

# The state of transcatheter aortic valve implantation training in Canadian cardiac surgery residency programs

Derrick Y. Tam, MD  
 Ahmed Makhdoum, MD  
 Maral Ouzounian, MD, PhD  
 Harindra C. Wijeyesundera, MD,  
 PhD  
 Gideon N. Cohen, MD, PhD  
 Stephen E. Fremes, MD, MSc

Accepted Feb. 15, 2018; Early-released  
 Oct. 1, 2018

## Correspondence to:

S. Fremes  
 Schulich Heart Centre  
 Sunnybrook Health Sciences Centre  
 2075 Bayview Ave, Rm H4 05  
 Toronto ON M4N 3M5  
 stephen.fremes@sunnybrook.ca

DOI: 10.1503/cjs.017517

**Background:** The current state of transcatheter aortic valve implantation (TAVI) training for Canadian cardiac surgical residents is unknown. Our goals were to establish a national inventory of TAVI educational resources, elucidate the role of residents in TAVI programs, and determine the attitudes and perspectives of residents and program directors regarding the importance of TAVI technology and training.

**Methods:** We sent Web-based surveys and reminders to all Canadian cardiac surgical residents and program directors between February and July 2017. We used descriptive analyses to summarize data in an aggregate and anonymous manner. We analyzed patterned responses to open-ended survey questions using thematic analysis.

**Results:** Seventy-eight of 92 residents (85%) and 11 of 12 program directors (92%) completed the survey, with broad representation from across Canada. A minority of residents (14 [18%]) and program directors (4 [36%]) reported that TAVI training in their program was adequate. Only 3 program directors (27%) reported that their residents had access to TAVI simulation training. Although most residents (76 [97%]) and program directors (10 [91%]) agreed that TAVI was important to the trainee's future practice, about two-thirds (54 [69%] and 7 [64%], respectively) agreed that TAVI should be a focus of fellowship training. A perceived lack of interest from interventional cardiologists to teach surgical residents, competition from TAVI fellows and lack of formalized time during residency were identified as perceived barriers to TAVI training.

**Conclusion:** As Canadian surgical residency training moves toward a Competence by Design curriculum, there remains a pressing need to create uniform learning objectives and expectations in the TAVI curriculum.

**Contexte :** On ne connaît pas l'état actuel de la formation en implantation transcathéter de valvule aortique (ITVA) que reçoivent les médecins résidents dans les programmes canadiens de chirurgie cardiaque. Nous voulions dresser un inventaire national des ressources pédagogiques en ITVA, expliquer le rôle des médecins résidents dans les programmes d'ITVA et déterminer les attitudes et les points de vue des résidents et des directeurs de programme quant à l'importance de la technologie d'ITVA et de la formation en la matière.

**Méthodes :** Entre février et juillet 2017, nous avons envoyé des sondages web et des rappels à tous les médecins résidents en chirurgie cardiaque et aux directeurs de ces programmes au Canada. Nous avons utilisé des analyses descriptives pour résumer les données de façon agrégée et anonyme. Nous avons analysé les réponses à des questions ouvertes et dégagé des tendances au moyen d'une analyse thématique.

**Résultats :** Soixante-dix-huit des 92 résidents (85 %) et 11 des 12 directeurs de programme (92 %) ont répondu au sondage, avec une vaste représentation de partout au Canada. Une minorité de résidents (14 [18 %]) et de directeurs de programme (4 [36 %]) ont déclaré que la formation en ITVA offerte par leur programme était adéquate. Seuls 3 directeurs de programme (27 %) ont déclaré que leurs résidents avaient accès à une formation en simulation de l'ITVA. Bien que la plupart des résidents (76 [97 %]) et des directeurs de programme (10 [91 %]) soient d'accord pour dire que l'ITVA est importante pour la pratique future du stagiaire, environ les deux tiers (54 [69 %] et 7 [64 %], respectivement) sont d'avis que la formation à l'ITVA devrait faire l'objet d'un stage particulier. Un manque perçu d'intérêt de la part des cardiologues interventionnels pour l'enseignement aux médecins résidents en chirurgie, la compétition entre les stagiaires pour la formation à l'ITVA et le manque de temps officiellement réservé à ce volet pendant la résidence ont été identifiés comme des obstacles perçus à la formation en ITVA.

**Conclusion :** À mesure que les programmes de résidence en chirurgie au Canada s'orientent vers une formation axée sur les compétences par conception, il demeure urgent de formuler des objectifs et des attentes d'apprentissage uniformes pour la formation en ITVA.

**T**ranscatheter aortic valve implantation (TAVI) has traditionally been reserved for patients with severe aortic stenosis at high or prohibitive surgical risk.<sup>1,2</sup> Recently, additional evidence has emerged to show that TAVI is a safe alternative in patients at intermediate surgical risk.<sup>3,4</sup> This has led to changes to both the US and European guidelines, which now give TAVI a class IIa recommendation for populations at intermediate risk, vastly expanding the pool of patients eligible for the procedure.<sup>5,6</sup> Guidelines from North American and European cardiology and cardiac surgery societies recommend that these interventions be performed by a multidisciplinary heart team including cardiac surgeons and interventional cardiologists.<sup>6,7</sup> Thus, there is a pressing need to train cardiac surgeons to be competent in performing TAVI through percutaneous means.

Cardiac surgery residents are expected to be familiar in the management of valvular heart disease including “alternative surgical approaches to cardiac valves (including Transcatheter Aortic-Valve Implantation [TAVI])”<sup>8</sup> by the end of their Royal College of Physicians and Surgeons of Canada (RCPSC) training. However, the current state of TAVI training in Canadian cardiac surgery residency programs remains unknown. The objectives of this study were to 1) establish a national inventory of TAVI educational resources, 2) elucidate the role of residents in the care of patients undergoing TAVI and 3) determine the attitudes and perspectives of residents and program directors regarding the importance of TAVI technology and training for future clinical practice.

## METHODS

We designed 2 national Web-based surveys, 1 for program directors and 1 for residents and recent graduates of cardiac surgery residency programs in Canada, to assess the current state of TAVI training from the perspective of residents and program directors (Appendix 1, available at [canjsurg.ca/017517-a1](http://canjsurg.ca/017517-a1)). The questionnaire was sent to all residents and recent graduates of cardiac surgery residency programs in Canada and to the directors of all Canadian cardiac surgery residency programs. Baseline characteristics and academic centre were collected for both groups. We evaluated the attitudes and perspectives of both groups with respect to the importance of TAVI technology and training for future clinical practice on a 5-point Likert scale. The resident survey contained 32 questions, and the program director survey contained 27 questions. The questionnaires and reminders at 2-week intervals were sent out from Feb. 2 to July 20, 2017.

### Statistical analysis

We performed descriptive statistical analysis to summarize the data in an aggregate and anonymous manner. Binary and ordinal variables were reported as counts and frequen-

cies and continuous variables were reported as mean (standard deviations) or median (range). To compare responses between residents and program directors, we transformed ordinal variables from the Likert scales to a binary variable (grouped such that responders who “strongly agreed” and “agreed” were compared to those who were “uncertain” or those who “disagreed” or “strongly disagreed”);  $\chi^2$  testing was used. We performed thematic analysis using a realist approach to analyze patterned responses from residents to open-ended survey questions. We used NVivo software for coding themes and subthemes in the survey responses. A map of relations between themes and subthemes was constructed. The study was approved by the Sunnybrook Health Sciences Centre Research Ethics Board, Toronto.

## RESULTS

The survey was sent to 92 residents and recent graduates, of whom 78 (85%) responded, and to 12 program directors, of whom 11 (92%) responded. Broad representation from all 12 Canadian residency programs and all postgraduate years of training was obtained. The mean postgraduate year of training reported was 3.4 (standard deviation [SD] 1.8) with 5 recent graduates answering the survey. The mean number of residents in each program was 7.2 (SD 3.2). All programs reported that TAVI was performed in at least 1 teaching hospital. The average number of hospitals within each program performing TAVI was 1.6 (SD 1.1).

### Residents' participation

More than half of residents (45 [58%]) reported attending TAVI clinics and rounds; most (69 [88%]) saw TAVI inpatient consultations. Residents reported low participation in transfemoral TAVI procedures: 55 residents (70%) never or rarely scrubbed in to the procedure. All residents reported 0 cases as primary operator (defined as “skin to skin”) for TAVI cases, and the median number of cases as secondary operator was also 0 (range 0–40). Program directors commonly identified obtaining transfemoral access (6 [54%]) and alternative access (8 [73%]) as aspects of the case in which residents were involved (Table 1).

### Available training resources

More than half of residents (44 [56%]) reported that there was didactic teaching on TAVI, delivered by both the cardiologist and the surgeon (39 [50%]) or the surgeon only (37 [47%]). Only 3 program directors (27%) reported that their residents had access to a TAVI simulator. Residents reported that access to hands-on TAVI training in residency was low (13 [17%]). A majority of residents (64 [82%]) and program directors (7 [64%]) reported that TAVI training in their program was inadequate ( $p = 0.2$ ).

Attitudes and beliefs

Although most residents (76 [97%]) (Table 2) and program directors (10 [91%]) agreed that TAVI was important to the trainee’s future practice, about two-thirds (54 [69%] and 7 [64%], respectively) agreed that TAVI should be a focus of fellowship training ( $p = 0.7$ ). Nonetheless, 65 residents (83%) and 7 program directors (64%) agreed that residents should get more training in TAVI during residency ( $p = 0.1$ ). Only 32 residents (41%) agreed that TAVI competency should be achieved after completion of residency.

Thematic analysis of residents’ responses regarding barriers to TAVI training identified 3 major themes: institutional and cultural barriers (cardiology-led procedure, low surgical involvement), RCPSC requirements (TAVI training not formalized in curriculum, lack of time during residency training) and evolving technology (competition with fellows, low procedure volume, uncertain role for surgery) (Fig. 1). A full explanation of the themes, subthemes and interactions is provided in the Figure 1 legend.

DISCUSSION

In this inventory of available TAVI training resources for cardiac surgical residents in Canada, we found that, overall, residents had limited access to didactic and simulation training. Furthermore, operative experience during the actual procedure was poor for most residents and was limited to obtaining alternative access. Although residents and program directors agreed that TAVI would be an integral part of a surgeon’s future practice, there was a lack of available resources for residents to prepare for a career in this procedure. These findings parallel the results of a recent survey of Canadian cardiac surgical residents on their experiences with obtaining wire skills during residency.<sup>9</sup> In that study, program directors agreed that catheter-based interventions would play an important role in the trainees’ future and that residents require more exposure to catheter-based skills.

Expectations for resident training in TAVI procedures vary widely between Canada and the United States. In the US, expectations are specific: as of July 1, 2017, residents have been mandated to perform 5 TAVI

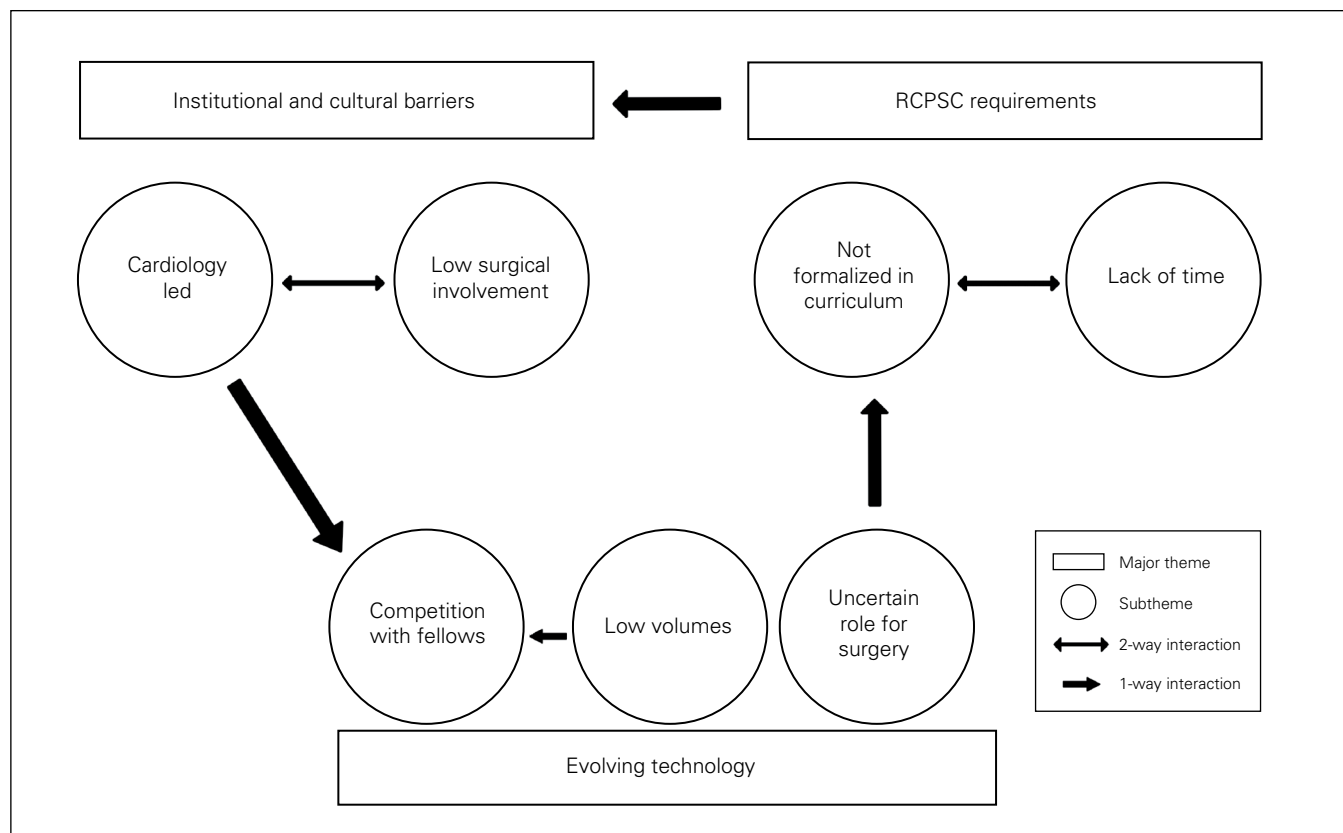
Table 1. Program directors’ responses regarding the role of the resident in transcatheter aortic valve implantation

How often do your residents perform the following aspects of the case?	Frequency; no. (%) of respondents <i>n</i> = 11				
	Never	Rarely	Sometimes	Frequently	Always
Obtain transfemoral access	5 (45)	2 (18)	3 (27)	1 (9)	0 (0)
Manipulate the wires	7 (64)	0 (0)	4 (36)	0 (0)	0 (0)
Place temporary pacing catheter	7 (64)	3 (27)	1 (9)	0 (0)	0 (0)
Cross the valve with the wire	7 (64)	1 (9)	2 (18)	1 (9)	0 (0)
Perform balloon valvuloplasty	8 (73)	1 (9)	1 (9)	1 (9)	0 (0)
Deploy the valve	9 (82)	1 (9)	0 (0)	1 (9)	0 (0)
Manipulate the C-arm	9 (82)	2 (18)	0 (0)	0 (0)	0 (0)
Use closure devices (e.g., Perclose)	7 (64)	2 (18)	2 (18)	0 (0)	0 (0)
Obtain alternative access (i.e., thoracotomy or hemisternotomy for transapical/direct aortic cases)	3 (27)	0 (0)	7 (64)	1 (9)	0 (0)

Table 2. Attitudes and perspectives of residents regarding the importance of transcatheter aortic valve implantation technology and training for future clinical practice

Survey item	Response; no. (%) of respondents <i>n</i> = 78				
	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
TAVI technology is important for your future practice	0 (0)	1 (1)	1 (1)	20 (26)	56 (72)
TAVI should be formally taught in a cardiac surgery residency training program	0 (0)	0 (0)	7 (9)	19 (24)	52 (67)
TAVI should be formally taught as a fellowship program	0 (0)	11 (14)	13 (17)	28 (36)	26 (33)
There is not enough time in the current training curriculum to teach TAVI	10 (13)	33 (42)	13 (17)	11 (14)	11 (14)
I would like more training in TAVI during residency	0 (0)	3 (4)	10 (13)	19 (24)	46 (59)
Wire handling skills are important for cardiac surgery residents	0 (0)	0 (0)	0 (0)	22 (28)	56 (72)
Residents should have exposure to the principles of TAVI during the residency program	0 (0)	0 (0)	0 (0)	16 (20)	62 (79)
Residents should not be expected to be competent TAVI operators by the end of residency	8 (10)	18 (23)	20 (26)	27 (35)	5 (6)

TAVI = transcatheter aortic valve implantation.



**Fig. 1.** Themes and subthemes identified in thematic analysis of open-ended responses from residents regarding barriers to achieving transcatheter aortic valve implantation (TAVI) competency. Respondents stated that both low involvement from surgical staff and dominance of cardiology-led procedures resulted in less opportunity for participation in cases. Participants also identified that structural fellows (mostly from cardiology) were also given priority in cases and that some cardiologists were reluctant to teach surgical residents. This reluctance may stem from an interaction between institutional/cultural barriers and the lack of specific TAVI objectives in the Royal College of Physicians and Surgeons of Canada (RCPC) curriculum. Thus, resident participation is further reduced, particularly in cardiology-led centres. Low case volumes owing to TAVI's being an emerging technology exacerbates the competition between residents and fellows for cases. Residents cited a lack of time in the formal curriculum to learn TAVI and that the exact objectives for TAVI training remain vague in the RCPC training requirements. A barrier to formalization of TAVI into the training curriculum may be the result of the developing and changing surgical role in the procedure as TAVI technology continues to evolve.

procedures as the primary operator and to assist in 10 TAVI procedures according to the Accreditation Council for Graduate Medical Education curriculum for cardiothoracic training.<sup>10</sup> In contrast, the RCPC's document "Objectives of training in the specialty of cardiac surgery"<sup>8</sup> is vague regarding the amount of and the specific content for TAVI training. The crux of the issue is what constitutes competency in TAVI for residents in cardiac surgery and the definition of "TAVI trained." In cardiac surgical training, residents are not expected to be competent in performing certain complex procedures (e.g., thoracoabdominal aneurysm repairs) by the end of their training. However, they are expected to understand the perioperative considerations, procedural steps, and postoperative care and management of these patients. The actual operative competency should be developed in subspecialty fellowship training. As a group of TAVI operators with experience in training TAVI fellows, we advocate that TAVI education for residents should be structured in a similar manner.

Although TAVI competency requires subspecialty fellowship training, cardiac surgery residents should have more structured exposure to the procedure. Residents should be expected to know the preoperative considerations (indications, patient selection, device selection, valve sizing), operative steps (for both transfemoral and alternative access) and postoperative care and management of potential complications. Our findings suggest that, currently, there is a lack of structured didactic and hands-on training; our residents may not be knowledgeable in TAVI fundamentals by the end of residency. Cardiac surgery is expected to have a fully implemented Competence by Design curriculum by July 2019.<sup>11</sup> Developing specific objectives for TAVI training represents an area for major improvement, and Competence by Design offers an opportunity to mandate more rigorous and uniform training in this important procedural skill.

Barriers to TAVI training identified in our study included low case volume, competition from structural

heart fellows, reported lack of time during training and a lack of willingness to teach on the part of cardiologists. These represent serious concerns that prevent residents from receiving the hands-on teaching essential to becoming familiar with the steps in performing TAVI. Potential solutions to overcome these barriers include providing a dedicated structural heart rotation during residency that includes time in the TAVI clinics, participation in multidisciplinary rounds, seeing inpatient consultations, perioperative and postoperative management, and participation in percutaneous valve cases. This should be complemented with a didactic curriculum that covers preoperative planning, procedural steps and postoperative management. The implementation of Competence by Design with TAVI as a core competency may drive the development of time-efficient rotations to teach residents the basics of TAVI and crucial wire skills. There is a need for institutional change and incentives for a multidisciplinary (i.e., heart team) approach to teaching surgical residents that includes the involvement of cardiologists, who have expertise in percutaneous intervention. Our respondents identified that a lack of involvement by surgeons in the actual procedure itself is a barrier to resident education in TAVI. Although a discussion of this factor is outside the scope of this paper, we recognize that there may be many barriers to participation of staff surgeons in the TAVI, which may include a lack of formal training in catheter-based intervention as well as institutional and cultural barriers. Nonetheless, given that guidelines recommend that TAVI be performed by a heart team,<sup>7</sup> this finding highlights the critical role of surgeons not only in performing the procedure but also in the education of residents and fellows alike.

### Limitations

The results of our study must be interpreted in the context of some limitations. Despite a resident response rate of 85%, our results may have been biased by nonresponse error, whereby nonrespondents may have a different perspective from that of respondents. Our respondents may not necessarily reflect and be representative of all residents. Given the small number of residents in each individual program, we were unable to assess for differences in resources and attitudes by program. Finally, surveys are prone to recall bias, and residents may not have accurately recalled the number of procedures performed or the steps of the procedures.

### CONCLUSION

There are limited educational resources for TAVI training for cardiac surgical residents across Canada. Although almost all of our respondents agreed that TAVI would play

a vital role in trainees' future clinical practice, they identified many perceived barriers to providing adequate training during residency. Finally, there is a lack of consensus as to whether TAVI competency should be acquired primarily in residency or in fellowship training. With the imminent change to a Competence by Design curriculum, there is an important need to develop a national TAVI curriculum for residents in Canadian cardiac surgery training programs.

**Affiliations:** From the Division of Cardiac Surgery, Department of Surgery, Schulich Heart Centre, Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Ont. (Tam, Makhdoum, Cohen); the Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ont. (Tam, Wijeyesundera, Fremes); the Division of Cardiac Surgery, Department of Surgery, Peter Munk Cardiac Centre, University Health Network, University of Toronto, Toronto, Ont. (Ouzounian); and the Division of Cardiology, Department of Medicine, Schulich Heart Centre, Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Ont. (Wijeyesundera).

**Competing interests:** H. Wijeyesundera has received research funding from Edwards Lifesciences and Medtronic. No other competing interests declared.

**Funding:** This research was supported by the Sunnybrook Education Advisory Council 2017 Education Research and Scholarship Grant. D. Tam is supported by the Ontario Ministry of Health and Long-Term Care Clinician Investigator's Program (Toronto). H. Wijeyesundera is supported by a Distinguished Clinician Scientist Award from the Heart and Stroke Foundation of Canada, Ottawa. S. Fremes is supported by the Bernard S. Goldman Chair in Cardiovascular Surgery, Sunnybrook Health Sciences Centre, Toronto.

**Contributors:** D. Tam, A. Makhdoum, G. Cohen and S. Fremes designed the study. D. Tam and A. Makhdoum acquired the data, which D. Tam, M. Ouzounian, H. Wijeyesundera, G. Cohen and S. Fremes analyzed. D. Tam, M. Ouzounian, H. Wijeyesundera and S. Fremes wrote the article, which all authors reviewed and approved for publication.

### References

1. Leon MB, Smith CR, Mack M, et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. *N Engl J Med* 2010;363:1597-607.
2. Smith CR, Leon MB, Mack MJ, et al. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *N Engl J Med* 2011; 364:2187-98.
3. Tam DY, Vo TX, Wijeyesundera HC, et al. Transcatheter vs surgical aortic valve replacement for aortic stenosis in low-intermediate risk patients: a meta-analysis. *Can J Cardiol* 2017;33:1171-9.
4. Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med* 2016;374:1609-20.
5. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: a Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation* 2017;135: e1159-95.
6. Baumgartner H, Falk V, Bax JJ, et al.; ESC Scientific Document Group. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J* 2017;38:2739-91.

7. Holmes DR, Mack MJ, Agnihotri A, et al. ACCF/AATS/SCAI/STS expert consensus document on transcatheter aortic valve replacement: developed in collaboration with the American Heart Association, American Society of Echocardiography, European Association for Cardio-Thoracic Surgery, Heart Failure Society of America, Mended Hearts, Society of Cardiovascular Anesthesiologists, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance. *J Thorac Cardiovasc Surg* 2012;144:e29-84.
8. Objectives of training in the specialty of cardiac surgery. Ottawa: Royal College of Physicians and Surgeons of Canada; 2013. Available: [www.royalcollege.ca/cs/groups/public/documents/document/y2vk/mdaw/~edisp/tztest3repsced000454.pdf](http://www.royalcollege.ca/cs/groups/public/documents/document/y2vk/mdaw/~edisp/tztest3repsced000454.pdf) (accessed 2018 Sept. 12).
9. Juanda N, Chan V, Chan R, et al. Catheter-based educational experiences: a Canadian survey of current residents and recent graduates in cardiac surgery. *Can J Cardiol* 2016;32:391-4.
10. Case requirements for residents beginning on or after July 1, 2017. Chicago: Review Committee for Thoracic Surgery, Accreditation Council for Graduate Medical Education; 2017. Available: <https://www.acgme.org/Portals/0/PFAssets/ProgramResources/CaseRequirementsForResidentsBeginningJuly2017.pdf?ver=2017-03-30-141914-970> (accessed 2018 Sept. 12).
11. Noly PE, Rubens FD, Ouzounian M, et al. Cardiac surgery training in Canada: current state and future perspectives. *J Thorac Cardiovasc Surg* 2017;154:998-1005.

## **CJS's top viewed articles\***

1. **Research questions, hypotheses and objectives**  
Farrugia et al.  
*Can J Surg* 2010;53:278-81
2. **Blinding: Who, what, when, why, how?**  
Karanicolas et al.  
*Can J Surg* 2010;53:345-8
3. **Clinical practice guideline: management of acute pancreatitis**  
Greenberg et al.  
*Can J Surg* 2016;59:128-40
4. **Defining medical error**  
Grober and Bohnen  
*Can J Surg* 2005;48:39-44
5. **Nonsurgical treatment of chronic anal fissure: nitroglycerin and dilatation versus nifedipine and botulinum toxin**  
Tranqui et al.  
*Can J Surg* 2006;49:41-5
6. **Surgical approach in primary total hip arthroplasty: anatomy, technique and clinical outcomes**  
Petis et al.  
*Can J Surg* 2015;58:128-39
7. **Complications associated with laparoscopic sleeve gastrectomy for morbid obesity: a surgeons' guide**  
Sarkosh et al.  
*Can J Surg* 2013;56:347-52
8. **Characteristics of highly successful orthopedic surgeons: a survey of orthopedic chairs and editors**  
Klein et al.  
*Can J Surg* 2013;56:192-8
9. **Hardware removal after tibial fracture has healed**  
Sidky and Buckley  
*Can J Surg* 2008;51:263-8
10. **Joseph Lister: father of modern surgery**  
Pitt and Aubin  
*Can J Surg* 2012;55:E8-9

\*Based on page views on PubMed Central of research, reviews, commentaries and discussions in surgery. Updated Nov. 8, 2018.