus on competence acquisition as opposed to a time-based rationale. One of the major novelties is that the last year of the training will become a transition year between residency and attendant practice.

See Editorial Commentary page 1006.

TABLE 1. Important dates in the evolution of cardiac surgery education in Canada

Year	Event
1929	Creation of the RCPSC
1946	RCPSC recognized thoracic surgery as surgical specialty
1961-1962	RCPSC recognized cardiovascular surgery and defined the combined fellowship in cardiovascular and thoracic surgery
1958	First training program dedicated to cardiovascular surgery in Toronto
1994	Thoracic surgery, vascular surgery, and cardiac surgery became 3 distinct specialties. Introduction of the Direct entry in an I6 integrated program in cardiac surgery
1996	RCPSC adopted CanMEDS framework (updated in 2005 and 2015)
2018-2020	Competency by Design to be implemented in cardiac surgery training programs

RCPSC, Royal College of Physician and Surgeons of Canada; I6, integrated 6-year.

their clinical activities with research and education. Some cardiac surgeons also work part-time as intensivists. Hence, Canadian cardiac surgeons operate in average 2 to 4 days per week, and their volume varies between 125 and 300 cases per year depending on the balance of their activities, with a mean annual caseload of 175 major cardiac cases per year. A survey undertaken by the Canadian Society of Cardiac Surgeons Workforce Committee in 2014 determined that the mean age of surgeons is 52 ± 9 years, and approximately 20% of cardiac surgeons were older than 60 years and almost one half were older than 50 years of age (M. Ouzounian et al, unpublished data, 2017). In the next 5 years, 28 cardiac surgeons are expected to retire, and 41 finishing residents are expected to be recruited (ratio recruitment/retirement = 1.5).

CURRENT STATUS OF CARDIAC SURGERY TRAINING IN CANADA

Accreditation of Cardiac Surgery Training Programs: The Royal College of Physicians and Surgeons of Canada and the CanMEDS Framework

Created in 1929, the RCPSC is the national association that oversees postgraduate medical education and certification in more than 68 disciplines. The RCPSC also verifies that physicians meet all the requirements necessary for their certification and accredits the learning activities that physicians pursue in their continuing professional development programs. The RCPSC is in charge of the accreditation of the residency programs at all 17 medical schools across Canada. It evaluates infrastructure, quality of faculty, case volume, resources specifically allocated for residents' education, and issues related to residents' quality of life. If a program does not conform to the specialty-specific objectives, the RCPSC may withdraw accreditation. In 1996, the RCPSC adopted the CanMEDS concept recently

updated to "CanMEDS 2015."² This medical education framework defines the 7 competencies required to be a competent physician in Canada. The competencies include "medical expert" (integrating role), "communicator," "collaborator," "leader," "health advocate," "scholar," and "professional."

Training Programs in Canada

Resident recruitment process. There are 12 accredited residency-training programs in cardiac surgery in Canada (Table 2). The universities and the provincial government determine the number of positions for new residents annually. Graduates of all Canadian medical schools are eligible to apply to these cardiac surgery programs. Although most programs take one trainee annually, some programs take trainees on alternate years. In addition, some programs take foreign and international medical graduates. Applicants must use a national independent organization named Canadian Resident Matching Service (CaRMS), which coordinates the matching process. CaRMS provides a transparent application and matching service for entry into postgraduate medical training for all specialties. Applicant files are reviewed by the program, and selected applicants are offered a formal interview. Selection committees usually consist of the program director, faculty, and residents, who assess the candidate based on academic, clinical, and interpersonal criteria. The candidates rank the training programs according to their preference, and each training program reciprocally ranks each candidate. An algorithm is then used to confirm the best match. Training paradigms for cardiac surgery differ across the globe. In comparison, the recruitment of trainees in France is based on the ranking after a nationwide competitive examination, named Examen Classant National, after 6 years of medical school.

TABLE 2. Canadian universities with a training program in cardiac surgery

Towns	University	History of program	Number of offered positions (2015)
Calgary	University of Calgary	2005-present	1
Edmonton	University of Alberta	1960-present	1
Halifax	Dalhousie University	1976-1989, 1999-present	1
Hamilton	McMaster University	1988-1992, 1999-present	1
London	Western University	1960-present	1
Montreal	McGill University	1965-present	0
Montreal	University of Montreal	1967-present	1
Ottawa	University of Ottawa	1976-present	1
Quebec	University of Laval	2008-present	1
Toronto	University of Toronto	1958-present	1
Vancouver	University of British Columbia	1960-present	1
Winnipeg	University of Manitoba	1967-present	1

Each year, all 7500 medical students must choose a city and a specialty according to their rank. The cardiac surgery residency training in France is a 5-year program. Two years are allocated for general surgery and 3 years for thoracic, vascular and cardiac surgery.

In the United States, medical students may apply to 1 of 3 general categories of cardiothoracic training programs. The traditional (5+2) program is a 2- or 3-year cardiothoracic fellowship after a 5-year residency in general surgery. The integrated 6-year (I6) cardiothoracic program has been available in selected institutions for less than 10 years. Graduates of the I6 programs are not eligible to take the general surgery board examinations required to practice general surgery. The final option is called a “fast track” program and involves 4 years of general surgery followed by 3 years of cardiothoracic surgery. This program is only available at a few US centers.

During the last 10 years, the number of applicants in Canada has varied from 75 in 2008 to 10 in 2012 (Figure 1, A), whereas the number of positions has remained stable at approximately 9 per year. Since 2006,

between 1 and 7 cardiac surgery positions have remained unfilled after the first iteration of the CaRMS. The reasons for this variation in the applicant pool over time remain uncertain. The absolute numbers of applicants (range 10 to 75) and residency-training programs in cardiac surgery in Canada are quite small ($n = 12$); thus, small variations in trainee interest have important repercussions on the number of applicants. It is likely that the perception of a difficult job market for new graduates may have contributed to this decline in interest. In a survey of all recent Canadian cardiac surgery graduates, Ouzounian and colleagues³ reported that only 54% of recent would strongly recommend cardiac surgery to potential trainees. A survey carried out in 2015 by the Canadian Society of Cardiac Surgeons Workforce committee identified 96 cardiac surgery trainees in the 12 accredited training programs. Among the 88 residents who responded to the survey, 28% were women, and the mean age was 30.4 ± 3.7 years. Sixteen residents (18%) were postgraduate year (PGY) 1, 10 (21%) were PGY2, 17 (18%) were PGY3, 14 (15%) were PGY3 and PGY4, and 17 (18%)

A

B

FIGURE 1. A, Cardiac surgery residency positions in Canada. Positions offered, filled, and vacant from 2005 to 2015 are shown. B, Design of current Cardiac Surgery Training Program in Canada. *PGY*, Postgraduate Year; *CaRMS*, Canadian Resident Matching Service.

were PGY6. The mean length of training including a fellowship was 9.4 years.

Canadian cardiac surgery training program curriculum. Residency training in cardiac surgery is currently 6 years in duration (Figure 1, B). The first 2 PGYs are dedicated to the “surgical foundations,” and several mandatory rotations are common for residents in all surgical specialties, such as trauma, emergency medicine, and general surgery (Table 3). Residents are exposed to core cardiology rotations, including cardiac catheterization, electrophysiology, echocardiography, and the coronary care unit. The residents have the opportunity to spend a year on clinical enrichment, during which they may pursue research training or specialized clinical rotations. Finally, the residents develop their core knowledge in cardiac surgery (adult and congenital), as well as vascular and thoracic surgery in their final three years.

Surgical foundations (junior resident: PGY1, PGY2). During surgical foundations, trainees have to acquire the knowledge, skills, and attitudes underlying the basics of the practice of surgery. The RCPSC Surgical Objectives are listed in Tables 3 and 4. During this period, trainees must spend at least 3 months in cardiac surgery, 2 months in general surgery, 1 month in anesthesia, 6 months in cardiology, 1 month in echocardiography, 4 months in thoracic or vascular surgery, 1 month in critical care unit, and 1 month in a service that provides initial trauma management. At the completion of surgical foundations training, each resident must complete an examination from the RCPSC on the principles of surgery.

Specialty (senior resident: PGY 3, 4, 5, and 6). During these 4 years, trainees are exposed to thoracic surgery, vascular surgery, and adult and congenital cardiac surgery. One year generally is dedicated for academic or clinical enrichment. This year is flexible in terms of content and location within the training period. The majority of trainees extend the academic enrichment year to obtain either a master's (56%) or doctoral (22%) degree. It also may be spent in clinical rotations to obtain further training in vascular surgery or one of the subspecialty areas within cardiac surgery.

During the senior rotations, trainees spend 18 months on the adult cardiac surgery service. There is no specific requirement in term of number of cases, but they usually perform between 50 and 100 major procedures as the first operator.

Residents are required to participate in weekly educational conferences, including journal clubs, morbidity and mortality conferences, scientific meetings, specialty-specific courses, and pertinent local medical meetings. The type, content, frequency, and quality of these conferences are not nationally standardized and vary according to the individual programs.

Gradation of responsibility is a significant objective of all programs. The level of responsibility varies according to the trainees' stage and the complexity of the cases, but residents are always under faculty supervision. There is formal duty-hour restriction; trainees cannot work more than 24 hours in a row. They must remain free of clinical duties the day after in-house calls. Junior residents are required to take between

TABLE 3. Training requirements in cardiac surgery in Canada

Type of rotation/specialty	Number of blocks/rotations required (1 block = 1 mo)
Foundational training in surgery: PGY1 and PGY2 (26 mo)	
Cardiac surgery	3
Critical care medicine	3
Anesthesia	1
General surgery	2
Trauma service	1
Cardiology (coronary care unit, ward cardiology, electrophysiology, interventional cardiology, adult echocardiography, cardiac imaging)	6
Emergency medicine	1
Vascular and/or thoracic surgery	4
Free choice among: pathology, infectious disease, geriatrics, nephrology, neurology, cardiology consultation, plastic surgery, ambulatory cardiology, cardiac surgery, general surgery, echocardiography	5
Royal College Exam: foundations	
Academic/clinical enrichment—usually in PGY3	6-13
Specialty in cardiac surgery: PGY4-6 (39 mo)	
Cardiac surgery (13 blocks as senior resident and 6 blocks as chief resident)	20
Thoracic surgery and vascular surgery (minimum 3 as senior resident in thoracic surgery and 6 as senior resident in vascular surgery)	13
Congenital cardiac surgery	6
Royal College Final Exam	

Trainees have to successfully complete 78 4-week blocks or rotations before presenting to the Royal College Certification Examination. PGY, Postgraduate year. Copyright 2015, The Royal College of Physicians and Surgeons of Canada. Referenced and produced with permission.

4 and 6 in-house calls per month, and senior residents are required to take between 4 and 8 in-house calls per month. Salaries start from CAD\$44,552 per year for a PGY1 to CAD\$66,069 per year for a PGY6.

Assessment of Trainees

Throughout their 6-year residency, trainees are evaluated at regular intervals after clinical rotation with in-training evaluation reports. Evaluation is based on direct observation in the clinical setting, and specific evaluation points are more qualitative than quantitative. There is also feedback from trainees about the educational value of each rotation. At the completion of training, a final in-training evaluation report evaluation is completed by the program director according to RCPSC guidelines and the CanMEDS requirements. The programs themselves are assessed by independent RCPSC overseers every 6 to 8 years to confirm they meet national standards.

Royal College Examination

During residency, trainees will sit 2 examinations to achieve full certification. The first (Surgical Foundations Examination) is undertaken after completion of a minimum of 2 years of training. Candidates are eligible to sit the Final Examination after satisfactory completion of 6 years in rotations that meet the specialty training requirements recognized by the RCPSC. There is a written and an oral component. The objective of the written examination is to test the breadth and depth of the candidate's knowledge in cardiac surgery through 90 short-answer questions, which are based on the objectives of training in the specialty of cardiac surgery (Table 4).

The oral component is designed to measure surgical judgment and situational awareness. It consists of 2 sessions, each lasting approximately 90 minutes. Each session comprises 4 separate case scenarios, each of which is administered in a different room by a different examiner. Each case scenario is standardized, lasting a maximum of

TABLE 4. Competencies required for a resident who has completed training in cardiac surgery in Canada

Medical expert

1. Function effectively as consultants, integrating all of the CanMEDS roles to provide optimal, ethical, and patient-centered medical care
2. Establish and maintain clinical knowledge, skills, and attitudes appropriate to cardiac surgery
3. Perform a complete and appropriate assessment of a patient
4. Use preventive and therapeutic intervention effectively
5. Demonstrate proficient and appropriate use of procedural skills, both diagnostic and therapeutic
6. Seek appropriate consultation from other health professionals, recognizing the limits of their expertise

Communicator

1. Develop rapport, trust, and ethical therapeutic relationship with patients and families
2. Accurately elicit and synthesize relevant information and perspectives of patients and families, colleagues, and other professionals
3. Convey relevant information and explanations accurately to patients and families, colleagues, and other professionals
4. Develop a common understanding on issues, problems, and plans with patients, families, and other professionals to develop a shared plan of care
5. Convey effective oral and written information about medical encounter

Collaborator

1. Participate effectively and appropriately in an interprofessional health care team
2. Work with other health professionals effectively to prevent, negotiate, and resolve interprofessional conflict

Manager

1. Participate in activities that contribute to the effectiveness of their health care organizations and systems
2. Manage their practice and career effectively
3. Allocate finite health care resources appropriately
4. Serve in administration and leadership roles, as appropriate

Health advocate

1. Respond to individual patient needs and issues as part of patient care
2. Respond to the health needs of the communities that they serve
3. Identify the determinants of health for the population that they serve
4. Promote the health of individual patients, communities, and populations

Scholar

1. Maintain and enhance professional activities through ongoing learning
2. Critically evaluate medical information and its sources, and apply this appropriately to practice decisions
3. Facilitate the learning of patients, families, students, residents, other health professionals, the public, and others
4. Contribute to the development, dissemination, and translation of new knowledge and practices

Professional

1. Demonstrate a commitment to their patients, profession, and society through ethical practice
2. Demonstrate a commitment to their patients, profession, and society through participation in profession-led regulation
3. Demonstrate a commitment to physician health and sustainable practice

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20 minutes. Each year, close to 90% of Canadian trainees successfully pass the RCPSC examination. Trainees have a maximum of 3 attempts to successfully pass the board examination.

Postgraduate Training or Fellowship

Additional training (1- or 3-year fellowship) has become a de facto requirement to get a job in an academic cardiac surgery center in Canada. Thus, all graduates completed at least 1 year of fellowship training after residency to develop skills in a niche area.³ When surveyed, less than one third of graduates extended their training due to a lack of employment.³ Fellowships usually are undertaken in centers of excellence in the United States or in Europe, and graduates generally seek additional training to acquire a specific skill set (minimally invasive valve surgery, heart failure, aortic surgery). The development of specialized programs (heart transplants/ventricular assist devices, robotics, congenital heart surgery) is determined by each individual center according to their patient population and academic goals. Some residents will be recruited for attending positions during their training, and a mutually agreed-on subspecialty fellowship will be chosen.

NEW CHALLENGES

Cardiac surgery training in Canada faces a series of unique challenges. Some of these are distinct from our American colleagues, but some also provide the opportunity for the evolution and redefinition of our specialty in Canada.

Medical Student Interest in Cardiac Surgery

In the past, because of the small number of positions and training programs, obtaining training was highly competitive, requiring early expression of interest and dedication for a career in cardiac surgery by a medical student. However, the number of interested students has decreased the years due to several reasons. Some have been wary of the potential threat of the expansion of cardiology-driven and catheter-based therapies, questioning the viability of the specialty. Students also have witnessed the current cohort of recent graduates from cardiac surgery that remain unemployed or “underemployed,”^{4,5} not recognizing the real threat of a desperate potential shortage of trained cardiac surgeons in the near future.^{6,7}

In addition, exposure to cardiac surgery is often limited in the first 2 years of medical school, particularly in smaller universities. In an effort to enhance specialty exposure, novel educational programs such as Surgical Exploration And Discovery have been introduced with active participation of cardiac surgery faculty.⁸

Program- and Specialty-Specific Challenges

Despite a national pathway defined by the RCPSC, there is a lack of homogeneity throughout Canada in terms of clinical

exposure, curriculum, and course content. For instance, congenital training is considered an essential component of the adult cardiac surgery program. In contrast, only a few institutions in Canada have an active congenital program. This has necessitated the need for several programs to negotiate interuniversity agreements to ensure appropriate training of their residents. However, training in a different program requires relocation of the trainees for that period of time and may be disruptive. The same collaboration is required to acquire adequate exposure in ventricular assist devices or transplantation.

Training in hybrid procedures, especially transcatheter valve replacement, is also an important educational challenge during residency. Catheterization labs or hybrid operating rooms are usually crowded environments (cardiologist, echocardiographer, cardiology trainees, and cardiac surgery trainees), and access to hands-on “action” is challenging. Simulation training may be a useful tool to permit the resident to acquire the technical skills for these complex procedures before doing them in the operating room.

Acquiring catheter-based skills during cardiothoracic residency is probably the most important issue in the current and future area. Indeed, Rubens and colleagues⁹ and Lazar¹⁰ recently reported that 80% of Canadian trainees or fellows in cardiac surgery expressed the need for more exposure in catheter-based rotations, and 67% indicated that they would have preferred greater exposure in the catheterization lab. In addition, all program directors firmly believed that a rotation in the catheterization lab should be mandatory for cardiac surgery trainees. The catheter skills for thoracic endovascular aortic repair and transcatheter aortic valve replacement also may be acquired during residency or during a postresidency fellowship in conjunction with radiologists, cardiologists, and surgeons who are proficient in these techniques.

Finding a Job After Residency

Because uncertainty remains regarding gainful employment after residency in cardiac surgery, residents support that training should be tailored to allow for alternative pathways for additional specialty training. Indeed, 38% of the recent Canadian cardiac surgery graduates who were surveyed in 2015 expressed a strong preference for diversifying the training of Canadian cardiac surgeons to offer multiple certification opportunities during core training, including vascular surgery and thoracic surgery.^{3,6,11} It is notable that 11% of the Canadian survey respondents reported practicing as a cardiac intensivist, some of whom have obtained formal intensive care certification. Furthermore, trainees who are not deemed to be suitable for a career in cardiac surgery should be identified early and helped to transition to another training program.

FIGURE 2. Proposed new curriculum for cardiac surgery training programs in Canada according to Competence by Design. The *Transition to Discipline* is a new stage that emphasizes the orientation and assessment of new trainees arriving from different medical schools and programs. The *Foundation* stage covers wide-ranging competencies that every trainee must acquire before moving on to more advanced, discipline-specific competencies. The *Core Competencies* make up the majority of the discipline. In the “new” stage, *Transition to Practice*, the senior trainee should demonstrate readiness to make the transition to autonomous practice. CBD, Competence by Design; MD, medical degree.

FUTURE Simulation

Cardiac and thoracic surgeons need to acquire technical abilities that could be practiced in simulation, without threatening patient safety. The use of explanted porcine hearts in “wet lab” environments has been used widely in the history of cardiothoracic surgery. Surgical simulation can provide a less-stressful environment for graduates for the training of technical skills and crisis management, and it is safer for the patients. Many publications reported the benefits of simulation in the field of cardiopulmonary bypass, cardiopulmonary bypass weaning,¹² intensive care, mitral surgery,¹³ and coronary surgery.¹⁴ Many cardiac surgery training programs already include simulation in their curriculum, including the annual Boot Camp offered to first- and second-year residents since 2015.

Competence by Design (CBD)

Given the unique pace of acquiring skills and knowledge of individual trainees, the RCPSC has shifted residency education from a time-based program (I6 years) to a competency-based learning, framed by multiple evaluated competency milestones. The purpose of CBD is to better individualize the training of each resident, without time constraint and better emphasis on competence acquisition. One of the major novelties is that the last year of the training

will become a transition year between residency and attendant practice. This year will follow the final examination of the RCPSC. A recent survey on the Canadian cardiac surgery workforce trainees showed that only one half of the finishing trainees felt competent to practice independently just after their residency.¹⁵ To better prepare residents to practice, the CBD taskforce is planning to transform the final year from conventional residency to a transition year.

Challenges of a competency-based system of education include reliable and valid methods of assessment, as well as establishment of passing standards for technical skills. A task force in association with the RCPSC currently is working on the implementation of the competency-based framework in cardiac surgery. This program (CBD; Figure 2) should be implemented as early as 2018 in some Canadian programs. Residents will develop ability over time in stages and will be assessed according to defined competencies and specific milestones. The Entrustable Professional Activities, a key cornerstone of this process, are a responsibility or task in the clinical setting that may be delegated to a resident by their supervisor once sufficient competence has been demonstrated.

SUMMARY AND CONCLUSIONS

The RCPSC, in collaboration with the universities, guarantee the high level and the relevance of the Canadian training programs in cardiac surgery. The future pathway of cardiac surgery training is a CBD initiative that should be effective as of 2018 in Canada for training in cardiac surgery. With joint efforts and diligence from the surgical educators in cardiac surgery and the RCPSC task force, a practice-ready cohort of graduates will be available to serve the needs of the Canadian population in cardiac surgical care.

Conflict of Interest Statement

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