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Medical memorialization

The urge to memorialize is robust in medicine, particularly so on the surgical side of the house. It defies changing times and fashions. The desire to be remembered may be the instinct that drives surgeons to work harder and longer than their peers in society. Medical memorialization, the desire of society to remember a physician, on the other hand, is a mystery. It appears to be random and often inaccurate. It is quietly revered, but must not be sought.

On Apr. 23, 2015, exactly 100 years after the Second Battle of Ypres, John McCrae will be inducted into the Canadian Medical Hall of Fame. His name had been put forward on 2 previous occasions to fill the single slot reserved each year for posthumous induction. Among this year’s other inductees, who are happily still alive, is Dr. Bernard Langer. Dr. Langer, former head of surgery at the University of Toronto, is being recognized for contributions to medical education, research and patient safety.1 John McCrae, revered for his poem “In Flanders Fields,” was probably elected this time because of his wartime service was placed in the context of the advanced state of his medical practice at the time of his enlistment. McCrae’s medical publications demonstrate his pioneering role in Canadian infectious disease medicine and anatomic pathology.2 He would have been remembered as a founder had he not died during the war. For John McCrae, this honour will add little to his fame. Schools and prizes have already been named for him. The Government of Canada designated him to be a “person of national historic significance” 70 years ago. Electing John McCrae to the Canadian Medical Hall of Fame is our way of reclaiming the soldier–poet for medicine. The goal of this article is to honour these physicians and to consider the role of memorialization in medicine.

The origin of memorialization can be traced from prehistorical oral sagas through the statuary of classical times to the monuments of the Victorian era. Memorialization was reserved for the ruling elite; its ultimate expression was a place in the pantheon. The hall of fame is today’s pantheon, and access to it has been democratized.

In the 19th century, advances in bacteriology resulted in the naming of many previously unknown organisms after their discoverer. This process, similar to explorers’ naming new-found landmarks, suggests that discoverers retain naming rights. This is not true in medicine. Unlike geography, claiming a name for a medical discovery or invention or bestowing it in honour of a third party, such as a sponsor or a member of a royal family, is not accepted. Universities may trade naming rights for donations, but the practice has more to do with the sponsorship of sports arenas than medicine. Neither of these forms constitute medical memorialization.

Eponyms, often considered a prized form of memorialization, may be applied for convenience of recall and communication. This is especially true of clinical signs — a cluster of observations that leads a clinician to an instantaneous diagnosis and the eternal faith of a patient. Many eponyms are inaccurate. For example, even though Thomas Cullen credited Joseph Ransohoff with the description of periumbilical staining, we remember it as Cullen’s sign.3 Eponyms applied to surgical procedures are even more inaccurate. Novel operations are built upon previous practice. Allen Whipple neither described, nor was the first to perform, the operation we call Whipple’s procedure. In spite of these inaccuracies, there are no protests, no campaigns to right these wrongs. This is because eponyms are derived from those who popularized the item rather than those who discovered or invented it. They are applied only if they facilitate communication. This explains why partial pancreatico-duodenectomy is called Whipple’s procedure but liver transplantation is not called Starzl’s procedure. Use of eponyms is therefore not an act of memorialization.

Memorialization is an inherent part of surgical education where we not only teach a procedure or an aspect of knowledge, but also how it was developed. In research it is the appropriate referencing of prior knowledge. These are preferred forms of memorialization today because they acknowledge the deed rather than remember the person. The statues, busts and portraits of medical pioneers have been removed from our hospitals. But there is a role for acknowledging the individual. There are some signs that portraiture is coming back into fashion, and 3-dimensional printing may make sculpture more popular.

The target audience of the Canadian Medical Hall of Fame is the whole of society, especially the young, because the real purpose of memorialization is to inspire. Dr. Langer’s induction will inspire students to choose a career in surgery and emulate his achievements.
Dr. McCrae’s induction will remind physicians of their obligation to serve their country and the global community.

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La commémoration médicale

Le besoin de commémoration est fort en médecine, particulièrement chez nos collègues chirurgiens. Il persiste malgré les modes, quelle que soit l’époque. C’est peut-être le désir de passer à l’histoire qui pousse les chirurgiens à travailler plus fort et plus longtemps que leurs pairs dans la société. La commémoration médicale, soit la volonté qu’a une société de perpétuer le souvenir d’un médecin, est, quant à elle, un mystère. Elle semble être aléatoire et se révèle souvent inexacte. Elle est discrètement vénérée, mais ne doit pas être recherchée.

Le 23 avril 2015, 100 ans exactement après la seconde bataille d’Ypres, John McCrae sera intronisé au Temple de la renommée médicale canadienne. Sa candidature avait été soumise 2 fois auparavant pour occuper la seule place réservée chaque année à une intronisation posthume. Le Dr Bernard Langer compte parmi les autres lauréats de cette année, qui sont heureusement toujours en vie. Le Dr Langer, ancien chef du Département de chirurgie de l’Université de Toronto, est reconnu pour ses contributions à l’éducation médicale, à la recherche et à la sécurité des patients1. John McCrae, révéré pour son poème intitulé « Au champ d’honneur », a probablement été sélectionné cette fois-ci parce que son service en temps de guerre a été placé dans le contexte du niveau avancé de sa pratique médicale au moment de son enrôlement. Les publications médicales du Dr McCrae démontrent son rôle de pionnier dans les domaines des maladies infectieuses et de la pathologie anatomique2. Il aurait été intronisé en qualité de bâtisseur s’il n’était pas mort pendant la guerre. Cette distinction ajoute peu à la renommée du Dr John McCrae : des écoles et des prix ont déjà été nommés en son honneur et le gouvernement du Canada l’a désigné « personne d’importance historique nationale » il y a 70 ans. L’intronisation du Dr John McCrae au Temple de la renommée médicale canadienne est notre façon de rapatrier au sein de la médecine le soldat-poète. L’objectif de cet article est d’honorer ces médecins et d’examiner le rôle de la commémoration en médecine.

La commémoration, qui remonte aux sagas préhistoriques transmises oralement, s’est manifestée plus tard dans les statues de l’époque classique et dans les monuments de l’époque victorienne. La commémoration était réservée à l’élite dirigeante et son expression ultime était l’élection au panthéon. Le Temple de la renommée est un panthéon moderne auquel l’accès a été démocratisé.

Au 19e siècle, avec les progrès en bactériologie, de nombreux organismes jusqu’alors inconnus ont été désignés du nom de leur découvreur. Cette pratique, semblable à celle des explorateurs qui baptisaient de nouveaux lieux, laisse entendre que les découvreurs conservent des droits d’appellation. Ce n’est pas le cas en médecine. Contrairement au domaine de la géographie, revendiquer un nom pour une découverte médicale ou une invention ou donner un nom en l’honneur d’un tiers, tel que celui d’un commanditaire ou d’un membre de la famille royale, n’est pas bien vu. Les universités peuvent offrir des droits d’appellation en échange de dons, mais cette pratique relève beaucoup plus de la commande de complexes sportifs que de la médecine. Aucune de ces 2 formes d’appellation ne constitue une commémoration médicale.

Les désignations éponymes, souvent considérées comme une forme prise de commémoration, peuvent
faciliter la mémorisation et la communication. Cela est particulièrement vrai en ce qui concerne les signes cliniques — un ensemble d’observations qui conduit le médecin à un diagnostic instantané et résulte en une confiance éternelle du patient. De nombreuses désignations éponymes sont toutefois inexactes. Par exemple, même si Thomas Cullen a attribué la description des taches périombilicales à Joseph Ransohoff, nous nous en souvenons comme du signe de Cullen³. Les appellations éponymes données aux procédures chirurgicales sont encore plus inexactes. Les interventions novatrices sont fondées sur des pratiques antérieures. Allen Whipple n’a ni décrit, ni été le premier à effectuer l’intervention connue sous le nom d’« opération de Whipple ». Malgré ces inexactitudes, il n’y a aucune contestation ni aucune campagne pour corriger ces erreurs. Cela est attribuable au fait que les désignations éponymes sont inspirées du nom de la personne qui a popularisé quelque chose plutôt que sur le nom de la personne qui a découvert ou inventé la chose en question. Elles sont utilisées seulement si elles facilitent la communication, ce qui explique pourquoi la pancréaticoduodénectomie se nomme « opération de Whipple » alors que la greffe de foie ne se nomme pas « opération de Starzl ». L’attribution d’une désignation éponyme n’est donc pas un acte de commémoration.

La commémoration est inhérente à la formation en chirurgie, dans laquelle non seulement nous enseignons une procédure ou une facette du savoir, mais aussi la façon dont elle a été développée. En recherche, cela se traduit par une référence ou par un renvoi aux connaissances antérieures. Ce sont aujourd’hui les formes privilégiées de commémoration parce qu’elles reconnaissent l’acte plutôt que la personne. Les statues, bustes et portraits des pionniers de la médecine ont été retirés de nos hôpitaux. La reconnaissance de l’individu a toutefois un rôle à jouer. Certains signes indiquent que l’art du portrait revient à la mode, et l’impression tridimensionnelle pourrait rendre la sculpture plus populaire.

Le public cible du Temple de la renommée médicale canadienne est l’ensemble de la société, et particulièrement les jeunes parce que le véritable objectif de la commémoration est d’inspirer. L’intronisation du Dr Langer inspirera les élèves à choisir une carrière en chirurgie et à imiter ses réalisations et celle du Dr McCrae rappellera aux médecins leur devoir de servir leur pays et la communauté mondiale.

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Références

Dr. Bernard Langer — inductee into the Canadian Medical Hall of Fame

Dr. Bernard Langer’s induction into the Canadian Medical Hall of Fame acknowledges his profound effect on medicine and surgery in Canada and an impact that has been truly international. In this brief biography, we highlight the major accomplishments that have made Dr. Langer a pre-eminent leader, innovator, teacher and exemplary surgeon.

Dr. Bernard Langer, “B.L.” or “Bernie,” as his friends and colleagues know him, was born in Toronto, Ont., in 1932. He received his medical degree from the University of Toronto in 1956, graduating with the Cody Gold Medal Award. Following an internship at the Toronto General Hospital (TGH), he completed his surgical training at the University of Toronto in 1962. During his residency, he married Ryna Manson and they began what was to become a family with 4 children: Jack, David, Pearl and Michael. Dr. Langer’s postresidency training, what would today be called a fellowship, was split between oncology with Dr. John Stehlin at M.D. Anderson Hospital in Houston, Tex., and experimental liver transplantation with Dr. Francis Moore at the Brigham Hospital in Boston, Mass.

Dr. Langer’s appointment to full attending staff at TGH in 1963 is recognized as a turning point in breaking down some of the antisemitic barriers in surgery that existed at the time. Although he practised the full range of general surgery, he developed an interest and expertise in the surgical management of portal hypertension and malignancies of the hepatobiliary system and pancreas — the genesis of the hepatico-pancreato-biliary (HPB) surgeon.

In 1972 Dr. Langer was appointed as the head of the Division of General Surgery at TGH, which was transformed under his leadership by his commitment to the emergence of subspecialties. His recruitment of Wayne Johnson and Paul Walker began the discipline of Vascular Surgery; Zane Cohen and Robin McLeod, Colorectal Surgery; Rudy Falk, Ulo Ambus and Lorne Rotstein, Surgical Oncology and Endocrine Surgery; and Bob Stone, Bryce Taylor and one of us (P.G.), HPB Surgery and Transplantation. This model became the standard for future recruitment and development within the Division of General Surgery at TGH and would serve as a model for other hospitals affiliated with the University of Toronto and across the country.

Dr. Langer is a “first generation” HPB and transplant surgeon. Along with the other pre-eminent HPB and transplant pioneers, like Henri Bismuth from France; John Terblanche from South Africa; and Dean Warren, Marshall Orloff and Tom Starzl from the United States, Dr. Langer’s advancement of the discipline of HPB surgery has resulted in it being

Summary

Dr. Bernard Langer’s induction into the Canadian Medical Hall of Fame acknowledges his profound effect on medicine and surgery in Canada and an impact that has been truly international. In this brief biography, we highlight the major accomplishments that have made Dr. Langer a pre-eminent leader, innovator, teacher and exemplary surgeon.
recognized as a specific discipline within general surgery. During his career, he contributed to its understanding, and major advances occurred in the reduction of the morbidity and mortality of complex HPB procedures, including major liver resections and the Whipple pancreatoduodenectomy. Dr. Langer started the liver transplant program in Toronto and performed Toronto’s first liver transplant in 1985. While pushing forward this specialty, he was also widely recognized as a “surgeons’ surgeon.” He was a gifted clinician and surgeon with very high standards and constantly challenged his colleagues to strive for excellence in patient care. Dr. Langer’s clinical nickname “The Hawk” came from his astute awareness of a patient’s clinical situation and his ability to manage it. Trainees and faculty members alike will recall his morbidity and mortality rounds, where he could incisively address the root cause of patient complications, even when these were outside his specific area of clinical expertise.

Dr. Langer’s impact on clinical care extended beyond his own patients. Through his leadership role in Cancer Care Ontario as a member of the Provincial Advisory Committee on Surgical Oncology, the Cancer Quality Council of Ontario and the Cancer Surgery Quality Committee, he championed standards for cancer care, including the Ontario Standards for HPB Surgery. This approach has translated across specialties and has served as a model for other provinces.

In 1982, Dr. Langer succeeded Dr. Donald R. Wilson as the R.S. McLaughlin Professor and chair of the Department of Surgery at the University of Toronto. He was the first non–surgeon-in-chief to do so, and his decade as chair was transformative for Toronto and highly influential across Canada and internationally. His most significant accomplishment is often identified as the creation of the Surgeon Scientist Program (SSP). He recognized Toronto’s reputation for excellence in clinical training, but saw the need for surgeons to engage in formalized research training as a requirement for the future academic success of individuals and the department. This highly successful program became the standard bearer for clinician–scientist training in faculties of medicine across the country. In 1994 the Royal College of Physicians and Surgeons of Canada established the Clinician Investigator Program, one largely modelled after the SSP. At the University of Toronto Department of Surgery, Dr. Langer’s “farm system” sustained and promoted academic excellence in surgery over the next 25 years and presumably will continue to do so into the future.

“As a physician leader, Bernie Langer was a true innovator, an extraordinarily gifted surgeon and a great teacher,” says Dr. David Naylor, dean of the University of Toronto Faculty of Medicine and former president of the University of Toronto. “The Surgeon Scientist Program he created has been widely emulated in other clinical departments across Canada and is a cornerstone of the department’s international reputation.”
Dr. Langer proposed and implemented a system of practice plans across the department that balanced individual division/hospital financial autonomy with the academic principle of income-sharing, with a view to fostering sub-specialization and supporting academic initiatives. The challenges in doing so are almost unimaginable, but speak to Dr. Langer’s personal leadership and, in particular, his ability to rally individuals in support of the academic mission. Over the years, the practice plans have evolved, but their underlying raison d’etre, namely the support of activities to promote excellence in clinical care, research and education, has remained unchanged.

While most recall Dr. Langer as a tireless advocate for research in the department, his contributions to education have also had profound impact. As department chair, he established education as one of the streams for academic promotion. This has served to broadly engage a department filled with individuals who felt distanced from the research mission. He also recognized that improving the quality of education required that our faculty engage in advancing our understanding of surgical education. Today’s department is heavily populated with surgeons who have formal training in medical education and who are not only excellent teachers, but who also contribute through scholarship. Dr. Langer is also recognized for his personal contributions to education through his creation of the fellowship in liver surgery, which grew from 1 fellow in 1982 to 3 fellows in transplant and HPB surgery in 1989 to 7 Fellows in 2 separate but integrated fellowships in HPB surgical oncology (accredited by America’s Hepato-Pancreato-Biliary Association and the Fellowship Council) and in abdominal organ transplantation (accredited by the American Society of Transplant Surgeons). At a reunion of former fellows in 2013, Dr. Langer was recognized:

Amongst his notable accomplishments, Dr. Langer has been recognized by the [University Health Network] for “making global impact.” His growing legacy of over 65 fellows practising HPB and transplant surgery throughout the world is tangible evidence of Dr. Langer’s truly remarkable global impact. We thank you, B.L., for your vision in establishing the fellowship, your high standards and clinical excellence in HPB and transplant surgery that is carried on in your fellows, and your mentorship that extends beyond clinical surgery.”

Dr. Langer has had significant influence outside of Toronto. He was president of the Canadian Association of General Surgeons in 1988–89 and President of the Society for Surgery of the Alimentary Tract in 1993–94 and subsequently the chair of their Board of Trustees; in 1999 he became the first vice president of the American Surgical Association. Through his engagement with the Royal College of Physicians and Surgeons of Canada, Dr. Langer has contributed to Canadian medicine by advancing many of his priorities. He was president and chair of the Royal College Council and Executive Committee from 2000 to 2002, and he created the Canadian Patient Safety Institute.

Dr. Langer’s contributions and influence have been recognized through many honours, including the creation of the University of Toronto Department of Surgery Langer Surgeon Scientist Award, the Bernard Langer Annual Lecture in Health Sciences at the University of Toronto, the Bernard and Ryna Langer Chair in General Surgery at the University of Toronto, and the Langer Lecture of the Canadian Association of General Surgeons Annual Meeting held at the Canadian Surgery Forum. He has received honorary fellowships from the Royal Australasian College of Physicians, the Colleges of Medicine of South Africa, the American College of Physicians and the Academy of Medicine of Singapore as well as an honorary doctorate from Queen’s University.

In 2002 Dr. Langer was appointed Officer of the Order of Canada. His extraordinary accomplishments are founded on a number of outstanding personal qualities. He always cared deeply for his patients, understanding not only their physical problems, but also personal or emotional issues that might be impacting their disease. Excellent technical ability was only one aspect of achieving the best outcome for his patients. The high degree of respect in the eyes of his surgical peers also facilitated his ability to influence his colleagues. Dr. Langer also exhibited exceptional leadership abilities. Teamwork was paramount. He engaged individuals with similar and disparate expertise to tackle tough problems. He promoted faculty, particularly those more junior, by giving them opportunities to participate and to develop their own leadership skills. He surrounded himself with excellent colleagues and listened carefully to their advice, but always remained true to his ideals. He was a tough negotiator but always sought the “win–win” outcome, even before this saying became popular. Finally, in an era when attention to personal life and family were considered a weakness, Dr. Langer always recognized the importance of the support of his wife Ryna and his family.

Bernard Langer’s induction into the Canadian Medical Hall of Fame is highly appropriate. The Hall of Fame is “dedicated to celebrating the accomplishments of medical heroes.” Dr. Langer is that, and more. He has been quoted as saying “If you don’t stand tall enough, you can’t see far enough.” Dr. Langer stood very tall and took us very far. He is a visionary, always looking beyond the present into the future.

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Amnesia in modern surgery: revisiting Wangensteen’s landmark studies of small bowel obstruction

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SUMMARY

Before the publications of Owen Wangensteen and his colleagues in the early 1930s, bowel obstruction was almost always fatal, and its treatment was ineffective. Patients rarely survived surgical attempts to relieve the obstruction. Although other investigators were active in the field, the understanding of the pathophysiology of obstruction belongs almost entirely to Wangensteen. In this commentary, we review Wangensteen’s landmark studies of small bowel obstruction and how they shaped the treatment of this condition.

During recent ward rounds, while reassessing a patient with adhesion-induced partial small bowel obstruction we learned that the nursing staff, at least some of the residents and even some attending staff were unaware of the exact role of nasogastric suction in its treatment. It called to mind some quotes of Dr. Owen Wangensteen, Chairman of the Department of Surgery at the University of Minnesota from 1930 to 1968. He said, “There exists a feeling among many physicians and students that anything over 10 years old has no pertinence,” and “If you only look forward, it’s tantamount to having a physician with total amnesia. How good would he be?” These observations are particularly appropriate to our patient, as Wangensteen literally wrote the book on bowel obstruction and received the 1935 Samuel D. Gross Prize for his research in this area.

Before the publications of Wangensteen and his colleagues in the early 1930s, bowel obstruction was almost always fatal, and its treatment was ineffective. Most surgeons believed that death was due to the production of toxic factors in the gut and their absorption into the blood stream. The source of the gaseous distention was attributed to the action of bacteria on retained food and the production of methane. The excess of fluid in the gut above the point of obstruction was appreciated, but the failure of patients to improve with intravenous infusions of saline was a great disappointment. Patients rarely survived surgical attempts to relieve the obstruction.

Although other investigators were active in the field, the understanding of the pathophysiology of obstruction belongs almost entirely to Wangensteen. He reiterated others’ experiments, showing where they were incorrect or misinterpreted. He then developed a series of convincing experiments in dogs that established the cause of the signs and symptoms and subsequently their treatment. His group measured the intraluminal pressures and absorption of fluids in the various parts of the gastrointestinal tract in healthy and in obstructed small bowel. They delineated the role of the lymphatics, the capillaries and the venules during obstruction. In addition, they defined the bacteriology of obstruction and its manifestations at various time points and in various areas of the obstructed gut. They tested whether the well-described lethality could be transferred to normal animals by the injection of intestinal secretions or peritoneal fluid from affected animals.
The most telling investigations were into the origin and make-up of the characteristic gas and fluid accumulations in distended gut. The initial part of the experiment was to ligate the mid-ileum in all the experimental animals. Then in half of the animals the esophagus was divided and the upper end brought out to the skin as a mucous fistula. In the other half the gastrointestinal tract, though completely obstructed, was otherwise left intact. All the animals received intravenous electrolyte infusions. The animals that had the esophagus diverted did not become distended with either gas or fluid and survived for prolonged periods. Those with an intact esophagus experienced the classical consequences of small bowel obstruction, from which they died despite the intravenous fluids. With this insightful series of experiments, Wangensteen proved that swallowed air causing distension was the culprit. In further trials, both in animals and in humans, he showed that removal of the air by means of gastric tubes rescued both experimental animals and patients alike. Under these circumstances, an operation could be done safely or, in many instances, could be avoided altogether. In the absence of swallowed air, healthy gut fluids; saliva; gastric, pancreatic and enteric juices; and bile could be absorbed by the obstructed small intestine. Wangensteen worked out the suction pressures that allow gastric air to be removed and constructed a bedside device that could do this effectively. He demonstrated that the excess fluid accumulation above the obstruction was due to the distension pressure of the swallowed air on the bowel wall impeding venous outflow but not arteriolar inflow. These conditions then interrupted fluid absorption by the intestinal mucosa. He also concluded that there was no advantage to advancing the tube beyond the stomach. The essential function of the gastric tube is to remove air, not fluid.

After having clarified the true function of the nasogastric tube on our ward rounds, a new question arose. If air is the important element removed by suction, but it is not measured by the suction device, how did Wangensteen know when to remove the tube? In his book, *The therapeutic problem in bowel obstructions: a physiological and clinical consideration,¹* Wangensteen listed the following criteria: 1) cessation of “gas pains;” 2) decrease of abdominal distension; 3) the visualization of gas in the colon on the radiograph in complete obstructions, indicating that the obstruction has been overcome; 4) less fluid aspirated through the tube, denoting that stasis is no longer prominent; and 5) toleration of temporary discontinuation of suction without recurrence of pain. It is interesting that the amount of fluid aspirated was number 4 on his list of criteria when for many surgeons today it is number 1 — a reflection of the misguided emphasis on intestinal fluid aspiration.

Wangensteen received the Gross Prize for these pioneering research studies, and their description is incorporated as Part I in his landmark book.² The remaining sections are devoted to clinical aspects and the recognition, diagnosis and guiding principles of treatment. Chapters are devoted to the various subtypes of congenital and acquired large and small bowel obstruction. In its subsequent revised editions, the book became a bible for the next 30 years and still guides the way surgeons approach this common problem.

Surgeons of a certain vintage will remember when the bedside apparatus was called the Wangensteen Suction. Paradoxically, the nasogastric tube is still called the Levin tube, although its invention in 1921 was as an investigative aid for radiology and antedated its use in bowel obstruction. Many of the authors writing in today’s standard textbooks of surgery do not properly describe these principles on which current decompression of the gut is based, probably assuming that they are self-evident.

The aphorism that those who don’t know history are condemned to repeat it happily applies to current surgeons who treat bowel obstructions as Wangensteen taught us — even if many don’t understand why.

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**Competing interests:** None declared.

**Contributors:** All authors contributed substantially to the conception and design and writing of the manuscript and revised and approved the final version for publication.

**References**

Endovenous radiofrequency ablation for the treatment of varicose veins

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Summary
Varicose veins are a common condition that can be treated surgically. Available operative modalities include saphenous venous ligation and stripping, phlebectomy, endovenous laser therapy and radiofrequency ablation. Radiofrequency ablation is the newest of these technologies, and to our knowledge our group was the first to use it in Canada. Our experience suggests that it is a safe and effective treatment for varicose veins, with high levels of patient satisfaction reported at short-term follow-up. More studies are needed to assess long-term effectiveness and compare the various available treatment options for varicose veins.

Varicose veins affect approximately 26% of the adult population and are a frequent cause of discomfort, loss of productivity and deterioration in health-related quality of life.1 Numerous therapies have been developed for the treatment of this condition. Conventional open surgical interventions include ligation of the great saphenous vein at the saphenofemoral junction and stripping. Smaller veins have also been treated with phlebectomies. More recently, less invasive modalities, such as foam sclerotherapy, endovenous laser therapy (EVLT) and endovenous radiofrequency ablation (RFA), have also been used. While endovenous approaches are associated with fewer postoperative complications, such as hematoma, pain or saphenous nerve injury, there is currently no strong evidence to suggest an overall advantage for any particular treatment approach.2

The RFA procedure involves using a catheter electrode to deliver a high-frequency alternating radiofrequency current that leads to venous spasm, collagen shrinkage and physical contraction.3 The patient’s leg is prepped with antiseptic solution and draped in a sterile fashion. With ultrasound guidance, the vein is cannulated, and local tumescent anesthetic is then injected around the target venous segment. The catheter is then introduced through a sheath. The radiofrequency current is then delivered, resulting in circular homogeneous denaturation of the venous collagen matrix and endothelial destruction at a temperature of 110–120° C. Venous segments 3–7 cm in length are treated in 20-second cycles. Patients are instructed to wear 20–30 mm Hg graduated elastic compression stockings for at least 14 days.

Compared with conventional open surgery, RFA can be performed in the outpatient setting without the requirement for hospital admission or general anesthesia. However, the procedure is not feasible in tortuous or very small or large veins, and it may be less cost-effective than open surgery because of the cost of the catheters.

To our knowledge, our institution was the first in Canada to offer RFA for the management of varicose veins using the venefit procedure with second-generation ClosureFast catheters (Covidien). Between 2010 and 2013, 173 patients underwent RFA performed by 3 vascular surgeons. The average age of the patients was 52 ± 14 years, and 143 (83%) of the patients were women. Our patients were referred to the clinic either by their family doctors...
or another vein clinic, and they underwent preoperative Doppler ultrasonography to identify reflux within the target vein. The decision to offer a patient RFA was based on the target vein anatomy and diameter. The maximum vein diameter considered for the procedure was 1.8 cm, and the minimum was 0.4 cm. Elderly patients also underwent arterial duplex scans to rule out arterial insufficiency.

Most (72%) patients underwent treatment of a single limb, and 89% of patients underwent treatment of a single vein. The great saphenous vein was most frequently treated (81%), followed by the small saphenous (7%) and the accessory great saphenous (1%).

Postoperatively, the median time that patients took off work was 2 days. While 80 (69%) patients needed no postoperative analgesics, 35 (30%) patients used from the counter oral analgesics, such as acetaminophen or ibuprofen. Only 1 patient needed an opioid analgesic. Duplex ultrasonography performed 2–4 weeks after the procedure demonstrated successful vein occlusion in 99% of patients. Only 1 patient showed evidence of partial recanalization on follow-up. Two (1%) patients reported persistent pain at 30-day follow-up, and 6 (4%) patients demonstrated skin discoloration. Eight (5%) patients with residual large veins returned to our clinic after the follow-up period and underwent phlebectomy procedures.

Telephone interviews were conducted several weeks after the procedure to assess patient satisfaction. Of the 111 (65%) patients contacted, 83% were extremely satisfied, 12% were very satisfied, 3% were somewhat satisfied, and 2% were not too satisfied with their RFA experiences. However, all of those who responded indicated that they would have this procedure again and would recommend it to a friend.

Our experience suggests that RFA is a safe and effective treatment for the management of varicose veins that is associated with a high success rate and patient satisfaction. Only 1 patient in our series demonstrated target-vein recanalization on follow-up. This was a cirrhotic patient with a history of hepatic failure who was on chronic anti-coagulation therapy for multiple medical comorbidities. Her vein was also 1.5 cm in diameter, which was close to the cutoff of 1.8 cm that we accept in our practice.

To our knowledge, our group is the first to describe the successful implementation of RFA in Canada, where public health insurance guidelines have greatly restricted the criteria for reimbursing venous procedures and where many vein surgeries are performed at private clinics. In the face of this changing reimbursement landscape, we believe that RFA is a viable alternative to more conventional open vein surgeries and EVLT, which are more widely available in Canada.

Our work as well as studies by other groups will hopefully continue to enrich the debate on the most suitable intervention for the management of venous disease. A 2011 review by Ontario’s Medical Advisory Secretariat found that RFA was superior to open vein surgery when comparing postoperative pain, duration of recovery, major adverse effects and patient preference, while open surgery was less costly than RFA. However, the same review found no evidence to suggest major differences in postoperative pain between RFA and EVLT when pain was adjusted for analgesic use, and any differences did not persist after 1-month follow-up. Furthermore, the 2 procedures did not differ when comparing treatment effectiveness or durability. This was mostly because of a lack of studies that have assessed long-term recurrence after either treatment. Prospective, long-term studies are thus clearly needed to compare the clinical and cost-effectiveness of both treatments and provide health care consumers with the best standard of care.

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Contributors: All authors contributed substantially to writing and/or revising and to the conception and design of the manuscript and approved the final version for publication.

References


A novel method for assessing visual perception of surgical planes

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Background: Recognition of tissue planes during surgery appears to be a skill acquired with experience. We conducted a pilot study to test this hypothesis using a novel method for evaluating this skill in a simulated environment.

Methods: Twelve surgeons of varying levels of experience were shown 16 captured images from a mesorectal excision. For each image, they were asked to draw the ideal dissection plane with a stylus on a tablet computer. We used a novel metric for comparing agreement between lines to determine the level of precision observed between junior and senior trainees and consultant surgeons and measure the accuracy of junior and senior trainees compared with consultant surgeons.

Results: We observed significant differences in precision for 9 of 16 images; 7 of these followed the predicted stepwise pattern associated with level of experience. Using consultant surgeons as the reference standard, we observed significant differences in accuracy between senior and junior trainees for 11 images, with senior trainees being more accurate in 10 of them. Only 2 images failed to contribute significant findings to our analysis.

Conclusion: The findings of this pilot evaluation of a novel method for measuring a surgeon’s ability to recognize tissue planes in a simulated model show that skill improves with experience. Further evaluation of this method will reveal its utility as an assessment tool and possibly as a training instrument.

Contexte : La reconnaissance des différents plans tissulaires durant la chirurgie semble être une compétence qui s'acquiert avec l’expérience. Nous avons procédé à une étude pilote pour vérifier cette hypothèse à l’aide d’une nouvelle méthode d’évaluation de cette compétence dans un environnement simulé.

Méthodes : Nous avons montré 16 images provenant d’une excision mésorectale à 12 chirurgiens de divers degrés d’expérience. Pour chaque image, ils devaient dessiner le plan de dissection idéal avec un stylo sur une tablette électronique. Nous avons utilisé un nouvel outil de mesure pour comparer la concordance entre les lignes et déterminer ainsi le degré de précision observé entre les résidents juniors et seniors et les chirurgiens consultants et comparer la précision des résidents juniors et seniors à celle des chirurgiens consultants.

Résultats : Nous avons observé des différences significatives quant à la précision pour 9 images sur 16, 7 d’entre elles étaient conformes aux séquences prévues compte tenu du degré d’expérience. En utilisant les chirurgiens consultants comme norme de référence, nous avons observé des différences significatives quant à la précision entre les résidents seniors et juniors pour 11 images, les résidents seniors étant plus précis pour 10 de ces images. Seulement 2 images n’ont pas permis d’alimenter de façon significative notre analyse.

Conclusion : Les résultats de cette évaluation pilote d’une nouvelle méthode de mesure de l’aptitude des chirurgiens à reconnaître les plans tissulaires dans un modèle simulé montrent que les habiletés s’améliorent avec l’expérience. Il faudra approfondir l’examen de cette méthode pour en confirmer l’utilité comme outil d’évaluation et instrument potentiel de formation.
It is considered a fundamental principle of good surgical technique to respect tissue planes during surgery. Tissue planes tend to be avascular; therefore, bleeding can be reduced. In addition, there is growing evidence of improved oncologic outcomes associated with adherence to dissection along tissue planes. This has been demonstrated clearly for rectal cancer resections. There is compelling evidence to suggest this is also true for colon cancer surgery and hepatobiliary surgery.

One of the challenges encountered when teaching trainees to operate within tissue planes is how to facilitate the trainee’s recognition of the plane. What is intuitively obvious to the expert surgeon is not always obvious to the trainee. There are likely visual clues that allow the expert to see what the novice does not yet appreciate. Currently it is not clear how this visual skill is learned during the course of clinical apprentice-based training.

Our hypothesis is that if the ability to perceive tissue planes is an acquired skill, then it should be possible to develop a visual test of that skill that discriminates between novice and expert surgeons.

**Methods**

We captured a series of 16 digital images representing progressive stages of a mesorectal excision from digitally recorded video. The chosen procedure was a da Vinci-assisted (Intuitive Surgical) laparoscopic proctectomy, and we obtained consent from the patient for the recording and use of the images for surgical instruction. The use of a da Vinci-assisted procedure, as opposed to a laparoscopic procedure, was of no particular consequence. We chose this particular case simply because the image quality and exposure of the tissue planes captured in the video were of such high quality that they seemed ideally suited for our pilot study. The images themselves were selected from video and chosen on the basis of clear views unobstructed by surgical instruments; they represented multiple viewpoints of the mesorectal envelope, as seen from the posterior, anterior, left and right dissection planes. Images were labelled minimally for orientation only.

Images were transferred to an iPad 2 (Apple Inc.) and presented in Sketchbook Pro software (Autodesk Inc.). Study participants were able to draw on the presented image using a stylus for capacitive touch screens (Slim Stylus, Targus). Each surgeon’s line was saved in a separate layer for later analysis.

We recruited 12 surgeons with varying levels of expertise to view the images on the iPad. Since this was a pilot study and we had no preconception as to what kind of results to expect, we did not perform any sample size or power analysis calculations.

The participating surgeons included 4 consultant surgeons experienced in performing a mesorectal excision, 4 senior trainees and 4 junior trainees. For each image, we instructed the surgeons to draw a free line representing the dissection plane on the image as if the stylus were a scalpel or preferred dissecting instrument. The surgeons were instructed to draw the line as precisely as possible and to extend the line for as long as they felt they could comfortably appreciate the dissection plane. They were permitted to erase and redraw the line, if needed.

**Statistical analysis**

To compare one drawn line with another, we formulated a distance metric (similar to the Hausdorff measure used in computational geometry) based on the Euclidean distance between evenly spaced points along the arc. Using Matlab (MathWorks), each line was iteratively bisected 3 times (b = 3), resulting in 8 segments specified by pairs of Cartesian coordinates (p = 2b+1; 9 pairs for the present study; Fig. 1). For each study group (G), this distance metric between any 2 lines (a, b) for a given image (i) was calculated as the summed distance (d), in pixels, between each of the coordinate pairs (x, y) as follows:

\[
d(Ga,b;i) = \sum_{j=1}^{p} \sqrt{(Gax_j - Gbx_j)^2 + (Gay_j - Gby_j)^2}
\]

Within each study group, there were 6 possible pairs of lines that could be compared for each image. Across the set of images, we calculated the means ± standard deviations of these 6 pairs for each of the 3 study groups.

The mean distance metric is inversely related to group precision (i.e., the greater the mean distance metric, the less agreement or consensus there is within that group with respect to the location of the ideal dissection plane). For each image, we compared this measure of precision for all
3 study groups using 1-way analysis of variance (ANOVA) with a significance level of $p = 0.05$. When significant differences were found, we performed pairwise comparisons using the Student $t$ test. We used Šidák’s equation to correct the level of significance for multiple comparisons: $\alpha_{PT} = 1 - (1 - \alpha_{PF})^{1/c}$, where $\alpha_{PT}$ is the corrected probability of a type-1 error for an individual test and $\alpha_{PF}$ is the probability of a type-1 error for a family of tests. For 3 comparisons and $\alpha_{PF} = 0.05$, then $\alpha_{PT} = 0.017$.

Since there is no “correct” line representing the tissue plane in each image, and therefore no gold standard with which to compare the accuracy of each line, for the purpose of our analysis we considered the consultant surgeons to be the experts. Accordingly, for each image, we compared each trainee line with each consultant surgeon line in the fashion described above. This produced 16 comparisons ($4 \times 4$) per group per line. The average of these 16 comparisons represents group accuracy, with smaller distances associated with greater accuracy. These were analyzed using the Student $t$ test, with significance set at $p = 0.05$.

**RESULTS**

For 9 of the 16 images (1–3, 5, 6, 9–11, 16), we observed a stepwise increase in precision according to level of experience from junior trainees to senior trainees to consultant surgeons, although not all were significantly different (Table 1). We observed significant differences in precision in 9 of the 16 images (2, 4–7, 9, 10, 13, 16). Considering these 9 images only, pairwise comparisons revealed significant differences in precision between 10 pairings. In only 1 image (7), significantly greater precision was found in the senior trainee group than in the consultant surgeon group.

In 13 of 16 images, the accuracy of the senior trainee group was greater than that of the junior trainee group (Table 2). These differences were significant for 10 of the images (3–7, 9–11, 14, 16). For image 12, the junior trainees appeared to be significantly more accurate than the senior trainees. We used the results for image 5 as a representative example of these findings. Lines drawn by consultant surgeons (Fig. 2), senior trainees (Fig. 3) and junior trainees (Fig. 4) differed significantly on 1-way ANOVA but not by pairwise comparison (Table 1). For this image, senior trainees were significantly more accurate than junior trainees (Table 2).

Images 8 and 15 contributed no significant findings to any of our analyses.

**DISCUSSION**

Visual processing of the spatial relations of image properties is known as visual spatial ability. It has been proposed that visual spatial ability can be classified in 5 categories: edge and surface extraction, edge orientation encoding, whole object recognition, mental visualization involving the spatial relations of object parts in 2 dimensions (2D), and mental visualization involving 2D and 3-dimensional (3D) spatial rotations and translations. These represent a hierarchy of ability ranging from low- to high-level ability.5,6

Nonverbal, visual–spatial problem solving abilities and the ability to distinguish essential from nonessential detail has been shown to correlate with superior surgical skill in general surgery trainees.$^7$ This finding was based on correlation between a battery of tests measuring visual–spatial perception, motor sequencing and fine-motor coordination and stress tolerance with a novel rating scale of visual spatial ability.

<table>
<thead>
<tr>
<th>Image</th>
<th>Consultant Mean distance ± SD (pixels)</th>
<th>Senior</th>
<th>Junior</th>
<th>1-way ANOVA $F$</th>
<th>$p$ value</th>
<th>Group comparisons ($p &lt; 0.017)^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1081 ± 327</td>
<td>1496 ± 744</td>
<td>2159 ± 894</td>
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<td>2</td>
<td>731 ± 356</td>
<td>1530 ± 480</td>
<td>1973 ± 479</td>
<td>12.158</td>
<td>0.001</td>
<td>Yes, Yes, NS</td>
</tr>
<tr>
<td>3</td>
<td>1406 ± 545</td>
<td>2087 ± 760</td>
<td>2917 ± 1888</td>
<td>2.322</td>
<td>0.13</td>
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<tr>
<td>4</td>
<td>479 ± 336</td>
<td>343 ± 174</td>
<td>1108 ± 373</td>
<td>10.620</td>
<td>0.001</td>
<td>NS, NS, Yes</td>
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<tr>
<td>5</td>
<td>738 ± 429</td>
<td>1468 ± 494</td>
<td>1846 ± 713</td>
<td>6.098</td>
<td>0.012</td>
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<td>6</td>
<td>770 ± 318</td>
<td>1161 ± 392</td>
<td>1497 ± 610</td>
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<td>0.046</td>
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<tr>
<td>7</td>
<td>1393 ± 651</td>
<td>693 ± 242</td>
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</tr>
<tr>
<td>8</td>
<td>1619 ± 991</td>
<td>2007 ± 935</td>
<td>1838 ± 691</td>
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<td>0.75</td>
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</tr>
<tr>
<td>9</td>
<td>551 ± 237</td>
<td>1050 ± 302</td>
<td>1942 ± 770</td>
<td>12.075</td>
<td>0.001</td>
<td>Yes, Yes, NS</td>
</tr>
<tr>
<td>10</td>
<td>366 ± 81</td>
<td>801 ± 214</td>
<td>1152 ± 199</td>
<td>30.347</td>
<td>&lt; 0.001</td>
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<tr>
<td>11</td>
<td>1665 ± 974</td>
<td>1869 ± 934</td>
<td>2184 ± 932</td>
<td>0.458</td>
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<tr>
<td>12</td>
<td>1511 ± 543</td>
<td>1867 ± 1001</td>
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<td>2.802</td>
<td>0.09</td>
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</tr>
<tr>
<td>13</td>
<td>451 ± 102</td>
<td>2066 ± 1130</td>
<td>1257 ± 324</td>
<td>8.430</td>
<td>0.004</td>
<td>NS, Yes, NS</td>
</tr>
<tr>
<td>14</td>
<td>1054 ± 371</td>
<td>1733 ± 549</td>
<td>1309 ± 402</td>
<td>3.525</td>
<td>0.06</td>
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<td>988 ± 653</td>
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<tr>
<td>16</td>
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<td>904 ± 302</td>
<td>1631 ± 631</td>
<td>6.973</td>
<td>0.007</td>
<td>NS, Yes, NS</td>
</tr>
</tbody>
</table>

ANOVA = analysis of variance; C = consultant surgeons; J = junior trainees; NS = nonsignificant; S = senior trainees; SD = standard deviation.

*p = 0.05, corrected for 3 comparisons.
surgical performance. This rating scale was composed of 12 items assessing mainly technical performance.

Since publication of that report, a growing body of evidence has been produced that demonstrates correlation between performance on various tests of visual–spatial ability and surgical performance. These studies have focused on a range of topics from measures of whole surgical tasks assessed in a laboratory setting to overall assessment of clinical performance. There seems to be stronger correlation between task performance and high-level visual–spatial abilities, such as 3D spatial rotations.

Relevant to the performance of laparoscopic surgery, a unique method for gauging the perceived depth relations of objects presented in a 2D display provided some support for the claim that visual perceptual skills necessary for understanding 3D structure can be improved with practice. However, some neurophysiological studies have suggested that in specific perceptual learning, the benefits of perceptual training would be relatively limited.

In the present study, we focused on the initial perception and spatial reasoning skills needed to initiate performing a particular surgical procedure. Based on the presumption that in order to dissect a tissue plane one must first be able to visualize that plane, we developed a novel technique for assessing the ability of surgeons to identify dissection planes on static images acquired from actual surgical procedures. It was the goal of this pilot study to evaluate the tool by determining whether there are measurable performance differences between surgeons and trainees.

Despite our small number of participants, we found significant differences consistent with our a priori hypothesis that recognition of surgical planes is a skill acquired through experience. Considering the within-group variability as an inverse measure of concordance or group precision, we found that we were able to demonstrate a stepwise increase in precision from junior trainees to consultant surgeons.

Table 2. Mean difference from consultant group

<table>
<thead>
<tr>
<th>Image</th>
<th>S v. C</th>
<th>J v. C</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1481 ± 789</td>
<td>1470 ± 988</td>
<td>0.97</td>
</tr>
<tr>
<td>2</td>
<td>1051 ± 541</td>
<td>1559 ± 844</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>1694 ± 917</td>
<td>3183 ± 1365</td>
<td>0.001</td>
</tr>
<tr>
<td>4</td>
<td>477 ± 274</td>
<td>1642 ± 667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>5</td>
<td>1133 ± 503</td>
<td>1610 ± 526</td>
<td>0.014</td>
</tr>
<tr>
<td>6</td>
<td>1019 ± 412</td>
<td>1557 ± 144</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>7</td>
<td>1245 ± 669</td>
<td>1956 ± 533</td>
<td>0.002</td>
</tr>
<tr>
<td>8</td>
<td>1711 ± 1046</td>
<td>1963 ± 712</td>
<td>0.42</td>
</tr>
<tr>
<td>9</td>
<td>776 ± 286</td>
<td>1329 ± 327</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>10</td>
<td>584 ± 248</td>
<td>1271 ± 456</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>11</td>
<td>1747 ± 782</td>
<td>2609 ± 767</td>
<td>0.004</td>
</tr>
<tr>
<td>12</td>
<td>1706 ± 683</td>
<td>731 ± 398</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>13</td>
<td>1843 ± 1282</td>
<td>1296 ± 462</td>
<td>0.13</td>
</tr>
<tr>
<td>14</td>
<td>1384 ± 495</td>
<td>1861 ± 596</td>
<td>0.020</td>
</tr>
<tr>
<td>15</td>
<td>1766 ± 1178</td>
<td>2068 ± 780</td>
<td>0.40</td>
</tr>
<tr>
<td>16</td>
<td>774 ± 332</td>
<td>1685 ± 843</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

C = consultant surgeons; J = junior trainees; S = senior trainees; SD = standard deviation.

Fig. 2. Consultant surgeons’ responses for image 5.

Fig. 3. Senior trainees’ responses for image 5.

Fig. 4. Junior trainees’ responses for image 5.
Limitations

One of the limitations of our methodology is the unavailability of a “correct” plane to use as a reference standard. Therefore, in order to assess accuracy we chose to consider the expert (consultant surgeons) group as the reference standard against which we compared trainee groups. We argue that in many instances the perfect plane of dissection may be a matter of conjecture. Using the experts as a control group, we preserved the variability inherent in multiple opinions. We anticipate that a larger number of experts would narrow this variability or improve the precision of the expert group. Interestingly, for this pilot study our small sample size was still sufficient to demonstrate that senior trainees were predominantly more accurate than junior trainees, which was consistent with our hypothesis.

One of the potential confounders of this study is content validity. It is possible that rather than testing differences in ability to perceive tissue planes, we are simply testing differences in trainees’ familiarity with this particular surgical procedure based on their experience and recall. Some of the lines drawn by junior trainees were not only away from the ideal plane, but also clearly demonstrated a lack of recognition of either the anatomy or the next step in the procedure. Future study will need to include an assessment of procedure-specific experience to determine whether this represents an overriding factor.

Another potential weakness is the small number of participants in this pilot study. Despite the ability to appreciate significant differences among the study groups for many of the images, the response of a single individual has the potential to have a large effect on the group. This will be addressed in future studies with larger study groups.

It would be a valid criticism to argue that in practice many factors contribute to the dynamic recognition of surgical planes. The purpose of this pilot was simply to determine if our methodology would be sensitive enough to discriminate between novices and experts based on static images alone. Given that we demonstrated the ability of this methodology to detect expected differences among study groups, we now have the possibility in future endeavors to study the effect of additional clues. This is an area ripe for further investigation, including the use of lead-in video to static images, the contribution of innate psychomotor ability, the difference in visual clues obtained from open compared with laparoscopic surgery or even the role of narrow band imaging. Some of these areas are already being pursued at our institution.

Not all of the images used in this study contributed to significant findings, which may be a result of type-II error owing to the small sample size. It is also possible that some images were less discriminating than others. Future study will require evaluating a larger library of images so that a better understanding of what represents a discriminating image can be developed.

Conclusion

Our pilot study demonstrated a novel method of evaluating visual perception and spatial reasoning of surgical tissue planes. This method shows promise as a tool that possesses the sensitivity to discriminate between levels of experience of surgical trainees. Many questions remain to be addressed through future study and work already in progress. With further development, this methodology has the potential to be developed into both an assessment tool and a training tool to enhance surgical instruction.

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Competing interests: None declared.

Contributors: C. Schlachta and R. Eagleson designed the study. C. Schlachta acquired the data, which all authors analyzed. C. Schlachta and R. Eagleson wrote the article, which all authors reviewed and approved for publication.

References

The integration of minimally invasive surgery in surgical practice in a Canadian setting: results from 2 consecutive province-wide practice surveys of general surgeons over a 5-year period

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Olivier Mailloux, MD
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Roger C. Grégoire, MD
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Background: Although minimally invasive surgery (MIS) has been quickly embraced, the introduction of advanced procedures appears more complex. We assessed the evolution of MIS in the province of Quebec over a 5-year period to identify areas for improvement in the modern surgical era.

Methods: We developed, test-piloted and conducted a self-administered questionnaire among Quebec general surgeons in 2007 and 2012 to examine stated MIS practice, MIS training and barriers and facilitators to the use of MIS.

Results: Response rates were 51.3% (251 of 489) in 2007 and 31.3% (153 of 491) in 2012. A significant increase was observed for performance of most advanced MIS procedures, especially for colectomy for benign (66.0% v. 84.3%, p < 0.001) and malignant diseases (43.3% v. 77.8%, p < 0.001) and for rectal surgery for malignancy (21.0% v. 54.6%, p < 0.001). More surgeons practised 3 or more advanced MIS procedures in 2012 than in 2007 (82.3% v. 64.3%, p < 0.001). At multivariate analysis, the 2007 survey administration was associated with fewer surgeons practising advanced MIS (odds ratio 0.13, 95% confidence interval 0.06–0.29). In 2012, more respondents stated they gained their skills during residency (p = 0.028).

Conclusion: From 2007 to 2012 there was a significant increase in advanced MIS procedures practised by general surgeons in Quebec. This technique appears well established in current surgical practice. The growing place of MIS in residency training seems to be a paramount part of this development. Results from this study could be used as a baseline for studies focusing on ways to further improve the MIS practice.

Contexte : Malgré l’adoption récente rapide de la chirurgie minimalement invasive (CMI), son utilisation pour les procédures complexes semble plus ardue. Afin d’identifier comment améliorer sa pratique, nous avons examiné l’utilisation de la CMI dans la province de Québec sur une période de 5 ans.

Méthodes : Nous avons développé, piloté, et distribué un questionnaire auto-administré aux chirurgiens généraux du Québec en 2007 et en 2012, afin d’examiner la pratique auto-rapportée de la CMI, la formation en CMI, et les barrières et facilitateurs à l’utilisation de la CMI.

Résultats : Le taux de réponse était de 51.3 % (251 sur 489) en 2007 et 31.3 % (153 sur 491) en 2012. L’utilisation de la majorité des procédures avancées de CMI a augmenté, particulièrement la colectomie pour maladie bénigne (66.0 % c. 84.3 %, p < 0.001) et maligne (43.3 % c. 77.8 %, p < 0.001), et la résection rectale pour cancer (21.0 % c. 54.6 %, p < 0.001). Plus de chirurgiens pratiquaient 3 procédures avancées de CMI ou plus en 2012 qu’en 2007 (82.3 % c. 64.3 %, p < 0.001). L’analyse multi-variée a indiqué que l’administration du questionnaire en 2007 était associée avec moins de chirurgiens pratiquant des procédures avancées de CMI (rapport de cote 0,13, intervalle de confiance à 95 % 0,05–0,29). En 2012, plus de répondants ont indiqué avoir obtenu leur expertise en CMI durant la résidence (p = 0,028).

Conclusion : De 2007 à 2012, la pratique de procédures avancées de CMI a augmenté significativement dans la province de Québec. L’approche minimalement invasive apparaît solidement établie dans la pratique chirurgicale actuelle. La place grandissante de la CMI dans les programmes de résidence semble avoir été cruciale dans cet essor. Les résultats de cette étude peuvent maintenant servir à développer d’autres projets visant à améliorer encore davantage la pratique de la CMI.
Laparoscopic surgery has been one of the most important revolutions in surgery in the last century. The widespread use of this technique grew to be known as minimally invasive surgery (MIS). Many reports have now highlighted the benefits of the laparoscopic over the open approach for the treatment of a variety of conditions, mainly through a decrease in pain, blood loss, length of hospital stay and complications.1,2

Most surgeons quickly adopted laparoscopic cholecystectomy, but the introduction of major procedures can appear more complex. General surgeons in Canada have been able to follow the trend of the rising popularity of MIS to satisfy health services and increased public expectations, but the use of advanced MIS procedures has been variable.3,4 The implementation of an MIS practice requires multiple conditions, such as technical skills and adapted tools. As these conditions vary among hospitals, the use of MIS may differ within a single health system. Moreover, the last few years have witnessed a quest for the least invasive procedure possible, with the advent of natural orifice transluminal endoscopic surgery (NOTES), single-port surgery or robotic surgery. Before considering widespread introduction of these latter techniques in current surgical practice, we need to better understand how previous developments have already been integrated.

To assess the current state of modern surgical practice, our aim was to describe the practice of MIS in the province of Quebec, the factors affecting it and its evolution over a 5-year timeframe. Therefore, in 2007 and 2012, we conducted practice surveys of Quebec general surgeons to determine self-reported MIS practice and training as well as the factors perceived to affect this surgical activity.

Methods

Sampling frame

The survey population was composed of Quebec’s general surgeons working in both university-affiliated and community hospitals. In 2007 and 2012, postal or email addresses of potential respondents were obtained through the membership database of the Quebec Surgical Association (QSA), membership in which is mandatory. The final list included 489 potential respondents in 2007 and 491 in 2012.

Questionnaire development

The questionnaire was developed by a group of experts composed of academic surgeons specialized in MIS who identified important domains and specific issues within those domains, highlighting those most pertinent to MIS practice. We first generated items without restriction, grouped them into domains, and proceeded to item reduction in order to retain only the most relevant ones.5

The questionnaire was designed using this final list of domains and items. The chosen domains were 1) parameters of surgical practice, 2) stated type of MIS practice, 3) MIS training, 4) barriers to MIS practice and 5) facilitators of MIS practice. Questions were constructed using closed answers. Advanced MIS procedures included all MIS procedures other than appendectomy, cholecystectomy and diagnostic laparoscopy. As both community and academic general surgeons in Quebec practise thoracic, endocrine or liver surgery, subspecialized procedures were included in this list. We used a 5-point Likert scale to assess the perceived importance of potential barriers and facilitators on an agree–disagree continuum. We tested the original questionnaire by inviting 5 surgeons to complete it. These individuals were asked to provide feedback about the flow, the clarity and the ease of administration of the questionnaire. The questionnaire was reviewed accordingly.

Questionnaire administration

In 2007, the survey was self-administered in French in a written form. No incentive was offered to complete the questionnaire. Each potential respondent received a mailed invitation to complete the survey. Two reminders were sent over a 6-month period. An administrative assistant compiled the final database of completed questionnaires. No identifying information was included. In 2012, the survey was administered in a web-based format using SurveyMonkey, and email invitations were sent to all potential respondents. Reminders and compilation of data were done in a similar way as in 2007.

Data analysis

By aiming for a 60% response rate, we expected a precision of 5.7% in both 2007 and 2012. The precision for these surveys was 6.2% in 2007 and 7.9% in 2012.5 We first performed descriptive analysis of completed questionnaires for both administration periods separately. Continuous data are expressed using means ± standard deviations (SDs) or medians and interquartile ranges (IQRs), as appropriate, and categorical data are reported as numbers and proportions. We conducted a univariate analysis to compare answers from respondents in 2007 and 2012, using a 2-sample t test, Fisher exact test or Pearson χ² test, as appropriate. We performed multivariate analysis using logistic regression to assess the variables associated with an advanced MIS practice (≥ 3 advanced MIS procedures). The year of survey administration as well as potential confounding variables were included in this model. Results are presented as odd ratios (ORs) with 95% confidence intervals (CIs). Data were considered to be significant at p < 0.05. Statistical analyses were conducted using XLSTAT version 2011.5 (Addinsoft SARL) for Microsoft Excel.
RESULTS

In 2007, 251 (51.3%) of the general surgeons surveyed completed the questionnaire, whereas 153 (31.3%) completed it in 2012. There were 12 exclusions in 2007 (retired surgeons) and none in 2012 (Fig. 1).

Demographic characteristics and surgical practice parameters

Demographic data and surgical practice parameters of respondents are presented in Table 1. No significant difference was observed between the characteristics of respondents in 2007 and 2012, except that there were fewer respondents working in areas with a population of 50 000–500 000 individuals in 2007 (45.7% v. 57.9%, \( p = 0.020 \)). Parameters of the surgical practice of respondents did not differ significantly between 2007 and 2012.

MIS practice characteristics

Table 2 presents MIS practice characteristics. Regarding basic MIS procedures, there was a significant increase in the number of surgeons practising laparoscopic appendectomies from 2007 to 2012 (82.3% v. 94%, \( p = 0.003 \)). More surgeons reported always using an open technique for pneumoperitoneum establishment in 2012 (63.5% v. 76% \( p = 0.011 \)). The 2012 survey showed an increased number of surgeons reporting the practice of 3 or more advanced MIS procedures (64.3% v. 82.3%, \( p < 0.001 \)).

Details regarding the type of advanced MIS procedures performed are included in Table 2. The most commonly performed procedure reported in both surveys was colectomy for benign disease followed by the same surgery for malignancy. More surgeons reported practising these procedures in 2012 for both benign (66.7% v. 84.3%, \( p < 0.001 \)) and malignant indications (43.3% v. 77.8%, \( p < 0.001 \)). The least often performed procedures at both time points were liver and lung resections.

MIS training

Perceptions of respondents on MIS training are reported in Table 3. From 2007 to 2012, the number of respondents stating that they gained their skills during residency (\( p = 0.028 \)) or by self-training (\( p < 0.001 \)) increased. In

![Flow diagram of respondents](image-url)
both 2007 and 2012, most respondents perceived that the responsibility of MIS training lies with provincial surgical societies (92.0% in 2007 and 90.4% in 2012), national surgical societies (82.1% in 2007 and 91.7% in 2012) and universities (57.4% in 2007 and 62.5% in 2012).

Barriers and facilitators to MIS practice

Significant differences in barriers and facilitators to MIS practice were observed between 2007 and 2012. More respondents in 2012 disagreed or strongly disagreed that

### Table 1. Comparison of respondents' demographics and practice characteristics between 2007 and 2012

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>2007 survey</th>
<th>2012 survey</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD yr</td>
<td>45.1 ± 10.6</td>
<td>43.7 ± 10</td>
<td>0.20</td>
</tr>
<tr>
<td>Male sex, no. (%)</td>
<td>141 (70.8)</td>
<td>106 (70.7)</td>
<td>0.97</td>
</tr>
<tr>
<td>Fellowship training, no. (%)</td>
<td>74 (31.1)</td>
<td>46 (30.7)</td>
<td>0.93</td>
</tr>
<tr>
<td>Surgical experience, mean ± SD yr</td>
<td>14.8 ± 10.7</td>
<td>13.5 ± 9.6</td>
<td>0.24</td>
</tr>
<tr>
<td>Community practice, no. (%)</td>
<td>114 (48.1)</td>
<td>85 (55.6)</td>
<td>0.15</td>
</tr>
<tr>
<td>Population, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 50 000</td>
<td>54 (22.9)</td>
<td>26 (17.1)</td>
<td>0.17</td>
</tr>
<tr>
<td>50 000–500 000</td>
<td>108 (45.7)</td>
<td>88 (57.9)</td>
<td>0.02</td>
</tr>
<tr>
<td>&gt; 500 000 individuals</td>
<td>74 (31.4)</td>
<td>38 (25)</td>
<td>0.18</td>
</tr>
<tr>
<td>Weekly operating time, mean ± SD d</td>
<td>1.4 ± 1.5</td>
<td>1.6 ± 1.3</td>
<td>0.32</td>
</tr>
<tr>
<td>Waiting time for malignant disease, mean ± SD wk</td>
<td>3.2 ± 2.0</td>
<td>3.7 ± 3.3</td>
<td>0.10</td>
</tr>
<tr>
<td>Waiting time for benign disease, mean ± SD wk</td>
<td>18 ± 3.2</td>
<td>17.3 ± 33.3</td>
<td>0.84</td>
</tr>
</tbody>
</table>

SD = standard deviation.

### Table 2. Comparison of the characteristics of MIS practice between 2007 and 2012

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>2007 survey</th>
<th>2012 survey</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic MIS procedures performed, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>214 (90)</td>
<td>141 (94.0)</td>
<td>0.45</td>
</tr>
<tr>
<td>Diagnostic laparoscopy</td>
<td>214 (90)</td>
<td>145 (96.0)</td>
<td>0.09</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>196 (82.3)</td>
<td>141 (94.0)</td>
<td>0.003</td>
</tr>
<tr>
<td>Technique used for pneumoperitoneum, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always open (Hasson)</td>
<td>141 (63.5)</td>
<td>114 (76)</td>
<td>0.011</td>
</tr>
<tr>
<td>Always closed (Veress) or both</td>
<td>81 (36.5)</td>
<td>36 (24)</td>
<td>0.011</td>
</tr>
<tr>
<td>Number of advanced MIS procedures performed, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No advanced procedure</td>
<td>36 (15.1)</td>
<td>10 (6.5)</td>
<td>0.011</td>
</tr>
<tr>
<td>1–2 advanced procedures</td>
<td>49 (20.6)</td>
<td>17 (11.1)</td>
<td>0.013</td>
</tr>
<tr>
<td>≥ 3 advanced procedures</td>
<td>153 (64.3)</td>
<td>126 (82.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Type of advanced procedures performed, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nissen fundoplication</td>
<td>90 (37.8)</td>
<td>75 (49)</td>
<td>0.029</td>
</tr>
<tr>
<td>Heller myotomy</td>
<td>52 (21.8)</td>
<td>51 (33.3)</td>
<td>0.012</td>
</tr>
<tr>
<td>Gastric resection</td>
<td>30 (12.8)</td>
<td>51 (33.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Liver resection</td>
<td>13 (5.46)</td>
<td>9 (5.9)</td>
<td>0.86</td>
</tr>
<tr>
<td>Biliary tract exploration</td>
<td>31 (13)</td>
<td>20 (13.1)</td>
<td>0.18</td>
</tr>
<tr>
<td>Distal pancreatectomy</td>
<td>21 (8.8)</td>
<td>27 (17.6)</td>
<td>0.009</td>
</tr>
<tr>
<td>Splenectomy</td>
<td>111 (46.6)</td>
<td>105 (68.6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Adrenalectomy</td>
<td>60 (25.2)</td>
<td>50 (32.7)</td>
<td>0.109</td>
</tr>
<tr>
<td>Colectomy (benign disease)</td>
<td>157 (66)</td>
<td>129 (84.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Colectomy (malignant disease)</td>
<td>103 (43.3)</td>
<td>119 (77.8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Rectal resection (benign disease)</td>
<td>87 (36.5)</td>
<td>97 (63.8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Rectal resection (malignant disease)</td>
<td>50 (21)</td>
<td>83 (54.6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Inguinal hernia repair</td>
<td>73 (30.7)</td>
<td>55 (36.2)</td>
<td>0.28</td>
</tr>
<tr>
<td>Ventral hernia repair</td>
<td>92 (38.7)</td>
<td>105 (68.6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>General video assisted thoracoscopy</td>
<td>74 (31.1)</td>
<td>53 (34.6)</td>
<td>0.47</td>
</tr>
<tr>
<td>Video-assisted thoracoscopy for lung resection</td>
<td>33 (13.9)</td>
<td>16 (10.5)</td>
<td>0.32</td>
</tr>
</tbody>
</table>

MIS = minimally invasive surgery.
insufficient operative time \((p < 0.001)\), lack of hospital resources \((p < 0.001)\), lack of training opportunities \((p < 0.001)\), lack of support from the hospital \((p < 0.001)\) or insufficient remuneration \((p = 0.06)\) were important barriers to MIS practice. In both surveys, most respondents did not believe that the lack of scientific evidence or medicolegal issues were obstacles to the implementation of MIS (Table 4).

**Multivariate analysis**

On multivariate analysis, the 2007 survey administration was associated with significantly fewer surgeons reporting an advanced MIS practice \((\geq 3\text{ advanced MIS procedures}; OR 0.13, 95\% CI 0.06–0.29)\). Other variables associated with not practising advanced MIS were age \((56–65\text{ yr}; OR 0.33, 95\% CI 0.13–0.82>; 65\text{ yr}; OR 0.15, 95\% CI 0.03–0.81)\), working in a community of fewer than 50,000 individuals \((OR 0.4, 95\% CI 0.19–0.83)\) and not performing MIS appendectomy \((OR 0.04, 95\% CI 0.01–0.10)\). The surgeons’ experience (years in practice), community practice setting and the lack of fellowship training were not associated with the number of advanced procedures performed (Table 5).

**Discussion**

The benefits of MIS over open surgery are well established in terms of decreased postoperative pain, blood loss, length of hospital stay and complications, and this technique is now part of modern general surgery practice; MIS even represents the standard of care in some cases. The ability of general surgeons to learn and apply these new skills is paramount to keep up with the rapidly evolving field of general surgery. Our study illustrates the evolution of MIS practice in Quebec over a 5-year period 30 years after its introduction. We observed a significant increase in the number of advanced MIS procedures practised in the province from 2007 to 2012, with more surgeons performing 3 or more advanced techniques in 2012.
(64.3% v. 82.3%, p < 0.001). Colectomy for benign disease remained the most commonly performed MIS according to both surveys (66.0% in 2007 and 84.3% in 2012). Most respondents stated that they acquired their MIS skills during residency or by self-training. Major variables of surgical practice, including operating time and

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### Table 4. Comparison of respondents’ perceptions barriers to MIS practice between 2007 and 2012

<table>
<thead>
<tr>
<th>Barriers to MIS practice, yr</th>
<th>Respondents, no. (%)</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient operating time</td>
<td>2012</td>
<td>42 (29.2)</td>
<td>51 (35.4)</td>
<td>10 (6.9)</td>
<td>31 (21.5)</td>
<td>10 (6.9)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>49 (22.6)</td>
<td>35 (16.1)</td>
<td>21 (9.7)</td>
<td>46 (21.2)</td>
<td>66 (30.4)</td>
<td></td>
</tr>
<tr>
<td>Lack of hospital resources</td>
<td>2012</td>
<td>31 (21.7)</td>
<td>53 (37.1)</td>
<td>12 (9.1)</td>
<td>43 (30.1)</td>
<td>2 (1.1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>40 (18.4)</td>
<td>38 (17.5)</td>
<td>39 (18)</td>
<td>66 (30.4)</td>
<td>34 (15.7)</td>
<td></td>
</tr>
<tr>
<td>Lack of training opportunities</td>
<td>2012</td>
<td>37 (26.1)</td>
<td>62 (43.7)</td>
<td>12 (9.9)</td>
<td>24 (16.9)</td>
<td>5 (3.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>58 (27.7)</td>
<td>58 (27.7)</td>
<td>42 (20)</td>
<td>31 (14.8)</td>
<td>21 (10)</td>
<td></td>
</tr>
<tr>
<td>Lack of support from the hospital</td>
<td>2012</td>
<td>41 (28.5)</td>
<td>59 (40.1)</td>
<td>19 (13.2)</td>
<td>23 (16)</td>
<td>2 (1.1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>48 (22.3)</td>
<td>51 (23.7)</td>
<td>46 (21.4)</td>
<td>41 (19.1)</td>
<td>29 (13.5)</td>
<td></td>
</tr>
<tr>
<td>Insufficient remuneration</td>
<td>2012</td>
<td>43 (29.9)</td>
<td>42 (29.2)</td>
<td>23 (16)</td>
<td>30 (20.1)</td>
<td>6 (4.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>61 (28.4)</td>
<td>31 (14.4)</td>
<td>48 (22.3)</td>
<td>44 (20.5)</td>
<td>21 (10.4)</td>
<td>0.006</td>
</tr>
<tr>
<td>Insufficient evidence-based data</td>
<td>2012</td>
<td>55 (38.5)</td>
<td>57 (38.9)</td>
<td>17 (11.9)</td>
<td>14 (9.8)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>71 (33.3)</td>
<td>68 (32)</td>
<td>43 (20.2)</td>
<td>26 (12.2)</td>
<td>5 (2.3)</td>
<td>0.05</td>
</tr>
<tr>
<td>Medico-legal issues</td>
<td>2012</td>
<td>58 (41.1)</td>
<td>48 (34)</td>
<td>23 (16.3)</td>
<td>10 (7.1)</td>
<td>2 (1.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>89 (42)</td>
<td>55 (26)</td>
<td>43 (20.2)</td>
<td>18 (8.5)</td>
<td>7 (3.3)</td>
<td>0.40</td>
</tr>
</tbody>
</table>

MIS = minimally invasive surgery.

---

### Table 5. Multivariate regression of variables associated with advanced MIS practice (performance of 3 or more MIS procedures performed)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient estimate</th>
<th>SD</th>
<th>OR† (95% CI)</th>
<th>p value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.77</td>
<td>0.75</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>2007 survey administration</td>
<td>–2.02</td>
<td>0.40</td>
<td>0.13 (0.06–0.29)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Female sex</td>
<td>–0.48</td>
<td>0.37</td>
<td>0.62 (0.3–1.27)</td>
<td>0.19</td>
</tr>
<tr>
<td>Surgeon age, yr&lt;br&gt; &lt; 35</td>
<td>0.53</td>
<td>0.53</td>
<td>1.70 (0.6–4.88)</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>0.46</td>
<td>1.35 (0.54–3.33)</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>–1.11</td>
<td>0.46</td>
<td>0.33 (0.13–0.82)</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>&gt; 65</td>
<td>0.85</td>
<td>0.15 (0.03–0.81)</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>&gt; 10 years in practice</td>
<td>0.31</td>
<td>0.73 (0.32–1.69)</td>
<td>0.46</td>
</tr>
<tr>
<td>No fellowship training</td>
<td>0.34</td>
<td>0.43</td>
<td>1.4 (0.6–3.28)</td>
<td>0.43</td>
</tr>
<tr>
<td>Population&lt;br&gt; &lt; 50 000</td>
<td>–0.93</td>
<td>0.38</td>
<td>0.4 (0.19–0.83)</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>&gt; 500 000</td>
<td>0.63</td>
<td>1.88 (0.75–4.72)</td>
<td>0.18</td>
</tr>
<tr>
<td>Community practice</td>
<td>–0.47</td>
<td>0.43</td>
<td>0.62 (0.27–1.45)</td>
<td>0.27</td>
</tr>
<tr>
<td>Weekly operating time (days)</td>
<td>0.05</td>
<td>0.50</td>
<td>1.05 (0.84–1.32)</td>
<td>0.67</td>
</tr>
<tr>
<td>Open technique for pneumoperitoneum</td>
<td>–0.38</td>
<td>0.34</td>
<td>0.68 (0.35–1.34)</td>
<td>0.27</td>
</tr>
<tr>
<td>Not performing MI appendectomy</td>
<td>–3.2</td>
<td>0.46</td>
<td>0.04 (0.02–0.1)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

CI = confidence interval; MI = minimally invasive; MIS = minimally invasive surgery; OR = odds ratio; SD = standard deviation.

*Number of advanced MIS procedures performed (< 2 v. ≥ 3) compared using logistic regression, Nagelkerke R² = 0.453.
†OR > 1 denotes increased practice of ≥ 3 MIS procedures; OR < 1 denotes decreased practice of ≥ 3 MIS procedures.
‡Wald χ² test.
hospital resources, were not perceived to be barriers to MIS practice, a trend that became more polarized in 2012.

When discussing the benefits of MIS for the treatment of various surgical conditions, the importance of surgical expertise in achieving these results is often highlighted: advanced MIS procedures are deemed beneficial if performed by experienced hands.10 Our data show that the practice of basic and advanced MIS has significantly increased in Quebec in the last 5 years. Advanced MIS procedures that were once restricted to tertiary care settings have now widely spread. Multivariate analysis confirmed that the year of survey administration was significantly associated with an advanced MIS practice (OR 0.13 OR, p < 0.001) for the 2007 administration.

Appendectomy was one of the first procedures to be performed laparoscopically and is now one of the first laparoscopic techniques taught to general surgery residents. However, only 60.3% of general surgeons in Ontario performed minimally invasive (MI) appendectomies in 2004, as reported in a study from that province published in 2004.4 Our survey had more encouraging results, with 94% of Quebec general surgeons practising MI appendectomy in 2012, which represents a significant increase over 2007 (82.3%, p = 0.003). In 2002–2003, a review of the practice of appendectomy in Quebec revealed that MIS was favoured in only 35% of cases of appendicitis.11 The growing place of MIS in surgical practice may parallel this continued rising trend for MI appendectomy. Indeed, the Ontario survey observed that surgeons who practised MI appendectomy were more prone to do advanced MIS on univariate analysis (81.5% v. 39.1%, p < 0.05). Multivariate analysis from the present study revealed that not practising MI appendectomy was associated with a lower proportion of surgeons with an advanced MIS practice (OR 0.04, 95% CI 0.02–0.1). Poulin and colleagues12 suggested that laparoscopic appendectomy is an interesting training procedure with which to transition toward laparoscopic colectomy. Ultimately, one may hypothesize that surgeons who do not practise MI appendectomy could be less comfortable with more advanced MI procedures.

The new generation of practising surgeons who have been trained in the MIS era may also contribute to the observed spread of advanced MIS procedures. Evolution over a few decades has allowed better integration of MIS not only in practice, but also in training with the development of new teaching tools and curricula.15–16 In the United States, specific requirements for MIS training have even been added by the Accreditation Council for Graduate Medical Education Residency Review Committee, and the Fundamentals of Laparoscopic Surgery course is now mandatory for the American Board of Surgery.17,18 Surveys of residents conducted in the early 2000s reported a perceived need for additional training in MIS both in Canada and in the United States.19,20 In 2003, Canadian general surgery residents identified limited advanced case volume, limited opportunity in the operating room and lack of attending surgeon interest as factors with a negative impact on their MIS training.19 With the evolution of the practice, this seems to have changed. In our survey, more respondents attributed their MIS training to residency (p = 0.028) in 2012 than in 2007. This reflects the adaptation of surgical training programs. Interestingly, universities were the last institution identified by respondents as being responsible for MIS training, which appear to contradict previously discussed findings. One hypothesis would be that with better MIS residency training, respondents feel that additional training for either maintenance of competence or acquisition of new skills then lies with surgical societies.

The practice of MIS relies on training but also on the available material resources and support, such as operating time or proper, up-to-date equipment. It takes time to build facilities and practice settings favouring adequate use of surgeons’ skills, such as MIS. The 5-year lapse between our surveys seems to have allowed for these conditions to be united. Indeed, respondents did not identify significant institutional or clinical barriers to MIS practice. This was even more polarized in 2012, which may represent improvement in hospital resources. Interestingly, operating time was less of an issue in 2012 than in 2007. This could simply be related to a change in availability of operating time for general surgeons, but it could also represent a better use of this time by surgeons more efficient in MIS.

Other findings from our survey parallel the evolution of data in MIS and testify to the changing culture in this field. First, the number of surgeons who practise colorectal resections for malignancy has nearly doubled in 5 years. This is in keeping with the acceptance of the MIS approach as a safe oncological procedure for colonic malignancies and the growing evidence for laparoscopic treatment of rectal cancer.21–23 Second, the number of MI inguinal hernia repairs performed did not differ between 2007 and 2012 (30.7% v. 36.2%, p = 0.28). Indeed, after being subject to great interest in the late 1990s and early 2000s, this technique lost popularity because of a reported higher rate of severe complications.24,25 Third, we observed a significant difference in the preferred technique for pneumoperitoneum creation. More respondents reported always using an open technique in 2012 than 2007 (63.5% v. 76%, p = 0.011). Although this viewpoint has been challenged, the literature suggests that the open approach is superior to the closed entry technique because it is less likely to cause complications.26–28 Our data are also in keeping with a survey of Canadian general surgeons reporting that more than 80% of them use the open technique.29

Limitations

The 51.3% and 31.3% response rates in 2007 and 2012 temper with the conclusions to be drawn from this survey. This represents an inherent challenge of survey studies, and is not out of the ordinary for a physician survey.5 The difference in the number of responses in both administrations might be due to the change of the administration tool from a written form
to a web-based electronic platform. This renders the significant differences observed in the study more prone to the response bias inherent to survey studies. Indeed, surgeons with a greater interest or an established practice in MIS may have been keener to complete the questionnaire. Furthermore, this low response rate may also portend underpower issues, where lack of difference has to be interpreted with caution. We also acknowledge that our data represent stated intentions and perceptions of one’s practice that may change with time and are not a perfect reflection of reality. Furthermore, questions addressed the number of surgeons performing MIS procedures but not the proportion of procedures actually performed using an MIS approach. Despite these limitations, we have collected interesting data about the evolution of MIS in Quebec. Beyond a snapshot of MIS practice, this study allows us to focus on the evolution of MIS in the modern surgical era.

**Conclusion**

We observed that from 2007 to 2012 there was a significant increase in the practice of advanced MIS procedures by general surgeons in Quebec. More surgeons have integrated MIS procedures in their practices, and this technique now appears well established in current surgical practice. The growing place of MIS in residency training seems to be a paramount part of this development over the last 5 years. Results from this survey could be used as a baseline for studies focusing on ways to further improve the existing MIS practice and examine the need for integrating newer technological advances in the current practice in relation with evidence-based data in the field.

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**Competing interests:** None declared.

**Contributors:** J. Hallet, M. Chhiv, R. Grégoire and J.-P. Gagné designed the study. O. Mailloux, M. Chhiv, R. Grégoire and J.-P. Gagné acquired the data, which all authors analyzed. J. Hallet and J.-P. Gagné wrote the article, which all authors reviewed and approved for publication.

**References**


Does more than a single chest tube for mediastinal drainage affect outcomes after cardiac surgery?

**Background:** The use of 1 or more mediastinal chest tubes has traditionally been routine for all cardiac surgery procedures to deal with bleeding. However, it remains unproven whether multiple chest tubes offer a benefit over a single chest tube.

**Methods:** All consecutive patients undergoing cardiac surgery (2005–2010) received at least 1 chest tube at the time of surgery based on surgeon preference. Patients were grouped into those receiving a single chest tube (SCT) and those receiving multiple chest tubes (MCT). The primary outcome was return to the operating room for bleeding or tamponade.

**Results:** A total of 5698 consecutive patients were assigned to 2 groups: 3045 to the SCT and 2653 to the MCT group. Patients in the SCT group were older, more often female and less likely to undergo isolated coronary artery bypass graft than those in the MCT group. Unadjusted outcomes for SCT and MCT, respectively, were return to the operating room for bleeding or tamponade (4.7% v. 5.0%; \( p = 0.50 \)), intensive care unit stay longer than 48 hours (25.5% v. 27.9%; \( p = 0.041 \)), postoperative stay > 9 days (31.5% v. 33.1%; \( p = 0.20 \)) and mortality (3.8% v. 4.6%; \( p = 0.16 \)). Logistic regression analysis, adjusted for clinical differences between groups, showed that the number of chest tubes was not associated with return to the operating room for bleeding or tamponade.

**Conclusion:** The use of multiple mediastinal chest tubes after cardiac surgery confers no advantage over a single chest tube in preventing return to the operating room for bleeding or tamponade.

**Contexte :** De tout temps, lors de chirurgies cardiaques, on a posé 1 ou plusieurs drains thoraciques médiastinaux pour gérer les saignements. Or, il n’a pas été démontré que la pose de plusieurs drains plutôt que d’un seul confère un avantage.

**Méthodes :** On a posé au moins un drain thoracique à tous les patients consécutifs soumis à une chirurgie cardiaque (2005–2010) au moment de l’intervention, selon la préférence des chirurgiens. Les patients ont été regroupés selon qu’on leur avait posé un seul drain thoracique (SDT) ou plusieurs (PDT). Le paramètre principal était le retour au bloc opératoire pour hémorragie ou tamponnade.

**Résultats :** En tout 5698 patients consécutifs ont été scindés en 2 groupes : 3045 dans le groupe SDT et 2653 dans le groupe PDT. Les patients du groupe SDT étaient plus âgés, plus souvent de sexe féminin et moins susceptibles de subir un pontage aortocoronarien isolé comparativement au groupe PDT. Les paramètres non ajustés pour les groupes SDT et PDT, respectivement, ont été retour au bloc opératoire pour hémorragie ou tamponnade (4,7 % v. 5,0 %; \( p = 0,50 \)), séjour de plus de 48 heures à l’unité des soins intensifs (25,5 % v. 27,9 %; \( p = 0,04 \)), durée du séjour postopératoire > 9 jours (31,5 % v. 33,1 %; \( p = 0,20 \)) et mortalité (3,8 % v. 4,6 %; \( p = 0,16 \)). L’analyse de régression logistique ajustée pour tenir compte des différences cliniques entre les groupes a révélé l’absence de lien entre le nombre de drains thoraciques et un retour au bloc opératoire pour hémorragie ou tamponnade.

**Conclusion :** La pose de plusieurs drains thoraciques plutôt que d’un seul après la chirurgie cardiaque ne confère aucun avantage en ce qui concerne le retour au bloc opératoire pour hémorragie ou tamponnade.
As a part of standard care in cardiac surgery, mediastinal and pleural chest tubes are placed to provide drainage of serosanguineous fluids from the mediastinum. This practice has become a standard perioperative procedure to monitor bleeding and possibly prevent complications, such as pericardial effusion, hemothorax and tamponade.

Despite their necessity, chest tubes are potentially a source of pain and irritation for patients. Some have suggested that the insertion of more than 1 chest tube per patient may exacerbate pain and discomfort, causing a decrease in ambulation that could negatively influence patient outcome. Currently, no evidence-based guideline exists that dictates whether a single (SCT) or multiple chest tubes (MCT) should be used. The number of chest tubes inserted is largely left at the discretion of the individual surgeon based on low-level evidence or traditional practice.

Though the literature suggests that SCT may provide adequate drainage, to our knowledge no studies have compared SCT with MCT in terms of patient outcomes. The objective of our study was to evaluate whether the number of chest tubes used could impact return to the operating room for bleeding or tamponade.

Methods

We retrospectively collected data on all patients who underwent coronary artery bypass grafting (CABG), valve or combined CABG plus valve surgery via a median sternotomy at the Queen Elizabeth II Health Sciences Centre (QEII HSC) in Halifax, NS, between Jan. 1, 2005, and Dec. 31, 2010. Patients were excluded from final analysis if surgery was not performed via median sternotomy or if they also underwent insertion of a ventricular assistance device, extracorporeal membrane oxygenation, pericardectomy, transmyocardial laser revascularization or a complex congenital procedure. Patients were grouped according to whether they received SCT or MCT at the time of their original operation.

Operative technique

During the study period 10 different cardiac surgeons practised in Halifax. The choice of SCT or MCT was entirely left to surgeon preference rather than fixed criteria. All interventions were performed via a midline sternotomy, and cardiopulmonary bypass was performed in a standardized manner. Briefly, body temperature during the procedure was allowed to drift to 32°C. Intermittent cold cardioplegia solution (a blood: crystalloid ratio of 1:4 at a temperature of 8–10°C) was delivered antegrade via the aortic root unless otherwise indicated. Patients in the SCT group had their drainage tube placed on the surface of the diaphragm into the pericardial well. Patients in the MCT had a combination of mediastinal and/or pleural positioning for the drainage tube. In most patients, the chest tube used was a modified 32-FR urethral catheter (Bard) in which additional holes were made to improve drainage from the mediastinum.

In all cases in which an internal mammary artery was used, the pleura was opened unless lung adhesions were present. The pericardium was left open to allow communication with the pleural space when opened to allow for serosanguineous drainage from the mediastinum to pleural space. It was standard practice that all drainage tubes were removed within 24 hours of surgery unless a persistent air leak was present or the patient experienced severe bleeding (> 50 mL/hr).

Data sources

Data were obtained from the Maritime Heart Centre Cardiac Surgery Registry, which is a clinical database that contains pre-, intra- and postoperative information on all patients undergoing cardiac surgery at the QEII HSC. This study was conducted with the full approval of the Capital District Health Authority Research Ethics Board. The requirement to obtain informed consent was waived under Section 2.1c of the Tri-Council Policy Statement. All personal identifiers were stripped before data analysis to ensure patient anonymity and confidentiality.

Variable selection

Preoperative variables of interest included age, sex, left ventricular ejection fraction (EF), diabetes, hypertension, serum creatinine, congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD). Procedure-related variables were isolated CABG, isolated valve, CABG plus valve, and CABG and/or valve plus other procedure. Urgency of surgery was categorized as emergent (immediate), urgent (within 24 hours), in-hospital (hospitalization required before surgery) or elective (waiting at home).

Statistical analysis

Categorical variables were reported as frequencies and percentages and were analyzed using a $\chi^2$ or Fisher exact test, as appropriate. Design variables were created for reference-level coding of categorical variables with more than 2 levels. A nonparsimonious multivariate logistic regression model was generated to examine the association of SCT and MCT with return to the operating room for bleeding or tamponade, adjusting for clinical differences between groups. Model discrimination was assessed by the area under the receiver operating characteristic (ROC) curve.
curve. We performed a bootstrap procedure to obtain 1000 subsamples with replacement, and the 95% confidence interval (CI) of the ROC was obtained from the 2.5 and 97.5 percentiles of the bootstrap distribution. Model calibration was assessed using the Hosmer–Lemeshow goodness of fit statistic and applying linear regression analysis to the calibration plot of deciles of observed versus predicted mortality. We considered results to be significant at $p < 0.05$. All statistical analyses were performed using the SAS software package version 9.3.

**Results**

**Study population**

A total of 5698 consecutive patients were included in our study. All patients were assigned to 2 groups based on the number of chest tubes placed at completion of the surgery: 3045 patients in the SCT and 2653 patients in the MCT group. Figure 1 illustrates the frequency of the use of MCT among 10 cardiac surgeons within our institution. The figure demonstrates how 5 surgeons predominantly used MCT in every patient, whereas 4 surgeons used MCT in 5% or fewer patients and, as such, used predominantly SCT.

*Fig. 1. Surgeon use of chest tubes. Each letter represents a single surgeon. The results are expressed as a percentage of the total number of cases performed by each surgeon.*

**Unadjusted univariate comparison between groups**

The characteristics of the study patients are shown in Table 1. Patients in the SCT group were older, more often female, less likely to undergo CABG and more likely to undergo a valve procedure than patients in the MCT group. The unadjusted outcomes between the groups are shown in Table 2. The overall unadjusted in-hospital mortality was 4.2% (3.8% in the SCT group v. 4.6% in the MCT group, $p = 0.16$). Similarly, 26.6% of patients required a stay in the intensive care unit (ICU) longer than 48 hours (25.5% in the SCT group v. 27.9% in the MCT group, $p = 0.041$) and 32.2% had a postoperative stay longer than 9 days (31.5% in the SCT group v. 33.1% in the MCT group, $p = 0.20$). Patients in the SCT group had a lower occurrence of internal mammary artery use than those in the MCT group (49.2% v. 50.7%, $p < 0.001$; Table 2).

A total of 276 (4.8%) patients returned to the operating room for bleeding or tamponade, and there was no significant difference between groups (4.7% in the SCT group v. 5.0% in the MCT group, $p = 0.50$). Blood products were required in 35.6% of patients (33.2% in the SCT group v. 38.3% in the MCT group, $p < 0.001$). Similarly, significantly more red blood cells, fresh frozen plasma, platelets...
and cryoprecipitate were used in patients in the MCT group than those in the SCT group (Table 3).

**Nonparsimonious multivariate model to predict return to the operating room for bleeding or tamponade**

We created a nonparsimonious multivariate logistic regression model to adjust for the differences between the SCT and MCT groups. Variables that emerged as independent predictors of return to the operating room for bleeding or tamponade were urgent/emergent surgery (odds ratio [OR] 2.1, 95% confidence interval [CI] 1.4–3.2), in-house surgery (OR 1.5, 95% CI 1.1–2.0), renal dysfunction with creatinine greater than 176 μmol/L (OR 1.6, 95% CI 1.0–2.5), age 80 years or older (OR 2.4, 95% CI 1.6–3.6), CABG plus valve surgery (OR 2.2, 95% CI 1.5–3.1) and CABG and/or valve plus other procedure (OR 2.4, 95% CI 1.7–3.6; Fig. 2). What is novel about our predictive model is that we also included individual surgeons as variables. Some surgeons emerged as independent predictors of the primary outcome or return to the OR, whereas others were protective and were less likely to return to the OR. Particularly relevant to the present study is the fact that the number of chest tubes used was not predictive of returning to the OR after adjusting for clinical differences between groups (OR 1.0, 95% CI 0.7–1.4). The ROC of the logistic regression model was 70% with a 95% CI of 68%–74%

In the present study we did not look systematically at the prevalence of radiographic pleural effusions. We did, however, look at the prevalence of thoracentesis.

| Table 1. Demographic and clinical characteristics of patients who received single or multiple chest tubes during the study period |
|-----------------|-----------------|-----------------|-----------------|
| Group, no. (%)  | SCT, n = 3045   | MCT, n = 2653   |
| Age, yr         |                 |                 |
| ≥ 80            | 366 (12.0)      | 256 (9.6)       |
| 70–79           | 903 (30.6)      | 801 (30.2)      |
| 60–69           | 887 (29.1)      | 865 (32.6)      |
| < 60            | 859 (28.2)      | 731 (27.6)      |
| Female sex      | 876 (28.8)      | 633 (23.9)      |
| Chronic renal failure | 0.57       |
| Creatinine > 176 μmol/L | 182 (6.0) | 158 (6.0) |
| Creatinine 110–176 μmol/L | 712 (23.4) | 652 (24.6) |
| Creatinine < 110 μmol/L | 2151 (70.6) | 1843 (69.5) |
| Diabetes        | 1029 (33.8)     | 952 (35.9)      |
| Ejection fraction ≤ 50% | 872 (28.8) | 746 (28.3) |
| COPD            | 478 (15.7)      | 431 (16.2)      |
| Urgency of the procedure | 0.44            |
| Elective        | 1420 (46.6)     | 1246 (47.0)     |
| In-hospital     | 1295 (42.5)     | 1095 (41.3)     |
| Urgent/emergent | 330 (10.8)      | 312 (11.8)      |
| Type of procedure | < 0.001       |
| Isolated CABG   | 1669 (54.8)     | 1862 (70.2)     |
| Isolated valve  | 685 (22.5)      | 334 (12.6)      |
| CABG and valve  | 344 (11.3)      | 252 (9.5)       |
| CABG and/or valve plus other procedure | 347 (11.4) | 205 (7.7) |

CABG = coronary artery bypass graft; COPD = chronic obstructive pulmonary disease; MCT = multiple chest tubes; SCT = single chest tube.

| Table 2. Unadjusted major morbidity and mortality outcomes between patients who received single or multiple chest tubes during the study period |
|-----------------|-----------------|-----------------|-----------------|
| Outcome         | SCT, n = 3045   | MCT, n = 2653   |
| Return to OR for bleeding or tamponade | 142 (4.7) | 134 (5.0) |
| In-hospital mortality | 116 (3.8) | 121 (4.6) |
| ICU stay > 48 hours | 775 (25.5) | 739 (27.9) |
| Postoperative stay > 9 d | 959 (31.5) | 878 (33.1) |
| IMA use         | 1788 (49.2)     | 1844 (50.7)     |

IMA = internal mammary artery; MCT = multiple chest tubes; OR = operating room; SCT = single chest tube.
while in hospital. The unadjusted rates of thoracentesis suggest that the overall prevalence was low and did not differ between the SCT and MCT groups (1.4% v. 1.3%, $p = 0.67$).

**DISCUSSION**

There is a paucity of literature to support the use of either SCT or MCT in cardiac surgery. Most of the recent

<table>
<thead>
<tr>
<th>Table 3. Blood products used in patients who received single or multiple chest tubes during the study period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>RBC</td>
</tr>
<tr>
<td>FFP</td>
</tr>
<tr>
<td>Platelets</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
</tr>
</tbody>
</table>

FFP = fresh frozen plasma; MCT = multiple chest tubes; RBC = red blood cells; SCT = single chest tube.

**Fig. 2.** Adjusted odds ratios on a logarithmic scale showing our findings from the multivariate analysis designed to evaluate predictors of return to the operating room for bleeding or tamponade. CABG = coronary artery bypass graft; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; EF = ejection fraction; HTN = hypertension; MCT = multiple chest tubes; SCT = single chest tube.
literature has focused on the type of drainage tubes used.\textsuperscript{1,7} The choice of the number of chest tubes used has traditionally been based on surgeon preference, which in turn has largely been derived from their experience, training or institutional policies. This was clearly illustrated in our data: some surgeons used predominantly SCT, whereas others used MCT regardless of the surgical procedure performed. One needs to acknowledge that the choice to use 32-FR urethral catheters as chest tubes is unusual and was based on a long-established history of their use in our institution. We claim without clear proof that these tubes are soft and malleable, allowing for additional drainage holes to be added easily (by simply cutting extra holes) and are convenient for stripping when the patient is in the ICU to ensure that patency is maintained. Our findings and practice have not been compared with newer chest tube technologies, such as Blake drains, or tubes with differing methods of mechanical active tube clearance technologies that are currently available as alternative means of drainage. The literature is inconclusive with respect to the superiority of these new technologies. To date, a limited number of publications are available, suggesting that it has been traditionally difficult to prove 1 method of drainage is superior to another.\textsuperscript{11,12}

The primary outcome of our study was to determine if the number of chest tubes used could impact return to the operating room for bleeding or tamponade. Using a logistic regression analysis to adjust for the clinical differences between patients in the SCT and MCT groups, we were unable to demonstrate whether the number of chest tubes used predicted return to the operating room or was protective.

We did, however, identify several important predictors of return to the operating room for bleeding or tamponade. These independent predictors, such as urgent procedures, complex procedures and renal dysfunction,\textsuperscript{8} are not surprising given their association with bleeding risk. For reasons that are unclear, age 80 years or older was shown to be an independent predictor of return to the operating room. The implications for this observation are important as an increasing number of octogenarians undergo cardiac surgery, suggesting that special considerations, such as the use of antiplatelet agents and perioperative anticoagulants, should be considered to reduce this risk in these patients.\textsuperscript{9}

We were able to demonstrate how the operating surgeon was predictive of return to the operating room, either by increasing or decreasing the likelihood independent of patient or procedure variables. This observation likely illustrates variations in clinical practices in which a variable threshold exists for returning to the operating room.

\textbf{Limitations}

We acknowledge this study was not designed to capture all the benefits or harms of using SCT or MCT. We chose our primary outcome based on the primary function of chest tubes being drainage of serosanguinous fluids from the mediastinum, which as such is a surrogate predictor of fluid accumulation (return to the operating room for bleeding or tamponade). The present study was retrospective and therefore not designed to capture detailed information on total chest tube drainage or radiographic evidence of pleural effusion, which is not available in our registry. Furthermore, our study cannot fully address differences among surgeons, including the possibility that some surgeons using more than 1 chest tube (MCT group) may have limited their incidence of return to the operating room if they had only used 1 chest tube.

Despite these limitations, and in support of our findings, we report an unadjusted prevalence of thoracentesis that was low and that did not differ between groups, suggesting that the use of chest tubes may have minimal clinical impact on the prevalence of pleural effusion. We can also say that the unadjusted prevalence of blood product use as a surrogate for bleeding was not higher in the SCT than the MCT group, which could have masked inappropriate drainage. However, one should note that detailed information on the exact time all antiplatelet agents or anticoagulants were stopped before surgery was not available for analysis, but could explain why urgency independently increased the likelihood of return to the operating room for bleeding. The standard practice in our institution is to maintain the use of acetylsalicylic acid but to hold clopidogrel for a minimum of 48 hours unless patients require urgent surgery.

\textbf{Conclusion}

Our study indicates that within our institution the use of MCT offered no overall benefit compared with SCT after cardiac surgery in terms of limiting the risk of returning to the operating room for bleeding or tamponade. Furthermore, others have shown that MCT can result in severe postoperative pain and discomfort.\textsuperscript{4-10} Thus, we advocate the use of SCT in patients undergoing open heart surgery. However, these results should be interpreted with caution given the limitations outlined in our discussion.

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\textbf{Competing interests:} None declared.

\textbf{Contributors:} J. Le and J.-F. Légaré designed the study. K. Buth acquired the data, which all authors analyzed. J. Le wrote the article, which all authors reviewed and approved for publication.

\textbf{References}


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Outcomes of infection following pediatric spinal fusion

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Background: Removal of instrumentation is often recommended as part of treatment for spinal infections, but studies have reported eradication of infection even with instrumentation retention by using serial débridements and adjuvant antibiotic phar-macotherapy. We sought to determine the effect of instrumentation retention or removal on outcomes in children with spinal infections.

Methods: We retrospectively reviewed the cases of patients who experienced early (< 3 mo) or late (≥ 3 mo) infected spinal fusions. Patients were evaluated at least 2 years after eradication of the infection using the following protocol outcomes: follow-up Cobb angle, curve progression and nonunion rates.

Results: Our sample included 35 patients. The mean age at surgery was 15.1 ± 6.0 years, 65.7% were girls, and mean follow-up was 41.7 ± 26.9 months. The mean Cobb angle was 63.6° ± 14.5° preoperatively, 29.4° ± 16.5° immediately after surgery and 37.2° ± 19.6° at follow-up. Patients in the implant removal group (n = 21) were more likely than those in the implant retention group (n = 14) to have a lower ASA score (71.4% v. 28.6%, p = 0.03), fewer comorbidities (66.7% v. 21.4%, p = 0.03), late infections (81.0% v. 14.3%, p = 0.01) and deep infections (95.2% v. 64.3%, p = 0.03). Implants were retained in 12 of 16 (75.0%) patients with early infections and 2 of 19 (10.5%) with late infections. Patients with implant removal had a higher pseudarthrosis rate (38.1% v. 0%, p = 0.02) and a faster curve progression rate (5.8 ± 9.8° per year v. 0.2 ± 4.7° per year, p = 0.04).

Conclusion: Implant retention should be considered, irrespective of the timing or depth of the infection.

Contexte : Le retrait des implants est souvent recommandé lors du traitement des infections rachidiennes, mais des études ont démontré qu’il est possible d’éliminer les infections tout en maintenant les implants en place, en ayant recours à des débride-ments répétés et à une antibiothérapie adjuvante. Nous avons voulu mesurer l’effet de la préservation ou du retrait des implants sur les résultats chez les enfants souffrant d’infections rachidiennes.

Méthodes : Nous avons passé en revue de manière rétrospective des cas de fusions rachidiennes infectées à un stade précoce (< 3 mois) ou tardif (≥ 3 mois). Les patients ont été évalués au moins 2 ans après l’éradication de l’infection à l’aide des paramètres suivants : angle de Cobb, progression de la courbure et taux de non fusion au moment du suivi.

Résultats : Notre échantillon comprenait 35 patients. L’âge moyen au moment de la chirurgie était de 15,1 ± 6,0 ans; 65,7 % étaient des filles et le suivi moyen s’est éche-lonné sur 41,7 ± 26,9 mois. L’angle de Cobb moyen était de 63,6° ± 14,5° en période préopératoire, de 29,4° ± 16,5° immédiatement après la chirurgie et de 37,2° ± 19,6° au moment du suivi. Les patients du groupe soumis au retrait de l’implant (n = 21) étaient plus susceptibles que les patients du groupe chez qui l’implant est demeuré en place (n = 14) de présenter un score ASA plus bas (71,4 % c. 28,6 %, p = 0,03) et un nombre moindre de comorbidités (66,7 % c. 21,4 %, p = 0,03), d’infections tardives (81,0 % c. 14,3 %, p = 0,01) et d’infections profondes (95,2 % c. 64,3 %, p = 0,03). Les implants sont demeurés en place chez 12 patients sur 16 (75,0 %) atteints d’infections précoces et chez 2 patients sur 19 (10,5 %) atteints d’infections tardives. Les patients chez qui l’implant a été retiré ont présenté un taux plus élevé de pseudarthrose (38,1 % c. 0 %, p = 0,02) et un taux de progression plus rapide de la courbure (5,8 ± 9,8° par année c. 0,2 ± 4,7° par année, p = 0,04).

Conclusion : Il y a lieu d’envisager le maintien des implants, indépendamment du moment d’apparition de l’infection et de sa profondeur.
Surgical site infections (SSIs) are the second most common adverse event in hospitalized patients.\(^1\) The incidence of postoperative infections is approximately 1%-5% in spinal fusions for idiopathic scoliosis and approximately 4%-14% for neuromuscular scoliosis.\(^2\) Neuromuscular scoliosis, the use of allograft bone, the need for postoperative blood transfusions, urinary tract infections (UTIs), increased duration of surgery or of hospital admission and fusions extending distally to the sacrum have all been associated with an increased likelihood of SSIs in pediatric spinal fusions.\(^3\)\(^-\)\(^6\) Postoperative infections can lead to the need for revision surgery, ongoing pain, prolonged hospitalization, osteomyelitis and death.\(^7\)

Removal of instrumentation is often recommended as part of treatment for spinal infections.\(^8\)\(^-\)\(^10\) However, other studies have reported eradication of infection even with instrumentation retention by using serial débridements and adjuvant antibiotic pharmacotherapy.\(^8\)\(^-\)\(^9\) The goal of this study was to determine the effect of instrumentation retention or removal on patient outcomes (e.g., Cobb angle at follow-up, curve progression rate, nonunion) in spinal infections in patients 2 years after infection eradication.

**METHODS**

We retrospectively reviewed the cases of all patients younger than 18 years treated with instrumented spinal arthrodesis for scoliosis (of various etiologies) at The Hospital for Sick Children in Toronto, Ont., between Jan. 1, 2000, and Dec. 31, 2009. Ethics approval was obtained from our institution. All specimens were cultured for 7 days. We used a modified Center for Disease Control–National Health Safety Network (CDC-NHSN) definition of SSIs, which was presence of at least 1 of the following: purulent discharge, positive cultures, evidence of infection on physical examination (tenderness, swelling, redness or heat), wound dehiscence, abscess discovery upon reoperation or evidence of infection on histopathological or radiologic examination.\(^10\)\(^-\)\(^11\) Infections were categorized as early (<3 mo) or late (≥3 mo), as described by Hedequist and colleagues.\(^1\) Infections were also categorized as being superficial or deep, as described by the CDC-NHSN and by Horan and colleagues.\(^11\) Deep infections were located in deep soft tissues (e.g., fascial and muscle layers) of the incision and involved the following structures: intervertebral disc, vertebra and paravertebral muscles.\(^11\)\(^-\)\(^12\) Superficial infections were located in the skin and subcutaneous tissue and above the fascial layer.\(^13\) Infection eradication was defined as no signs of infection on physical examination and no reported pain with normal blood parameters, as described by Ahmed and colleagues.\(^13\)

All patients were categorized in either the implant removal group or the implant retention group based on their postinfection treatment management. Data on preoperative, perioperative, postoperative and follow-up clinical information as well as diagnostic imaging pertinent to the index surgery, infection, treatment course and outcome were collected for each patient.

Preoperative variables included age, sex, weight, time to follow-up from index surgery, scoliosis etiology, neurologic motor level, Cobb angle, Scoliosis Research Society (SRS) curve type, hematocrit, past medical and surgical history. Perioperative variables included American Society of Anesthesiologists (ASA) score, surgical approach, perioperative antibiotic use, duration of surgery, drain usage, type of instrumentation, bone graft usage, blood loss, perioperative transfusion, volume of packed red blood cells (pRBCs) transfused, distal extent of instrumentation and the number of motion segments instrumented. The postoperative factors included immediate Cobb angle, postoperative transfusion, volume of pRBCs transfused and UTI within 2 weeks of the index surgery.

With respect to the infection, variables included timing, location, duration of the antibiotic therapy, culture results and removal versus retention of instrumentation. The number of irrigation and débridements performed as part of the treatment plan, either before infection eradication (implant retention group) or before implant removal, was also recorded.

Patient outcomes included Cobb angle at follow-up, change in Cobb angle (defined as the percent change of the primary Cobb angle at follow-up with respect to the immediate postoperative state), curve progression rate (defined as the change of the primary Cobb angle per year since the immediate postoperative state), and pseudarthrosis (defined as motion radiographically and/or motion during surgical exploration).\(^14\)\(^-\)\(^15\)

**Statistical analysis**

Statistical analyses were performed using SAS software version 9.1, with the \(\alpha\) value predefined at 0.05. Data were evaluated using analysis of covariance for continuous data (assuming unequal variance between groups) and the \(\chi^2\) test for categorical data (or Fisher exact test for cells containing fewer than 5 patients). Patients were analyzed based on implant removal or implant retention as part of their treatment course.

**RESULTS**

Between 2000 and 2009, 827 pediatric patients underwent instrumented spinal fusions for scoliosis. Among them, we identified 35 patients (idiopathic: \(n = 17, 48.9\%\); neuromuscular: \(n = 11, 31.4\%\); congenital/other: \(n = 7, 20\%)\) who experienced an early (\(n = 16, 45.7\%)\) or late infection (\(n = 19, 54.3\%)\), resulting in a total infection rate of 4.2%. Of these 35 patients, the implants were removed in 21 and retained in 14 patients. The mean age of patients at the time of surgery was 15.1 ±
6.0 years; 65.7% were girls and 34.3% were boys. The types of metal used in patients who experienced infections were stainless steel (n = 15, 42.9%), titanium (n = 2, 5.7%) and unknown (n = 18, 51.4%); the latter group of patients did not have any information written in their charts. Mean follow-up from the time of surgery was 41.7 ± 26.9 (median 38.0, range 12–123) months. Preoperative Cobb angles were 63.6 ± 14.5° and immediate postoperative Cobb angles were 29.4 ± 16.5°, resulting in a 55.2 ± 19.6° curve correction. Follow-up Cobb angles were 37.2 ± 19.6°. Eradication of infection was successful in all 35 patients at the time of follow-up (Table 1).

With respect to baseline preoperative variables, patients who had, compared with those who did not have, implant removal were more likely to have no neurologic deficit (85.7% v. 42.9%, p = 0.019) and were generally healthier, with fewer medical comorbidities (66.7% v. 21.4%, p = 0.031; Table 1).

For peri- and postoperative variables, late infections were more prevalent in the implant removal than the implant retention group (81.0% v. 14.3%, p = 0.001), with the majority of these infections being deep (95.2% v. 64.3%, p = 0.017). In the implant retention group, 7 (50.0%) patients had 1 irrigation and débridement, 2 (14.3%) patients had 4, and 5 (35.7%) patients did not have any (they had superficial infections only) before infection eradication (Tables 2 and 3). In the implant removal group, 1 (4.8%) patient had 2 irrigation and débrideaments, 3 (14.3%) patients had 3, 1 (4.8%) patient had 5, 1 (4.8%) patient had 8, and 15 (71.4%) patients had concurrent irrigation and débrideaments with their definitive implant removal. The mean number of irrigation and débrideaments was 1.14 ± 2.15 in the implant removal group and 1.07 ± 1.33 in the implant retention group (p = 0.90; Table 3).

In terms of outcomes, patients in the implant removal group had a significantly higher rate of associated pseudarthrosis at follow-up than those in the implant retention group (38.1% v. 0% pseudarthrosis, p = 0.012). Of the 8 patients with pseudarthrosis, 7 had late

---

**Table 1. Preoperative variable of patients with infected spinal fusions in the implant retention and removal groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All patients, n = 35</th>
<th>Implant retention, n = 14</th>
<th>Implant removal, n = 21</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12 (34.3)</td>
<td>7 (50)</td>
<td>5 (23.8)</td>
<td>0.11</td>
</tr>
<tr>
<td>Female</td>
<td>23 (65.7)</td>
<td>7 (50)</td>
<td>16 (76.2)</td>
<td></td>
</tr>
<tr>
<td>Age, yr</td>
<td>15.1 ± 6.0</td>
<td>16.8 ± 8.4</td>
<td>14.0 ± 3.6</td>
<td>0.20</td>
</tr>
<tr>
<td>Follow-up, mean ± SD mo</td>
<td>41.7 ± 26.9</td>
<td>39.0 ± 26.9</td>
<td>43.5 ± 27.4</td>
<td>0.63</td>
</tr>
<tr>
<td>Weight, mean ± SD kg</td>
<td>50.7 ± 22.7</td>
<td>51.0 ± 28.3</td>
<td>50.5 ± 18.8</td>
<td>0.96</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
<td></td>
<td>0.11</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>17 (48.9)</td>
<td>4 (28.6)</td>
<td>13 (61.9)</td>
<td></td>
</tr>
<tr>
<td>Neuromuscular</td>
<td>11 (31.4)</td>
<td>7 (50.0)</td>
<td>4 (19.1)</td>
<td></td>
</tr>
<tr>
<td>Congenital/other</td>
<td>7 (20.0)</td>
<td>3 (21.4)</td>
<td>4 (19.1)</td>
<td></td>
</tr>
<tr>
<td>Neurologic motor level</td>
<td></td>
<td></td>
<td></td>
<td>0.019</td>
</tr>
<tr>
<td>Thoracic</td>
<td>9 (25.7)</td>
<td>6 (42.9)</td>
<td>3 (14.3)</td>
<td></td>
</tr>
<tr>
<td>Lumbar/sacral</td>
<td>2 (5.7)</td>
<td>2 (14.3)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Nil</td>
<td>24 (68.6)</td>
<td>6 (42.9)</td>
<td>18 (85.7)</td>
<td></td>
</tr>
<tr>
<td>Primary Cobb angle, mean ± SD</td>
<td>63.6 ± 14.5</td>
<td>61.7 ± 17.3</td>
<td>64.8 ± 12.5</td>
<td>0.54</td>
</tr>
<tr>
<td>SRS curve</td>
<td></td>
<td></td>
<td></td>
<td>0.77</td>
</tr>
<tr>
<td>Thoracic</td>
<td>18 (52.9)</td>
<td>8 (57.1)</td>
<td>10 (50.0)</td>
<td></td>
</tr>
<tr>
<td>Thoracolumbar</td>
<td>12 (35.3)</td>
<td>4 (28.6)</td>
<td>8 (40.0)</td>
<td></td>
</tr>
<tr>
<td>Lumbar</td>
<td>4 (11.8)</td>
<td>2 (14.3)</td>
<td>2 (10.0)</td>
<td></td>
</tr>
<tr>
<td>Previous surgery</td>
<td></td>
<td></td>
<td></td>
<td>0.22</td>
</tr>
<tr>
<td>Nonspineal surgeries</td>
<td>11 (32.4)</td>
<td>6 (46.2)</td>
<td>5 (23.8)</td>
<td></td>
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<tr>
<td>Spinal surgeries</td>
<td>5 (14.7)</td>
<td>3 (23.1)</td>
<td>2 (9.5)</td>
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</tr>
<tr>
<td>Nil</td>
<td>18 (52.9)</td>
<td>4 (30.8)</td>
<td>14 (66.7)</td>
<td></td>
</tr>
<tr>
<td>Medical history</td>
<td></td>
<td></td>
<td></td>
<td>0.031</td>
</tr>
<tr>
<td>Nil</td>
<td>17 (48.6)</td>
<td>3 (21.4)</td>
<td>14 (66.7)</td>
<td></td>
</tr>
<tr>
<td>Respiratory, cardiac, renal, GI</td>
<td>11 (31.4)</td>
<td>7 (50.0)</td>
<td>4 (19.1)</td>
<td></td>
</tr>
<tr>
<td>Multiple</td>
<td>7 (20.0)</td>
<td>4 (28.6)</td>
<td>3 (14.3)</td>
<td></td>
</tr>
<tr>
<td>Hematocrit, mean ± SD</td>
<td>0.34 ± 0.04</td>
<td>0.34 ± 0.04</td>
<td>0.35 ± 0.04</td>
<td>0.63</td>
</tr>
</tbody>
</table>

GI = gastrointestinal; SD = standard deviation; SRS = Scoliosis Research Society.

*Unless otherwise indicated.
infections and 7 had deep infections. Implant removal also resulted in a faster curve progression rate. For the 14 patients in the implant retention group the progression was 0.2° per year for a mean follow-up of 39.0 (range 12–87) months, whereas for patients in the implant removal group the progression was 5.8° per year for a mean follow-up of 43.5 (range 12–123) months (p = 0.036). Of the 16 patients who experienced early infections, 12 (75%) were in the implant retention group and had a change in Cobb angle of 18.8 ± 43.4% and 4 (25%) were in the implant removal group and had a change in Cobb angle of 24.8 ± 30.2% (p = 0.91). For the 19 patients who experienced late infections, 2 (10.5%) were in the implant retention group (1 superficial and 1 deep infection) and had a change in Cobb angle of 29.8 ± 42.1% and 17 (89.5%) patients were in the implant removal group (89.5%) and had a change in Cobb angle of 80.0 ± 122.4% (p = 0.47; Table 3).

**Discussion**

Data from the SRS Morbidity and Mortality database published in 2011 indicated an overall infection rate of 0.8% for superficial and 1.3% for deep infections for pediatric scoliosis surgery. The reported infection rate for neuro-muscular scoliosis was 5.5% (31.4% in our study population) and 1.4% for idiopathic scoliosis (48.9% in our study population). Thus, given the high percentage of neuro-muscular scoliosis among patients who received surgery during our study period, our overall infection rate of 4.2% is comparable to those reported in other series.

Spinal infections may be eradicated using several strategies, but implant removal has often been advocated owing to the potential for biofilm creation on spinal implant. Routine implant removal has also been recommended if Propionibacter is isolated. In our series, 50.0% of cultures grew gram-positive microbes, without any documented cases of Propionibacter. While the timing of infections has also been suggested as a determinant for whether implant retention or removal is chosen, the definitions of early and late infections are inconsistent in the literature, with definitions of late or delayed infections ranging from 30 days to more than 1 year postinstrumentation.

Kowalski and colleagues, who defined late infections as those occurring 30 days after instrumentation, reported a failure rate of 22.7% for patients who had early infections.

**Table 2. Perioperative variables of patients with infected spinal fusions in the implant retention and removal groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All patients</th>
<th>Implant retention</th>
<th>Implant removal</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA score</td>
<td>0.033</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-II</td>
<td>19 (54.3)</td>
<td>4 (28.6)</td>
<td>15 (71.4)</td>
<td></td>
</tr>
<tr>
<td>&gt; III</td>
<td>16 (45.7)</td>
<td>10 (71.4)</td>
<td>6 (28.6)</td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td></td>
<td></td>
<td></td>
<td>0.19</td>
</tr>
<tr>
<td>Anterior</td>
<td></td>
<td>1 (2.9)</td>
<td>1 (7.1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Posterior</td>
<td>23 (65.7)</td>
<td>7 (50.0)</td>
<td>16 (76.2)</td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>11 (31.4)</td>
<td>6 (42.9)</td>
<td>5 (23.8)</td>
<td></td>
</tr>
<tr>
<td>Perioperative antibiotic use</td>
<td>35 (100)</td>
<td>14 (100)</td>
<td>21 (100)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Duration of surgery, mean ± SD, min</td>
<td>492.6 ± 152.7</td>
<td>504.5 ± 144.7</td>
<td>484.6 ± 160.9</td>
<td>0.71</td>
</tr>
<tr>
<td>Instrumentation</td>
<td></td>
<td></td>
<td></td>
<td>0.20</td>
</tr>
<tr>
<td>Pedicle screws/rods</td>
<td>20 (57.1)</td>
<td>6 (42.9)</td>
<td>14 (66.7)</td>
<td></td>
</tr>
<tr>
<td>Sublaminar wiring/rods</td>
<td>14 (40.0)</td>
<td>8 (57.1)</td>
<td>6 (28.6)</td>
<td></td>
</tr>
<tr>
<td>Growing rods</td>
<td>1 (2.9)</td>
<td>0 (0)</td>
<td>14 (66.7)</td>
<td></td>
</tr>
<tr>
<td>Bone graft</td>
<td></td>
<td></td>
<td></td>
<td>0.009</td>
</tr>
<tr>
<td>Autograft</td>
<td>20 (57.1)</td>
<td>5 (35.7)</td>
<td>15 (71.4)</td>
<td></td>
</tr>
<tr>
<td>Allograft</td>
<td>10 (28.6)</td>
<td>4 (28.6)</td>
<td>6 (28.6)</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>5 (14.3)</td>
<td>5 (35.7)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Blood loss, mean ± SD, mL/kg</td>
<td>26.1 ± 23.5</td>
<td>30.6 ± 27.1</td>
<td>23.1 ± 20.9</td>
<td>0.37</td>
</tr>
<tr>
<td>Transfusion</td>
<td>24 (68.6)</td>
<td>10 (71.4)</td>
<td>14 (66.7)</td>
<td>0.77</td>
</tr>
<tr>
<td>Volume of transfusion, mean ± SD, mLAg</td>
<td>9.8 ± 9.9</td>
<td>12.1 ± 12.2</td>
<td>8.4 ± 8.0</td>
<td>0.29</td>
</tr>
<tr>
<td>Distal fusion level</td>
<td></td>
<td></td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td>Thoracic</td>
<td>1 (2.9)</td>
<td>0 (0)</td>
<td>1 (4.8)</td>
<td></td>
</tr>
<tr>
<td>Lumbar</td>
<td>31 (88.6)</td>
<td>13 (92.9)</td>
<td>18 (85.7)</td>
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</tr>
<tr>
<td>Sacrum/pelvis</td>
<td>3 (8.6)</td>
<td>1 (7.1)</td>
<td>2 (9.5)</td>
<td></td>
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<tr>
<td>Fusion length, mean ± SD, no. of segments</td>
<td>12.4 ± 3.5</td>
<td>12.9 ± 3.5</td>
<td>12.1 ± 3.5</td>
<td>0.50</td>
</tr>
<tr>
<td>Drain usage</td>
<td>15 (42.9)</td>
<td>8 (57.1)</td>
<td>7 (33.3)</td>
<td>0.16</td>
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</table>

ASA = American Society of Anesthesiologists; SD = standard deviation.
*Unless otherwise indicated.
and whose treatment consisted of débridement, implant retention and suppressive (parenteral followed by oral) antimicrobial therapy \((n = 5)\). However, the failure rate was 21.9\% for patients who had late infections treated with débridement and implant removal \((n = 7)\) and 53.8\% for those with late infections treated with débridement and implant retention \((n = 7)\).^{22} Hedequist and colleagues,\(^1\) who defined late infections as those presenting more than 3 months after the index surgery, reported that no patient was cleared of infection without implant removal \((n = 26)\). They recommended performing immediate implant removal for all patients with late infections and revision surgery at a later date, if needed, for progressive deformity or pseudarthrosis. Ho and colleagues,\(^7\) who defined late infections as those that occurred more than 3 months after the index surgery, reported a nearly 50\% reoccurrence rate \((20 of 43 patients)\) if the spinal implant was retained after the initial irrigation and débridement.\(^7\) While many additional irrigation and débridements were performed, 13 of 22 (59\%) of patients with late infections ultimately did not have their implants removed. Hahn and colleagues,\(^23\) who defined late infections as those appearing a minimum of 57 weeks after the index instrumentation, reported 100\% eradication of late infections with instrumentation removal. In our study, 10.5\% of implants were retained in patients who experienced late infections \((≥ 3 \text{ mo})\); in patients who experienced late, deep infections, 31.0\% of implants were retained.

Implant removal is not without its drawbacks. Implant removal has been associated with a loss of coronal correction of approximately 10° in the main thoracic curve in adolescent patients with idiopathic scoliosis.\(^2\) Ho and colleagues\(^7\) reported on 10 patients treated with implant removal \((mean follow-up 10 months)\); 6 of them experienced a more than 10° increase in deformity in at least 1 plane. Muschik and colleagues\(^24\) reported a progression of 6° for thoracic curves and 5° for lumbar curves at an average follow-up of 3.6 years after implant removal. Our patients had accelerated curve progression, both in absolute and proportional terms, when implants were removed. In our series, the change in Cobb angle at follow-up compared with the immediate postoperative state was higher in the implant removal group than the implant retention group, but the difference was not significant \((69.5° ± 112.3° \text{ v. } 20.3° ± 41.8°, p = 0.08)\). Furthermore, patients in the implant removal group had a

| Table 3. Postoperative and outcome variables of patients with infected spinal fusions in the implant retention and removal groups |
|----------------------------------|----------------|----------------|----------------|----------------|----------------|
| | Group, no. (%)* | | | | |
| | All patients | | | | |
| | \(n = 35\) | | | | |
| Initial irrigation and débridements, mean ± SD | 1.11 ± 1.84 | 1.07 ± 1.33 | 1.14 ± 2.15 | 0.90 |
| Antibiotic use (48 h postoperative) | 34 (97.1) | 14 (100) | 20 (95.2) | 0.41 |
| Immediate postoperative Cobb angle, mean ± SD | 29.4 ± 16.5 | 29.5 ± 15.8 | 29.2 ± 17.3 | 0.96 |
| Length of hospital stay, mean ± SD, d | 16.0 ± 19.8 | 20.4 ± 27.8 | 13.3 ± 12.6 | 0.32 |
| Transfusion | 4 (11.4) | 1 (7.1) | 3 (14.3) | 0.52 |
| Volume of transfusion, mean ± SD, mL/kg | 1.1 ± 3.6 | 0.4 ± 1.6 | 1.6 ± 4.4 | 0.36 |
| UTI | 7 (21.2) | 3 (21.4) | 4 (21.1) | 0.98 |
| Timing | | | | < 0.001 |
| Early | 16 (45.7) | 12 (85.7) | 4 (19.1) | |
| Late | 19 (54.3) | 2 (14.3) | 17 (80.9) | |
| Location | | | | 0.017 |
| Superficial | 6 (17.1) | 5 (35.7) | 1 (4.8) | |
| Deep | 29 (82.9) | 9 (64.3) | 20 (95.2) | |
| Pseudarthrosis | 8 (22.9) | 0 (0) | 8 (38.1) | 0.012 |
| Adjuvant antibiotic therapy | 33 (94.3) | 13 (92.9) | 20 (95.2) | 0.77 |
| Duration of antibiotic therapy, mean ± SD, d | 117.9 ± 107.1 | 122.9 ± 111.6 | 114.6 ± 106.6 | 0.83 |
| Culture | | | | 0.014 |
| Gram-positive | 17 (50.0) | 6 (46.2) | 11 (52.4) | |
| Gram-negative | 5 (14.7) | 5 (38.5) | 0 (0) | |
| Atypicals | 2 (5.9) | 0 (0) | 2 (9.5) | |
| None isolated | 5 (14.7) | 0 (0) | 5 (23.8) | |
| Polymicrobial | 5 (14.7) | 2 (15.4) | 3 (14.3) | |
| Follow-up Cobb angle, mean ± SD | 37.2 ± 19.6 | 33.0 ± 17.6 | 39.7 ± 20.6 | 0.36 |
| Percent coronal loss, mean ± SD | 49.8 ± 93.2 | 20.3 ± 41.8 | 68.5 ± 112.3 | 0.08 |
| Curve progression rate, mean ± SD, °/yr | 3.8 ± 8.7 | 0.2 ± 4.7 | 5.8 ± 9.8 | 0.036 |

SD = standard deviation; UTI = urinary tract infection.

*Unless otherwise indicated.
faster curve progression rate (5.8° ± 9.8° per year v. 0.2° ± 4.7° per year, p = 0.036) at an average follow-up of 3.48 ± 2.24 years.

As noted by Viola and colleagues,17 it is difficult to determine whether spinal infections lead to pseudarthrosis or if pseudarthrosis is a predisposing risk factor for infections. Previously, Katonis and colleagues12 reported that no association existed between pseudarthrosis and early infections in patients who had spinal fusions. However, an association between late infections and pseudarthrosis has previously been reported to range from 20% to 62%,17,20 which is consistent with our findings. Of the 17 patients with late infections in our study, 7 (41.1%) patients had pseudarthrosis at a mean follow-up of 50.6 (range 13–78) months. Only 1 case of pseudarthrosis occurred in a patient who experienced an early infection.

**Limitations**

Our study has several limitations. First, we defined successful outcomes only with respect to clinical and radiographic parameters. However, Mok and colleagues25 reported that after treatment (in an adult population) of infection in 16 patients with spinal rods (12 treated with implant retention and 4 treated with implant removal), patients with infections reported similar SF-36 scores to matched controls who underwent spinal fusion but did not experience infections. Second, owing to the low incidence of SSIs, our sample size was small, and thus our ability to examine treatment was minimal. However, infection was eradicated successfully in all patients, and the main difference in treatment was the decision to remove or retain the instrumentation.

**Conclusion**

While implant removal may be needed for the treatment of infected spinal fusions, removal of instrumentation often reveals a pseudoarthrosis and is associated with a high risk of scoliosis progression. When clinically possible, a trial of implant retention should be considered, irrespective of the timing or depth of the infection, and probably no definition of late infections should be used as an absolute indication for immediate rod removal.

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**Competing interests:** None declared.

**Contributors:** J. Wright designed the study. A. Khoshbin and M. Lysenko acquired the data, which all authors analyzed. A. Khoshbin wrote the article, which all authors reviewed and approved for publication.

**References**


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Persistent neuropathic pain after inguinal herniorrhaphy depending on the procedure (open mesh v. laparoscopy): a propensity-matched analysis

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Fayçale Beouche, MB
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Christian Dualé, MD, PhD
Claude Dubray, MD, PhD
Pierre Schoeffler, MD

Background: A greater incidence of persistent pain after inguinal herniorrhaphy is suspected with the open mesh procedure than with laparoscopy (transabdominal preperitoneal), but the involvement of neuropathy needs to be clarified.

Methods: We examined the cumulative incidence of neuropathic persistent pain, defined as self-report of pain at the surgical site with neuropathic aspects, within 6 months after surgery in 2 prospective subcohorts of a multicentre study. We compared open mesh with laparoscopy using different analysis, including a propensity-matched analysis with the propensity score built from a multivariable analysis using a generalized linear model.

Results: Considering the full patient sample (242 open mesh v. 126 laparoscopy), the raw odds ratio for neuropathic persistent pain after inguinal herniorrhaphy was 4.3. It reached 6.8 with the propensity-matched analysis conducted on pooled subgroups of 194 patients undergoing open mesh and 125 undergoing laparoscopy (95% confidence interval 1.5–30.4, \(p = 0.012\)). A risk factor analysis of these pooled subgroups revealed that history of peripheral neuropathy was an independent risk factor for persistent neuropathic pain, while older age was protective.

Conclusion: We found a greater risk of persistent pain with open mesh than with laparoscopy that may be explained by direct or indirect lesion of nerve terminations. Strategies to identify and preserve nerve terminations with the open mesh procedure are needed.

Contexte : On soupçonne que l’incidence de la douleur persistante à la suite d’une hernioplastie inguinale est plus élevée avec la mise en place d’un filet par voie ouverte qu’avec la laparoscopie (transabdominale prépéritonéale), mais encore faut-il clarifier le rôle de la neuropathie.

Méthodes : Nous avons mesuré l’incidence cumulative de la douleur neuropathique persistante, décrite comme une douleur au site opératoire accompagnée d’éléments neuropathiques déclarés par le patient dans les 6 mois suivant la chirurgie, auprès de 2 sous-cohortes prospectives d’une étude multicentrique. Nous avons comparé la mise en place d’un filet par voie ouverte et la laparoscopie à l’aide de différentes analyses, dont une analyse avec appariement des scores de propension, les scores de propension découlant d’une analyse multivariée générée à partir d’un modèle linéaire généralisé.

Résultats : En tenant compte de tout l’échantillon de patients (242 soumis à la mise en place d’un filet par voie ouverte c. 126 soumis à la laparoscopie), le rapport des cotes brut pour la douleur neuropathique persistante après l’hernioplastie inguinale était de 4.3. Il a atteint 6.8 à l’analyse par appariement des scores de propension réalisée auprès de sous-groupes réunis de 194 patients soumis à la technique ouverte avec treillis et 125 soumis à la laparoscopie (intervalle de confiance à 95 % 1,5–30,4, \(p = 0,012\)). Une analyse des facteurs de risque pour ces sous-groupes réunis a révélé que des antécédents de neuropathie périphérique constituaient un facteur de risque indépendant à l’égard de la douleur neuropathique persistante, tandis que l’avancée en âge a conféré un effet protecteur.

Conclusion : Nous avons observé un risque plus élevé de douleur persistante associée à la mise en place d’un filet par voie ouverte qu’avec la laparoscopie, ce qui pourrait s’expliquer par des lésions directes ou indirectes aux terminaisons nerveuses. Des stratégies s’imposent pour identifier et préserver les terminaisons nerveuses lors de la mise en place d’un filet par voie ouverte.

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A recent systematic review estimated the risk of postsurgical persistent pain (PSPP) to be 7%–12% after inguinal herniorrhaphy, depending on the method of meta-analysis. This finding may have relevant consequences for public health, as inguinal herniorrhaphy is one of the most frequently practised surgeries in industrialized countries. Furthermore, a proportion of the reported cases of PSPP after inguinal herniorrhaphy is suspected to be neuropathic, as nerve dysfunction has been reported after inguinal herniorrhaphy. In addition, a literature-based estimation that took into account certain symptoms of persistent pain, such as numbness, paroxysmal pain or touch-evoked alldynia, stated that 30.5% of persistent pain was probably or definitely of neuropathic origin. It has also been suggested that there is less risk of persistent pain with laparoscopic than with open inguinal hernia repair. However, it is unknown whether this difference between the 2 techniques is maintained for neuropathic aspects of persistent pain. This mechanism is widely considered to be a factor of severity and chronicization. In a recently published prospective open-ended French multicentric cohort study, the risk of persistent neuropathic pain in the 6 months following inguinal hernia repair was estimated at 12.4% for open mesh surgery and 3.2% for laparoscopic surgery. We further studied these 2 subcohorts to assess the risk of persistent neuropathic pain associated with laparoscopic and open inguinal hernia repair. Our observational nonrandomized design resulted in unequal distributions of relevant covariates between comparison groups, but the level of evidence was improved by using an analysis based on propensity score.

**METHODS**

Our methodology is described in detail elsewhere. Briefly, this multicentric French study was approved by the appropriate institutional research ethics boards (CCPPRB d’Auvergne and CPP Sud-Est VI for amendments), and the trial was registered on ClinicalTrials.gov (NCT00812734). In each centre, the study was coordinated by a referent anaesthetist and conducted by the anaesthesiology team.

The study population consisted of prospective adult patients who, having given written informed consent, were scheduled in a recruitment centre for primary inguinal herniorrhaphy. We examined 2 procedures: open mesh and laparoscopy (transabdominal preperitoneal). The study centres were selected on the basis of their activity for these 2 procedures, aiming at a balance between them. The exclusion criteria for both procedures were planned laparotomy, reoperation, surgery for eventration, expected difficulty in the patient’s ability to understand or complete the questionnaires and potential inability to reach the patient during the 6 months following surgery. The exclusion criterion specific to the open mesh procedure was a bilateral or intraperitoneal procedure. Laparoscopy had to be planned as such. Consecutive recruitment of patients was required.

The assessment of patients for inclusion in the study occurred 1–2 weeks before surgery. Patients completed a questionnaire about their working activities and history of previous pain, then the physician recorded information on potential symptoms of peripheral neuropathy and possible risk factors for peripheral neuropathy. The medical data sheet was completed on discharge from the surgical ward and included information on the strategies used for anaesthesia, peri- and postoperative analgesia and the occurrence of early complications. At 3 and 6 months after surgery, patients received by mail a questionnaire in which they were asked to report whether they felt pain at the surgical site. If so, patients were asked to describe the intensity of this pain over the previous 48 hours using a visual analogue scale (VAS). Other questions concerned the time course of the pain since surgery and the clinical features; some questions were derived from the DN4 diagnostic questionnaire and included within our questionnaire. If questionnaires were not completed and returned, we contacted the patients by telephone.

Postsurgical persistent pain was defined as self-reported pain at the surgical site; the pain was considered neuropathic in cases of 4 or more positive responses to the DN4 questions. Throughout the follow-up period, patients were able to visit a referent practitioner for analgesic treatment if required, or they could request a referral to the closest specialist pain centre. The primary outcome was the cumulative incidence of neuropathic postsurgical persistent pain, defined by occurrence at either the 3-month or 6-month follow-up. The primary end point was the effect of procedure type (open mesh v. laparoscopy) on the primary outcome, adjusted for covariates likely to influence either the occurrence of persistent pain or the choice of a given procedure.

**Statistical analysis**

We performed our analyses using SAS software version 9.3 (SAS Institute Inc.). Results are expressed as means ± standard deviations for normally distributed data and as medians and interquartile ranges for non-normally distributed data. Categorical data are expressed as number of cases and percentage of the total. Type-I error was set at 5%. We conducted risk factor analyses on the pooled data from the 2 subcohorts. The covariates to be considered in the multivariate analyses were first defined on the basis of their likelihood to influence the dependent outcome. These covariates were age, sex, body mass index (BMI), the centre at which the surgery took place, Pain Catastrophizing Scale score, type of surgery, location of preoperative pain (if any), history of peripheral neuropathy, report of a putative neurotoxic condition (see Dualé and colleagues for a detailed description of these 2 preceding
composite outcomes), the use and time of use of locoregional anesthesia, the use of intraoperative opioids and of intra- or postoperative ketamine, and the report of any early postoperative complications. Owing to the large number of centres, the centre where surgery was performed was not retained in the analysis.

To assess the risk of persistent neuropathic pain depending of the type of surgery, we calculated odds ratios (ORs) and their 95% confidence intervals (CIs) using different methods with a presumed progressive level of relevance: raw univariate analysis; multivariate analysis with simple adjustment, selection of factors and propensity score adjustment; and propensity score matching. Open mesh surgery was considered to be the reference to which laparoscopy was compared. We conducted the multivariable risk factor analysis using a multistep approach: 1) reduction of the number of covariates either by eliminating those with very low variability or by building new composite variables with greater relevance; 2) transformation of the continuous variables into ordinal variables according to their terciles taken as cut-off values to avoid bias due to a non-linear relation with the dependent outcome; 3) elimination of the covariates for which the p value of the univariate Wald test exceeded 0.25 (with the exception of centre, age and BMI, which were forced into the model regardless of the p value); and 4) logistic regression with an automated backward elimination procedure with a significance threshold of p < 0.05 to stay in the model. We used a propensity score to represent the probability that a patient with particular background characteristics (i.e., preoperative outcomes) would undergo the open mesh technique instead of laparoscopy. This score was calculated using logistic regression, with type of surgery as the dependent variable and all background characteristics as explanatory variables, as selected on the basis of their putative association with either the dependent outcome or exposure to the surgical procedure. These characteristics were sex, BMI, age, Pain Catastrophizing Scale score, history of peripheral neuropathy, putative neurotoxic condition and existence/location of preoperative pain. Continuous variables were separated in terciles. The hypothesis was that background characteristics in both groups would be similarly distributed within propensity score strata. We performed a multivariate analysis with propensity score adjustment for additional perioperative covariates. The final step consisted of constructing 2 samples of patients (1 in each subcohort), matched according to a 1:2 algorithm without replacement within 0.25 standard deviations of the logit of their estimated propensity scores. Conditional logistic regression, accounting for correlation within matched pairs, was used to compare the outcome of interest between patients who underwent the open mesh technique and those who underwent laparoscopy.

The sample size calculation was performed on the basis of the prevalence of persistent pain after inguinal herniorrhaphy, as reported in the literature. As different rates were reported in the literature, we estimated a 30% rate after pooling all the related studies available at the time of our study (see Duvalé and colleagues for details). With a risk a set at 5%, a precision measure set at 5% and a prediction of 20% loss to follow-up during the study, we planned an initial sample of 389 patients for each subcohort.

**Results**

We had some difficulty recruiting patients for the laparoscopy cohort; the results of an intermediate analysis of the primary outcome undertaken in September 2009 showed a cumulative incidence clearly inferior to the expected one, and the recruitment was discontinued at 40% of the initial objective. For the open mesh cohort, the same intermediate analysis showed a cumulative incidence slightly inferior to the expected one, and the recruitment was discontinued at 96% of the initial objective. A total of 530 patients were included (156 in the laparoscopy group, 374 in the open mesh group), and the surgeries took place between June 2006 and December 2008. Our analyses included only the patients for whom complete information on the studied outcomes was available: 126 patients who underwent laparoscopy and 242 who underwent open mesh repair, representing 80.7% and 64.7%, respectively, of all patients. The demographic and clinical characteristics of both subcohorts are summarized in Table 1; a full description is available elsewhere. Ten patients were taking medication for pain 6 months after surgery, and 4 of them were considered to have neuropathic pain based on positive responses to the DN4 diagnostic questionnaire. When graded according to the World Health Organization’s (WHO) analgesic ladder, 4 patients had a first-step and 3 had a second-step treatment, and 1 was treated for neuropathic pain (antidepressant plus gabapentin).

The centre where surgery was undertaken was not retained as a factor in the multivariate analysis, because the number of centres was too large and the number of patients per centre was too small and because, overall, each centre predominantly performed 1 of the 2 types of surgery. The intraoperative use of systemic opioids was the only factor representing the anesthetic practice that was retained for analysis, as it was less associated with the type of surgery and represented both the practice of general anesthesia and the time course of locoregional anesthesia (e.g., systemic opioids are not given for a surgery performed under successful spinal anesthesia). Two factors facilitating the incidence of neuropathic pain were identified by the stepwise logistic regression model: open mesh surgery (Table 2) and history of neuropathic event (OR 3.19, 95% CI 1.45–7.05, p = 0.004). Age older than the third tercile was found to be a protective factor (OR 0.18, 95% CI 0.06–0.53, p = 0.049). Table 2 shows the different ORs for the risk of occurrence of postsurgical persistent neuropathic pain.
Table 1. Demographic and clinical characteristics of the study sample

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<th>Characteristic</th>
<th>Group, no. (%)*</th>
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<tbody>
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<tr>
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<tr>
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<td>Weight (mean ± SD), kg</td>
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<td>Preoperative pain</td>
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<td>80 (63.5)</td>
</tr>
<tr>
<td>Postoperative complication</td>
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</tr>
<tr>
<td>Persistent pain at 3 mo†</td>
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</tr>
<tr>
<td>All cases</td>
<td>29 (21.0)</td>
</tr>
<tr>
<td>Positive response to DN4</td>
<td>4 (2.9)</td>
</tr>
<tr>
<td>Pain score (VAS out of 10), median [IQR]</td>
<td></td>
</tr>
<tr>
<td>DN4 (+)</td>
<td>2.3 [1.6 – 2.9]</td>
</tr>
<tr>
<td>DN4 (+)</td>
<td>Missing data</td>
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<tr>
<td>Persistent pain at 6 mo‡</td>
<td></td>
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<tr>
<td>All cases</td>
<td>18 (14.0)</td>
</tr>
<tr>
<td>Positive response to DN4</td>
<td>1 (0.8)</td>
</tr>
<tr>
<td>Pain score (VAS out of 10), median [IQR]</td>
<td></td>
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<tr>
<td>DN4 (+)</td>
<td>1.5 [0.8 – 2.1]</td>
</tr>
<tr>
<td>DN4 (+)</td>
<td>Missing data</td>
</tr>
<tr>
<td>Report of persistent neuropathic pain, any time</td>
<td></td>
</tr>
<tr>
<td>All cases</td>
<td>4 (3.2)</td>
</tr>
</tbody>
</table>

DN4 = DN4 diagnostic questionnaire; IQR = interquartile range; SD = standard deviation; VAS = visual analogue scale.

*Unless otherwise indicated.
†n = 138 in the laparoscopy group and n = 254 in the open mesh group.
‡n = 128 in the laparoscopy group and n = 328 in the open mesh group.
§The 3 available pain scores were 1.2, 2.2 and 2.4 /10.
¶The pain score was 10/10 for the only case.
neuropathic pain (open mesh v. laparoscopy). For the multivariate analysis with propensity-score adjustment, the use of perioperative ketamine and the occurrence of postoperative complications were taken as additional perioperative covariates. The ORs were quite stable regardless of the method of analysis used with the exception of propensity-matched analysis, which had a lower precision owing to a smaller sample size. The OR tended to increase with the level of evidence, reaching a value slightly inferior to 7 for the propensity-matched analysis.

**Discussion**

The main result of the present substudy is the strong difference in risk of occurrence of persistent neuropathic pain, with a nearly 7-fold greater risk of pain associated with open mesh compared with laparoscopic surgery. On the other hand, the risk of persistent pain, regardless of the suspected mechanism, was not substantially greater after open mesh than laparoscopic surgery (Table 1). This information adds to the debate about the optimal technique for herniorrhaphy, as a neuropathic mechanism is considered a factor of severity and chronicization of postsurgical persistent pain. In addition, the role of preoperative history of peripheral neuropathy in the occurrence of persistent neuropathic pain, as shown previously, was confirmed in our subcohorts. In addition, we observed no protective role of locoregional anesthesia, probably because this technique acts to block central sensitization rather than neuropathic processes.

Since both open mesh and laparoscopic surgery were developed in the late 1990s as an alternative to meshless herniorrhaphy, the issue of long-term complications of these 2 concurrent techniques has been addressed. Two meta-analyses conducted by the European Hernia Society, which covered the publication periods before and after May 2008, respectively, failed to show a different risk of persistent pain between the 2 techniques. However, a recent review suggested a 3-fold greater risk (18% v. 6%) with open surgery than with laparoscopy, and this finding is supported by a focus on the most prominent randomized trials or well-sized prospective cohort studies. It must be noted that pain was not the primary outcome in the trials and that none of these studies quantified the neuropathic aspect of pain. More information was recently provided by a prospective study of persistent pain 6 months after herniorrhaphy in 244 patients who underwent Lichtenstein and and 198 who underwent laparoscopic procedures, respectively, with clinical and psychophysical examination. The adjusted OR for persistent pain was 0.45 (95% CI 0.23–0.87) for the laparoscopic compared with the Lichtenstein procedure (i.e., open mesh doubled the risk). The study also showed that patients who underwent open mesh surgery exhibited increased thresholds to warm and hot sensations in the groin area, a symptom suggesting nerve lesion. It must be noted that, in that study, each centre offered only 1 type of surgery, but no adjustment based on propensity score was performed. Such adjustment reduces the bias due to factors that could influence the likelihood for each patient to undergo one procedure over another.

As stated in the sample size estimation, based on the available literature we expected a 30% rate of persistent pain, regardless of the neuropathic features, at least for open mesh surgery. The rates observed in the present study were lower than expected, although this did not alter the statistical precision in estimating the risk. This is also consistent with a recent meta-analysis of 89 studies that estimated a 7%–12% risk of persistent pain after herniorrhaphy, regardless of the technique performed. This decrease in global risk over the years may be explained either by an improvement in surgical techniques or by better precision in assessing pain. The authors also estimated that 30.5% of the pain reported was probably or definitely neuropathic, which is consistent with the observation of raw prevalence rates of pain at 6 months after open mesh surgery (18.3% for all pain and 7.9% for neuropathic pain). The lack of literature related to the association between neuropathic pain and laparoscopy makes any comparison with the present results difficult. The internal validity of the present study is supported by the results of the risk factor analysis, as a protective role of older age has been previously suggested in inguinal herniorrhaphy.
Limitations

The present study has some methodological limitations. First, self-report screening questionnaires for neuropathic pain do not have a 100% sensitivity and specificity, and diagnosis should be confirmed by clinical examination. Second, details of the precise location of neuropathic pain were not collected, although this information is important to estimate which nerve termination(s) may be involved. Third, information about the device used for open mesh repair (e.g., flat mesh, plug, bilayer) was not recorded. Techniques of nerve preservation were not noted either, as they had not been identified as a standard technique at the time of survey administration; there was no notion during our study period of any practice of intentional neursectomy for herniorrhaphy in France.

In addition, the incidence rates reported here do not imply that all cases will turn into chronic pain with relevant consequences on daily life. Severe cases of reported pain made up only about 4% of the whole cohort (18/458) 6 months after surgery, and few patients had treatment beyond the first step of the WHO analgesic ladder. This is in accordance with the literature, with respective rates of 2%–7% for severe persistent pain and 1%–3% for need for a treatment. It cannot be ruled out that pain spontaneously resolved in some patients, as some studies with longitudinal follow-up showed a decrease in the rate of persistent pain with postsurgical delay. At this point, only long-term cohorts who undergo clinical examinations can help to obtain relevant information.

Conclusion

The results of the present study are not sufficient to recommend the systematic use of laparoscopic surgery instead of open mesh for inguinal herniorrhaphy. First, laparoscopic repair may have disadvantages, such as a longer duration of the procedure and a higher rate of serious complications, including visceral and vascular injuries. Second, the surgeons’ experience, the patients’ preference and their confidence in the team are well-known factors influencing the quality of the results. A recent review conducted by a collective of expert surgeons pointed out the challenge in developing strategies to identify and encourage the correct handling of the nerves involved in this surgery (i.e., ilioinguinal, iliohypogastric and genitofemoral nerves). There is still no high-level evidence to recommend a particular nerve-preserving technique. It must be added that intraoperative nerve lesion is not the only possible mechanism of neuropathic pain. In patients who experience neuropathic pain and have been reoperated for this reason, examination has revealed not only cases of transection, neuroma or entrapment by sutures, but also entrapment in the fibrosis around the sutured mesh.11,12

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Competing interests: C. Duvalé declares support from Pfizer for the conduct of the study in the form of subsides paid to the University Hospital of Clermont-Ferrand, for communication about the results of the study and postsurgical persistent neuropathic pain during the EFIC Congress in Hamburg, Germany (September 2011), and for training materials for primary and secondary care physicians, to highlight the prevalence of postsurgical persistent neuropathic pain. No other competing interests declared.

Contributors: L. Ouchchane, C. Duvalé and C. Dubray designed the study. N. Patric, M. Libier, F. Bouche, M. Belon, J.-M. Vedrinne, B. El Drayi, L. Vallet, F. Ruiz, C. Biemann, P. Duchène, C. Chirat, S. Soule-Sonneville, C. Duvalé and P. Schoeffler acquired the data, which L. Ouchchane and C. Duvalé analyzed. C. Duvalé wrote the article, which all authors reviewed and approved for publication.

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Canadian practice patterns for pancreaticoduodenectomy

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Background: Discordant practice patterns may be a consequence of evidence–practice gaps or deficiencies in knowledge translation. We examined the current strategies used by hepato-pancreatico-biliary (HPB) surgeons in Canada for the perioperative management of pancreaticoduodenectomy (PD).

Methods: We generated a web-based survey that focused on the perioperative measures surrounding PD. The survey was distributed to all members of the Canadian Hepato-Pancreatico-Biliary Association.

Results: The survey was distributed to 74 surgeons and received a response rate of 50%. Many similarities in surgical techniques were reported; for example, most surgeons (86.5%) reconstruct the pancreas with pancreaticojejunostomy rather than pancreaticogastrostomy. In contrast, variable techniques regarding the use of peritoneal drainage tubes, anastomotic stents, octreotide and other intraoperative modalities were reported. Most surgeons (75.7%) reported that their patients frequently required preoperative biliary drainage, yet there was minimal agreement with the designated criteria. There was variability in postoperative care, including the use of epidural analgesia and timing of postoperative oral nutrition.

Conclusion: We identified heterogeneity among Canadian HPB surgeons, suggesting a number of evidence–practice gaps within specific domains of pancreatic resections. Focused research in these areas may facilitate technical agreement and improve patient outcomes following PD.

Contexte : La discordance entre les modes de pratique pourrait être due à des lacunes au plan des pratiques fondées sur des preuves ou à une déficience du transfert des connaissances. Nous avons étudié les stratégies actuellement utilisées par les chirurgiens hépato-pancréato-biliaires (HPB) au Canada pour la prise en charge périoropératoire de la pancréatoduodénectomie (PD).

Méthodes : Nous avons préparé un questionnaire électronique sur les mesures périopératoires entourant la PD. Le questionnaire a été distribué à tous les membres de l'Association hépato-pancréato-biliaire canadienne.

Résultats : Le questionnaire a été distribué à 74 chirurgiens et a généré un taux de réponse de 50 %. De nombreuses similitudes dans les techniques chirurgicales ont été signalées : par exemple, la majorité des chirurgiens (86,5 %) reconstruit le pancréas par pancréatojéjunostomie plutôt que par pancréatogastrostomie. En revanche, on a observé une variabilité dans les techniques d'utilisation des drains péréitoneaux, des endoprothèses anastomotiques, des octroïdes et autres modalités peropératoires. La majorité des chirurgiens (75,7 %) ont signalé que leurs patients avaient souvent besoin de drains biliaires préopératoires et pourtant, les critères désignés ne semblaient pas faire l'unanimité. On a aussi noté des différences dans les soins postopératoires, y compris en ce qui concerne le recours à l’analgésie péridurale et le moment de la reprise de l’alimentation orale après la chirurgie.

Conclusion : Nous avons observé une hétérogénéité dans la pratique des chirurgiens HPB canadiens, ce qui donne à penser qu’il existe des lacunes au plan des pratiques fondées sur des preuves pour certains aspects précis des résections pancréatiques. Une recherche plus approfondie sur ces aspects pourrait favoriser le consensus technique et améliorer les résultats chez les patients après une PD.
Pancreatic ductal adenocarcinoma is the fourth leading cause of cancer-related deaths worldwide. In 2014, there were an estimated 4700 new cases of pancreatic cancer in Canada and 4400 deaths, with a 5-year relative survival rate of 8%. Although there have been recent advances in understanding the underlying pathophysiology of pancreatic cancer as well as the diagnosis, staging and treatment of early-stage tumours, minimal progress has been made in the early detection, prevention and treatment of late-stage disease.

Surgery remains the only potential curative intervention; however, owing to the late clinical presentation of disease only 15%–20% of pancreatic tumours are technically resectable. The treatment of choice for resectable tumours found within the pancreatic head or uncinate process is pancreaticoduodenectomy (PD), also known as a Whipple resection. Pancreaticoduodenectomy is a high-risk procedure that is typically performed by specialized surgeons at high-volume centres; however, despite significant reductions in postoperative mortality and morbidity over the past few decades, overall prognosis after resection for patients with pancreatic adenocarcinoma remains poor.

The improved perioperative outcomes may be credited to recent technical advancements in the surgical management of pancreatic malignancies; however, rapid evolution of perioperative care has the potential to introduce heterogeneity into surgical practice. The process of translating new research findings into routine clinical practice may be stagnant and inconsistent, yet failing to do so (known as an evidence–practice gap) can negatively affect the quality of patient care.

Our objective was to survey Canadian surgeons who perform PD to understand current perioperative practice patterns. We sought to elucidate the existence of evidence–practice gaps in this population and identify domains in which future research opportunities may yield fruitful findings.

Methods

We generated a survey to evaluate the current practice patterns in Canada for the surgical treatment of pancreatic cancer. The survey contained 41 questions with multiple domains of interest, including training and practice; perioperative management of all pancreatic cancer; and preoperative, intraoperative and postoperative measures for PD. Three hepato-pancreatico-biliary (HPB) surgeons piloted the survey, and we used their feedback to optimize the clarity of the survey.

This web-based survey was designed and distributed using the online survey tool SurveyMonkey. It was distributed by email to all members of the Canadian Hepato-Pancreatico-Biliary Association and to surgeons affiliated with the HPB CONCEPT Team, a national collaborative group of HPB surgeons. Followings a modified Dillman method, we gave recipients 5 weeks to respond to the survey and sent them weekly electronic reminders. After this 5-week period, each nonresponder was sent an individualized reminder to complete the survey. All responses were collected anonymously.

Survey data were descriptively analyzed and illustrated using GraphPad Prism software version 5.03 (GraphPad Software, Inc.).

Results

Of the 74 Canadian surgeons invited to participate, 37 (50.0%) completed the survey in its entirety. Nearly all respondents practised in academic hospitals located in urban centres (Table 1). Most surgeons had subspecialty training in HPB (73.0%), followed by transplantation (43.2%) and surgical oncology (27.0%). Most participants (67.6%) devoted more than 75% of their practices to HPB surgeries, with a diverse range of years in practice and in the volume of surgeries performed annually. All surgeons actively performed PD.

Participants were asked a variety of questions regarding perioperative techniques when performing the pancreaticoenteric reconstruction during PD. Nearly all surgeons (86.5%) reported always performing pancreaticojejunostomy (PJ) rather than pancreaticogastrostomy (PG) (Fig. 1A). Furthermore, nearly all surgeons (94.4%) reported using the duct-to-mucosa method rather than the dunking method when performing PJ. The use of octreotide and other somatostatin analogues was polarized, with the majority of respondents either never (54.1%) or always (27.0%) administering it (Fig. 1B). Hemostatic agents, such as fibrin glue or Tisseel, were not commonly used, with most surgeons citing occasionally or not at all using them (Fig. 1C). In contrast, there was great variability regarding the use of PJ anastomotic stents (Fig. 1D).

Participants were asked about their use of various drains and endoluminal catheters. Most surgeons reported that their patients frequently undergo preoperative biliary drainage (75.7%; Fig. 2A). There was significant variability in the criteria used to select patients for stenting, including laboratory tests (liver function tests, serum bilirubin), clinical symptoms (jaundice) and surgical wait times. There was minimal agreement on the intraoperative placement of peritoneal drainage tubes (Fig. 2B). Just over half (59.5%) of surgeons reported always using nasogastric (NG) suction tubes (Fig. 2C).

In the postoperative setting, there is no discernible consensus for the ideal method of analgesia after PD. A greater number of surgeons reported always (10.8%) or frequently (36.8%) using epidural analgesia than surgeons who reported always (29.7%) or frequently (37.8%) using intravenous patient-controlled analgesia (IV PCA; Fig. 3). Two surgeons described occasionally using transversus abdominis plane (TAP) blocks. Heterogeneity was also observed regarding the timing of oral nutrition introduction postoperatively.
large proportion of respondents reported that they start clear fluids at 49–72 hours (43.3%) and solid foods at 73–120 hours (45.9%), yet many surgeons cited earlier and later times (Fig. 4). Interestingly, only a small number of participants (37.8%) described implementing standardized postoperative pathways, such as an enhanced recovery after surgery (ERAS) program.

**DISCUSSION**

Reconstruction of pancreaticoenteric continuity is a critical step following PD owing to its association with major postoperative complications. A leak of the pancreatic anastomosis and subsequent fistula formation remains the most significant contributor to morbidity and mortality.17 Potential interventions that are subject to ongoing debate include the anastomotic technique, octreotide, hemostatic agents and anastomotic stents.

In the present study, there was remarkable agreement among surgeons regarding the preferred reconstruction technique, with the majority always performing PJ compared with PG. Many studies have compared PJ with PG, and a consensus over the most effective technique remains to be determined; although several reports have shown similar outcomes between the 2 manoeuvres,18–21 others have found that PG reduces the incidence of postoperative fistula.22–24 Given the overwhelming preference for PJ over PG, quality evidence supporting a single technique has the potential to drastically change the postoperative course for patients undergoing PD.

Octreotide and other somatostatin analogues function to inhibit the release of endocrine and exocrine pancreatic secretions,25 a process that effectively reduces the volume of secretions and may decrease the incidence of anastomotic leaks and pancreatic fistulas. The precise role of prophylactic octreotide remains controversial; a number of recent studies have reported inconsistent effects on postoperative complications, yet a Cochrane review on the subject concluded that perioperative complications were reduced following somatostatin analogue treatment during pancreatic resections.26 Interestingly, despite this evidence most Canadian surgeons do not administer somatostatin analogues. It is unclear whether this apparent lack of knowledge translation is a result of knowledge deficits or critical appraisal of the existing data.

Other modalities that have been investigated in an attempt to optimize the pancreaticoenteric reconstruction have not been shown to be of great benefit. Hemostatic agents, such as a fibrin glue sealant, have recently been found to have no significant impact on the incidence of pancreatic leak, fistula formation or other postoperative complications.27,28 Moreover, PJ anastomotic stents, which have been hypothesized to facilitate drainage of secretions from the pancreatic duct and reduce the rate of leaks and fistulas, have not been convincingly shown to be of benefit.29,30

There remains considerable controversy surrounding the role of biliary stenting before PD. Patients with pancreatic cancer often present with obstructive jaundice due to biliary obstruction, placing them at risk for coagulation disturbances, hepatic dysfunction and cholangitis, thus promoting biliary decompression. More recently, the routine use of preoperative biliary drainage has been linked to increased perioperative infectious complications, morbidity and mortality.31 Despite this evidence, the use of biliary drains has increased over the last 2 decades.32 Given this

<table>
<thead>
<tr>
<th>Table 1. Characteristics of study population (n = 37)</th>
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<tr>
<td>Characteristic</td>
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HPB = hepato-pancreatico-biliary. *Includes transplants.
Fig. 1. Frequency of various perioperative techniques used for pancreaticoenteric anastomosis during pancreaticoduodenectomy (PD). PJ = pancreaticojejunostomy.

Fig. 2. Frequency of various perioperative drainage procedures surrounding pancreaticoduodenectomy (PD).
apparent discordance between strong level-I evidence and actual clinical practice, the development of guidelines regarding the role for preoperative biliary drainage are needed. Indications may include the presence of cholangitis, liver dysfunction, severe jaundice and delayed time to surgery. This is a target for future research and knowledge translation to avoid unnecessary preoperative biliary drainage and associated complications.

The use of prophylactic intraperitoneal drains has historically been routine practice following pancreatic surgery with the intent to remove postoperative fluid collections and to facilitate early detection of anastomotic leaks, fistulas and hemorrhages. Contrary to this dogma, a growing body of evidence has failed to demonstrate a decrease in the frequency and severity of postoperative complications or the necessity for intervention and that the use of intraperitoneal drains after PD should not be mandatory. However, a randomized controlled trial was recently stopped early by the Data Safety Monitoring Board because mortality increased from 3% to 12% in patients undergoing PD without intraperitoneal drainage; these patients also had increased frequency and severity of complications. The authors cautioned against abandoning the use of intraperitoneal drains in all patients undergoing PD, explicitly stating that this would not be safe. This study’s divergent findings from the literature emphasize that further investigation into the utility and safety of this practice are of paramount importance.

Nasogastric suction has also historically been standard practice after major intra-abdominal procedures. Proponents postulate that NG suction decreases the risk of postoperative complications, such as ileus, anastomotic leaks, fistulas and wound dehiscence. More recent studies challenge this dogma and suggest that routine NG decompression is not warranted after elective abdominal surgeries. Specifically, routine NG tubes after PD may negatively impact the postoperative course and result in unnecessary patient discomfort. They also contribute to prolonged hospital stays, and their early removal is a critical component of fast-track surgical pathways. Thus, many authors advocate NG placement selectively in patients with delayed gastric emptying. Our data demonstrate that the majority of respondents always or frequently use NG suction after PD, indicating an important evidence–practice gap in the surveyed population.

Our study identified further variability regarding the optimal method of postoperative analgesia, with epidural analgesia somewhat favoured over IV PCA. Interestingly, this observation reflects the general opinion throughout the surgical literature. Epidural analgesia provides superior pain relief after PD than IV PCA, however, the impact of epidural analgesia on postoperative morbidity and mortality is not completely understood. Recent studies have suggested that epidural use results in fewer postoperative complications, in contrast, epidural analgesia has been found to promote hemodynamic instability following PD and possibly contributes to an increased incidence of various gastrointestinal and respiratory complications. Further research is warranted to determine the appropriate method of analgesia following PD in order to optimize pain relief and minimize complications.

The ERAS program is a novel, multimodal, structured concept that is designed to accelerate postoperative recovery, shorten the length of stay in hospital and decrease the rate of complications. The ERAS program has recently been safely applied to major pancreatic resections, such as PD, with demonstrated improved short-term outcomes. One of the most reproducible predictors of successful ERAS is early oral nutrition, with clear fluids often initiated on postoperative day 1 and solid foods on postoperative days 3–5; this is earlier than reported by the majority of our study population, who are mostly not practising ERAS. Other critical features of ERAS include minimizing epidural use,
limiting postoperative NG suction, removing drains early and ambulating early. Many of these measures have been described in the present study, and ERAS is one strategy to promote their use and narrow the evidence–practice gap.

Limitations

Our study has some limitations. We relied on surgeons self-reporting practice patterns rather than auditing actual practice patterns; it is possible that surgeons perceive or report practising differently than they actually do. There were a moderate absolute number of respondents; however, this is intrinsic to the study given that HPB care is centralized to high-volume, academic centres in Canada compared with other countries.17 Despite this homogeneous survey population, our study still demonstrated heterogeneous responses, contesting the impact of any possible selection bias. Finally, our study was limited by its descriptive nature and the inability to determine why there is disagreement among surgeons’ practices. Further research is needed to determine whether the variability identified is associated with ineffective knowledge translation or evidence–practice gaps.

CONCLUSION

We have evaluated Canadian practice patterns for PD. Our primary objective was to determine areas of agreement in perioperative technique and to identify evidence–practice gaps between what procedures are supported throughout the literature versus those that are routinely practised. Given the rapid evolution of surgical practices and the growing number of pancreatic cancer diagnoses and subsequent resections,2 these conflicts may significantly impact morbidity and mortality. We identified significant heterogeneity in perioperative techniques and the existence of numerous evidence–practice gaps, indicating opportunities to guide future effective research and knowledge translation strategies.

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Competing interests: None declared.

Contributors: All authors designed the study and acquired and analyzed the data. D. Cyr wrote the article, which all authors reviewed and approved for publication.

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Surgical approach in primary total hip arthroplasty: anatomy, technique and clinical outcomes

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Since its inception in the 1960s, total hip arthroplasty (THA) has revolutionized the treatment of hip arthritis. A number of surgical approaches to the hip joint exist, each with unique advantages and disadvantages. The most commonly used approaches include the direct anterior, direct lateral and posterior approaches. A number of technical intricacies allow safe and efficient femoral and acetabular reconstruction when using each approach. Hip dislocation, abductor insufficiency, fracture and nerve injury are complications of THA, although their relative risk varies by approach. Numerous clinical trials have sought to elicit differences in patient-reported outcomes, complication rates and return to function among the surgical approaches. This review outlines some of the technical pearls of performing a THA through either a direct anterior, direct lateral or posterior approach. A literature review outlines the impact of surgical approach on clinical outcomes and clinically relevant complication rates.

Total hip arthroplasty (THA) has revolutionized the treatment of hip arthritis. A number of surgical approaches to the hip joint exist, each with unique advantages and disadvantages. The most commonly used approaches include the direct anterior, direct lateral and posterior approaches. A number of technical intricacies allow safe and efficient femoral and acetabular reconstruction when using each approach. Hip dislocation, abductor insufficiency, fracture and nerve injury are complications of THA, although their relative risk varies by approach. Numerous clinical trials have sought to elicit differences in patient-reported outcomes, complication rates and return to function among the surgical approaches. This review outlines some of the technical pearls of performing a THA through either a direct anterior, direct lateral or posterior approach. A literature review outlines the impact of surgical approach on clinical outcomes and clinically relevant complication rates.

In the 1960s, total hip arthroplasty (THA) has revolutionized the treatment of painful hip arthritis. More than 24 000 THA procedures are performed annually in Canada. Surgical approach in THA is a recent area of interest in the literature. Each approach requires a thorough understanding of anatomy to optimize femoral and acetabular visualization, minimize complications and optimize patient outcomes.

The purpose of this review is to outline the anatomy and the technical aspects of the 3 commonly used surgical approaches to the hip: the direct anterior, direct lateral and posterior approaches. We conducted an evidence-based review examining studies that compared various clinical outcomes and complication rates across the 3 approaches. Although surgeon experience and anecdotal success are important factors when choosing surgical approaches for THA, our review demonstrates many important differences among the approaches that may influence surgeon choice in the future.

METHODS

We performed a comprehensive literature search using PubMed and Medline. The keywords “hip,” “arthroplasty,” and “approach” were used to identify papers examining the topic of interest. The terms “anterior,” “lateral” and
“posterior” were added to our search in order to identify articles that were approach-specific. We included comparative studies published from 2000 to 2014 in our review. Study titles and abstracts were reviewed to determine level of evidence to ensure high-quality literature (i.e. meta-analyses, systematic reviews, randomized controlled trials) was included. We included articles published earlier than 2000 if they contributed to the discussion on surgical technique or the incidence of particular complications.

**DIRECT ANTERIOR APPROACH**

**Overview**

The direct anterior approach to the hip was first described by Smith-Peterson in the 1940s, and was later modified by Heuter in the 1950s. Internationally, this approach is gaining popularity in the hip arthroplasty community. Advocates of this approach consider its advantages to be the muscle-sparing nature of its internervous intervals, earlier restoration of gait kinematics and low dislocation rates. The direct anterior approach can be performed with or without the use of a specialized table or fluoroscopy. Our institution favours the use of a specialized table and intraoperative fluoroscopy, which is described later in this section.

**Anatomy and technical considerations**

The procedure begins by positioning the patient supine on a specialized traction table (Fig. 1). Both feet are firmly secured to boots attached to lever arms that permit positioning of each lower extremity and applying traction to either limb. The perineal post located between the legs stabilizes the patient on the operating room table and provides a point of counter-traction.

The surgical incision begins 2–4 cm lateral to the anterior superior iliac spine of the pelvis (Fig. 2). It is then carried distally and laterally for about 8–12 cm at 20° from the sagittal plane of the patient toward the lateral aspect of the patient’s ipsilateral knee. The lateral femoral cutaneous nerve (LFCN) is identified, transposed medially and protected. After protecting the LFCN, the fascia overlying the tensor fascia latae (TFL) is incised, and a plane is then developed with or without the use of a specialized table or fluoroscopy.

![Fig. 1. Example of the specialized table (Hana fracture table, Mizuho OSI) used during a direct anterior approach. Boots attached to lever arms allow traction and free positioning of the leg during each procedure. A perineal post provides counter-traction, and a motorized lift allows improved femoral exposure.](image-url)
between the TFL and sartorius. The surgeon will then encounter the interval between the rectus femoris and gluteus medius. A Charnley hip retractor displaces the rectus femoris medially and the gluteus medius laterally to expose the anterior joint capsule of the hip. After coagulating or suture ligating the ascending branch of the lateral femoral circumflex artery, a Mueller retractor is placed inferior to the femoral neck, and a capsulotomy is performed. The joint capsule is incised along the length of the femoral neck from the acetabulum to the intertrochanteric line (Fig. 3).

Gentle traction is then applied to the operative limb. Mueller and Hohmann retractors are placed intracapsularly around the femoral neck. A reciprocating saw is used to make a femoral neck osteotomy. The femoral head is then removed with a corkscrew (Fig. 4). The osteotomy can be repeated and the resultant napkin ring of bone removed to increase the ease of removing the femoral head.10,12

Once the femoral head is removed, traction is released and the leg is externally rotated to improve exposure for acetabular preparation. The Charnley hip retractor maintains exposure medially. Placement of the final acetabular component is facilitated by the use of an offset inserter handle to minimize soft tissue injury (Fig. 5). Intraoperative fluoroscopy is used to optimize component anteversion and inclination.

Femoral preparation can be difficult owing to limited proximal femoral exposure with this approach. The operative limb is carefully placed in a position of extension, adduction and external rotation to improve the accessibility of the proximal femur. Overly forceful external rotation can result in soft tissue injuries to the knee and ankle as well as intraoperative fracture. A specialized bone hook is then inserted around the posterior aspect of the femur just proximal to the insertion of the gluteus maximus tendon. This bone hook can be used manually to elevate the proximal femur anteriorly. In the subset of patients in whom the femur cannot be sufficiently mobilized anteriorly, sequential release of the conjoint tendon and piriformis can also improve mobilization of the femur. Rarely, a release of the anterior 1–2 cm of the origin of the TFL off the iliac wing may be required. An offset femoral broach handle eases access to the proximal femur during preparation (Fig. 6). Trialing can be combined with intraoperative fluoroscopy to assess leg length and offset. Femoral anteversion is identified based on the posterior cortex of the proximal femur or by using the femoral epicondyles as a reference point. Once the final implants are in situ and the hip is reduced, implant positioning is verified with fluoroscopy, and the stability of the construct can be assessed out of traction.10–12

**DIRECT LATERAL APPROACH**

**Overview**

The direct lateral approach to the hip was described by Hardinge in 1982.13 Approximately 60% of Canadian
orthopedic surgeons perform THAs using a direct lateral approach. This approach provides adequate exposure of both the proximal femur and acetabulum. It has the benefit of providing an extensile exposure to the femur as required. A very low dislocation rate has also been reported in clinical follow-up.

Anatomy and technical considerations

The procedure begins by positioning the patient in the lateral decubitus position. The operative limb is draped freely to assist with dislocating the hip and exposing the proximal femur and acetabulum. A sterile bag is incorporated into the extremity drape to allow the surgeon to dislocate the hip and visualize the femur during preparation.

A longitudinal incision is made extending 3–5 cm proximal and about 5–8 cm distal to the tip of the greater trochanter (Fig. 7). The fascia is split at the interval between the TFL and gluteus maximus in line with the skin incision. A Charnley retractor is then used to retract the incised fascia latae. The tendon and muscle fibres of the gluteus medius are then visualized and split at the midway point between the most anterior and posterior extent of the muscle, or in a one-third anterior/two-thirds posterior fashion. The split is carried distally to the vastus ridge, leaving a cuff of gluteus medius tendon for repair following the procedure (Fig. 8). The gluteus minimus and joint capsule are split either in line with the neck of the femur or in line with the tendinous fibres of the gluteus minimus. Some surgeons perform a capsulectomy to facilitate dislocating the hip. The surgeon then dislocates the femoral head by externally rotating and flexing the hip and knee. The foot is positioned in the sterile bag anteriorly. Hohmann retractors are positioned around the femoral neck, allowing the surgeon to safely perform a femoral neck osteotomy using an oscillating saw.

Once the femoral neck osteotomy is completed, the surgeon will have access to the acetabulum and proximal femur. The acetabulum is prepared with the leg externally rotated and the knee in extension on the table. Hohmann retractors are carefully placed anteriorly, posteriorly and inferiorly around the acetabulum to provide adequate visualization. A Hibbs retractor or additional Hohmann retractor can be used to retract superior soft tissues if visualization is impaired (Fig. 9). Soft tissue landmarks, such as the transverse acetabular ligament, reamer positioning relative to the floor and cup positioning guides, can be used to verify acetabular version and inclination.

Fig. 5. Example of retractor placement during implantation of the acetabular component. Note the use of an offset inserter handle to minimize soft tissue trauma during insertion.

Fig. 6. (A) An offset femoral broach handle permits easier access to the proximal femur during preparation. (B) A bone hook assists with anterior displacement of the femur and can be secured in position using a sterile bracket.
When preparing the proximal femur, the hip is flexed to near 90° and externally rotated, and the foot is placed in the sterile bag anteriorly with the knee flexed. Two Hohmann retractors, 1 blunt placed posteriorly around the lateral aspect of the proximal femur and 1 sharp placed medially around the proximal femur, allow slight anterior displacement of the femur. A third Hohmann retractor is stationed posteriorly in line with the long axis of the femur to protect the abductors during femoral preparation.

**POSTERIOR APPROACH**

**Overview**

The posterior approach to the hip was popularized by Moore in the 1950s. A recent survey of surgeons from around the world suggests that the posterior approach is the most common surgical approach used internationally for THAs. In Canada, about 36% of arthroplasty surgeons use this approach. It provides adequate visualization of both the acetabulum and femur during both reconstructive procedures. The approach spares the abductor muscles during surgical exposure of the acetabulum and femur. It also has the benefit of providing an extensile exposure to the femur and acetabulum as required.

**Anatomy and technical considerations**

Similar to the direct lateral approach, for the posterior approach the patient is placed in the lateral decubitus position. Again, the involved limb is draped freely to facilitate dislocating the hip and to permit maneuverability of the limb to improve visualization throughout the procedure.

The skin incision begins 5 cm distal to the greater trochanter, centred on the femoral diaphysis. The incision continues proximal to the greater trochanter. At that point, it curves toward the posterior superior iliac spine for 6 cm. Alternatively, the incision can continue proximally in line with the femur with the hip flexed to 90° (Fig. 10).

The surgeon then incises the fascia latae overlying the gluteus maximus and bluntly splits the muscle down to the short external rotators (Fig. 11). A Charnley retractor is positioned to retract the gluteus maximus. The sciatic nerve is carefully protected as it travels immediately posterior to the short external rotators. After identification of the piriformis, the short external rotators and piriformis are then...
tenotomized at their insertion onto the greater trochanter. They are then tagged with a braided suture for identification and repair at the end of the procedure. This will then expose the posterior joint capsule, which is incised to reveal the femoral neck and head. Alternatively, the joint capsule can be incised with the short external rotators in a single layer during tenotomy. The femoral head is then dislocated by internally rotating the hip. A femoral neck osteotomy is then performed using Hohmann retractors anteriorly and posteriorly to protect soft tissues.

Once the osteotomized bone is removed, access is gained to the acetabulum and proximal femur. Careful placement of Hohmann retractors around the acetabulum permits adequate exposure for the reconstruction (Fig. 12). The femur is retracted anteriorly to expose the acetabulum to allow adequate restoration of acetabular anteversion. A posterior retractor or self-retaining retractor can be used to retract the posterior joint capsule to facilitate acetabular visualization. During acetabular preparation, soft tissue landmarks, such as the transverse acetabular ligament, reamer position relative to the floor and cup-positioning guides, are used to verify acetabular version and inclination.

The proximal femur is exposed with the leg internally rotated, flexed and slightly adducted. This places the long axis of the tibia vertically. Blunt bone skids or Hohmann retractors can be used to elevate the femur to improve exposure (Fig. 13). Femoral preparation can then be completed in this position. Following the reconstruction, the short external rotators and posterior capsule are repaired through transosseous bone tunnels in the proximal femur or a direct repair to soft tissues.

**EXTENSILE EXPOSURES**

Extensile exposures of the hip allow the surgeon to access more of the proximal femur or acetabulum in patients requiring management of complex acetabular or femoral bone defects; revision surgery; surgery for pathologic lesions of the proximal femur or acetabulum; or intraoperative complications, such as fracture. One of the disadvantages of the direct anterior approach is that exposure of the proximal femur is limited. As the direct anterior approach is part of the classic Smith–Peterson approach, acetabular exposure is adequate for THA. Access to the posterior acetabulum may require a 2-incision technique. Further proximal femoral exposure may require substantial soft tissue stripping of the vastus lateralis or a second incision using a lateral approach.17
Both the direct lateral and posterior approaches have extensile approaches. A trochanteric osteotomy or slide can improve access to the posterior column of the acetabulum using a direct lateral approach. Another option to access the posterior aspect of the acetabulum is to develop a plane posteriorly between the gluteus minimus and medius. The direct lateral approach can also be extended distally by splitting the vastus lateralis to access more of the proximal femur. Extending the exposure proximally is limited by the proximity of the superior gluteal nerve approximately 5 cm proximal to the tip of the greater trochanter. To extend the posterior approach distally along the femoral shaft, the gluteus maximus insertion can be detached.12,17

Risks and complications

Dislocation

Postoperative dislocation following THA has a deleterious effect on patient outcomes and, when required, revision surgery incurs tremendous costs to the health care system.18,19 Medicare data from more than 58 000 elective THAs in the United States suggest a dislocation rate of approximately 4%.20 However, this rate may be influenced by surgical approach at the time of the index procedure.

One of the purported benefits of the anterior and lateral approaches is lower dislocation rates than the posterior approach. A study by Sariali and colleagues21 prospectively followed 1764 patients who underwent primary THA performed through an anterior approach; patients were followed for 1 year postoperatively and had a dislocation rate (all dislocated anteriorly) of 1.5%. Another large series by Siguier and colleagues5 reported a dislocation rate of 0.96% in 1037 patients who underwent primary THA. Matta and colleagues6 reviewed 494 primary THAs performed through a direct anterior approach and reported 3 dislocations for a rate of 0.61%. The low dislocation rate has been attributed to verifying both acetabular and femoral component positioning via fluoroscopy and preserving static stabilizers, such as the posterior joint capsule.5,6

Preservation of the posterior soft tissue envelope may also explain the low dislocation rate observed with the lateral approach. A large retrospective review by Demos and colleagues22 reported 6 dislocations in 1515 patients (0.4%) undergoing a primary THA through a lateral approach. Masonis and Bourne15 performed a systematic review of the literature and determined a dislocation rate of 0.55% for 3438 THAs using the lateral approach. The definition of what constitutes a lateral approach may vary from study to study; therefore, the results of systematic reviews should be interpreted with scrutiny.

Dislocation rates for the posterior approach reported in the literature vary from 1% to 5%.16,23–26 Careful reconstruction of the capsule and short external rotators may decrease the risk of postoperative dislocation.12,16,25 Kwon and colleagues16 performed a meta-analysis to determine the rate of dislocations using a posterior approach with and without posterior soft tissue repair and found an 8 times greater relative risk of dislocation when soft tissue repair was not performed. Several repair techniques have been described for the posterior soft tissues. Examples include capsulorrhaphy of the capsule and short external rotators in 1 layer and transosseous bone tunnels in the greater trochanter.23,28

Abductor insufficiency

Abductor muscle insufficiency is a common clinical scenario following a direct lateral approach. It can cause abductor muscle weakness, a Trendelenburg gait or sign, inefficient gait mechanics and peritrochanteric pain.13,29–31 The insufficiency likely results from failure of the repaired tenotomy following a direct lateral approach, chronic degeneration of the gluteus medius tendon preoperatively, or irreparable tears at the time of THA in up to 20% of patients undergoing the procedure.12,31 The latter point, as well as technical pitfalls, such as inadequate restoration of femoral offset, may explain why some patients undergoing primary THA
through a posterior or anterior approach may still exhibit abductor insufficiency postoperatively. Masonis and Bourne reviewed more than 2400 THAs involving a direct lateral approach and reported an incidence of 4%–20% for abductor insufficiency postoperatively. Careful closure of abductor tenotomy during the direct lateral approach and guided rehabilitation focusing on abductor and core strengthening in patients with preoperative abductor insufficiency can help improve patient outcomes.

Fracture

Intraoperative fractures can be a devastating complication resulting in increased duration of surgery, difficult postoperative mobilization due to weight-bearing modifications, prolonged functional recovery and poor patient outcomes. Jewett and Collis reviewed their experience with the direct anterior approach in 800 patients who underwent primary THA. The authors reported 19 (2.3%) intraoperative trochanteric fractures and no ankle fractures; most fractures occurred during femoral elevation with a bone hook and soft tissue avulsion. Interestingly, 15 of the intraoperative fractures occurred within the first 200 cases of the series. Matta and colleagues reviewed 494 direct anterior THAs and reported 7 (1.4%) intraoperative proximal femur fractures (4 fractures of the medial calcar during femoral broaching and 3 fractures of the greater trochanter during bone hook elevation). Three (0.6%) nondisplaced ankle fractures occurred when using isolated external rotation of the limb to dislocate the hip.

There is a paucity of literature examining the rate of intraoperative fracture risk with the direct lateral and posterior approaches. A retrospective review by Hendel and colleagues of 372 primary THAs revealed 15 intraoperative greater trochanter fractures (4.0%) using a lateral approach. Similar to the reports using the direct anterior approach, the authors suggest increased soft tissue tension and resultant avulsion during femoral preparation as the cause of the fractures.

There are some central tenets that can be applied in order to reduce the risk of intraoperative fracture. Examination of soft tissue tension before and after leg manipulation with any surgical approach can help reduce the rate of fracture. Soft tissue releases, such as the short external rotators for improved femoral exposure with a direct anterior approach, should be a part of every surgeon’s repertoire. Finally, surgeon experience with novel techniques undoubtedly plays a role in reducing the incidence of intraoperative complications.

Nerve injury

The prevalence of nerve injuries during THA has been reported to be around 1%. Nerve injury can occur under several different circumstances, including direct trauma during dissection or placement of devices, such as wires or acetabular screws; retraction; thermal injury from methylmethacrylate; compression due to hematoma; leg lengthening; and component positioning. Commonly injured nerves include the superior gluteal, lateral femoral cutaneous, sciatic and femoral nerves.

A superior gluteal or femoral nerve palsy is a potential complication following a direct lateral approach to the hip. The superior gluteal nerve passes between the glutus medius and minimus muscles approximately 5 cm proximal to the greater trochanter. Retrospective and prospective studies suggest an incidence of 2.2%–42.5% for superior gluteal nerve injuries following reconstructive hip procedures using a direct lateral approach. This nerve palsy can lead to abductor insufficiency and poorer functional outcomes following THA; fortunately, many cases improve spontaneously. One study reported persistent electromyographic abnormalities in the glutus medius 1 year postoperatively in 3 of 40 patients who underwent THA through a lateral approach. Interestingly, only 1 of these patients demonstrated clinical signs of abductor insufficiency (i.e., Trendelenburg sign) at latest follow-up.

Neurapraxia of the lateral femoral cutaneous nerve can occur in 15%–80% of patients undergoing THA through a direct anterior approach owing to the nerve’s variable course around the anterior superior iliac spine and as it crosses the surgical plane at the sartorial-TFL plane more distally. Most of these neuromas resolve without any long-term sequelae. A postoperative neuroma is a potential complication leading to increased pain, although this complication is rarely reported in the literature.

The risk of sciatic nerve injury is greater during the posterior approach. Schmalzried and colleagues reviewed more than 3000 THAs and found an incidence of isolated sciatic nerve palsy of 1.3%. In most patients, sensory or motor deficits resolved spontaneously. Another study identified 14 sciatic motor nerve palsies in a cohort of more than 27 000 patients who underwent primary THA. Nine of these 14 patients had either partial or no recovery of residual motor deficits at a mean of 83 months postoperatively. Therefore, preserving the integrity of the nerve in order to optimize patient outcomes following THA cannot be understated.

The femoral nerve is at risk with over-rigorous placement of soft tissue retractors over the anterior aspect of the acetabulum for all approaches. The rate of femoral nerve palsies for THA ranges from 0.1% to 2.4%. Mulliken and colleagues did not identify any femoral nerve injuries in 770 consecutive patients who underwent THA with a direct lateral approach. The highest reported rate of femoral nerve palsy using a direct lateral approach was that in a study by Simmons and colleagues. They reported 10 palsies in 440 hips, with all patients experiencing a full functional recovery 1 year postoperatively. Matta and colleagues reported 1 femoral nerve palsy in 494 patients. In all cases
reported in the literature, the palsy was attributed to retractor placement over the anterior rim of the acetabulum.

**REVIEW OF CLINICAL OUTCOMES**

**Lateral versus posterior approach**

The direct lateral and posterior approaches are fundamentally similar in that they are both muscle-splitting approaches to the hip.\(^\text{2,13}\) However, as illustrated earlier, the surgical anatomy and potential complications differ between these approaches, which can influence patient outcomes.

The most important determinants of a successful THA are based on its goals of treatment: mitigation of pain, improved quality of life and restoration of function.\(^\text{3,4}\) Barber and colleagues\(^\text{55}\) prospectively followed for 2 years 28 patients undergoing direct posterior and 21 undergoing direct lateral THA, each performed by a single surgeon. Both groups had similar improvements on the Harris Hip Score (HHS) at the 2-year follow-up and had no observable differences in dislocations or in the incidence of a Trendelenburg gait.

A more recent prospective study\(^\text{56}\) randomly assigned 60 patients to undergo THA through either a posterior or lateral approach. The primary end point was the HHS at the 12-week follow-up. The authors also captured data from the Western Ontario and McMaster Osteoarthritis Index (WOMAC) and the Short-Form 36 (SF-36) questionnaires as well as information on complications, such as dislocations and periprosthetic fractures. Both approaches showed similar improvements across the HHS, WOMAC and SF-36 questionnaires at multiple time points up to and including 12 weeks postoperatively. The rate of dislocation and fracture did not differ significantly between the groups.

A common comparator between the posterior and lateral approach is the incidence of abductor insufficiency. Several studies have suggested the direct lateral approach has an increased incidence of abductor insufficiency following THA.\(^\text{15,24,30,56}\) The reported incidence varies from 0% to 16% for the posterior approach and from 4% to 20% for the direct lateral approach.\(^\text{15}\) However, there is tremendous heterogeneity in the methods used to diagnose abductor insufficiency in many of these studies. Many studies use subjective findings, such as the presence of Trendelenburg gait or sign or lateral trochanteric pain, which may lead to poor inter-rater reliability, to make the diagnosis. Magnetic resonance imaging (MRI) is becoming a popular method for assessing soft tissue pathology following THA.\(^\text{57–60}\) Several studies have shown that metal suppression pulsed MRI sequences can identify abductor damage in patients with symptomatic abductor tears following THA.\(^\text{59–61}\) Future prospective studies using MRI to assess soft tissue integrity postoperatively will provide a more objective measure of the incidence of abductor tears.

**Anterior versus lateral approach**

The direct anterior approach is increasing in popularity and is the preferred surgical approach of 10% of orthopedic surgeons performing THA.\(^\text{4}\) Reduced blood loss, earlier functional recovery, low dislocation rates and shorter stays in hospital have been attributed to the muscle-sparing properties of the anterior approach.\(^\text{6}\) The literature also suggests that minimizing muscle damage during surgery is a reason for patients to choose particular surgeons who practise muscle-sparing techniques.\(^\text{7}\) Thus, several recent studies have compared the direct anterior approach to both the direct lateral and posterior approaches.

From 2006 to 2009, Alecci and colleagues\(^\text{62}\) retrospectively reviewed peri- and intraoperative outcomes of THAs performed through either a direct lateral (\(n = 198\)) or direct anterior (\(n = 221\)) approach. The mean duration of surgery was 8 minutes longer in the direct anterior group, which was a statistically significant difference between the groups. The direct lateral group experienced increased perioperative blood loss and blood transfusions compared with the direct anterior group. Finally, length of stay in hospital was reduced significantly from 10 to 7 days when a THA was performed through an anterior approach.

A similar study by Restrepo and colleagues\(^\text{63}\) randomly assigned 100 patients to either the direct anterior or lateral approach to THA. Interestingly, the authors found no significant differences in duration of surgery, blood loss, need for blood transfusions or length of stay in hospital between the 2 groups. The authors also examined patient outcome measures. The direct anterior group outperformed the direct lateral group on the HHS, SF-36 and WOMAC questionnaires at 6 weeks postoperatively. However, these significant differences in clinical outcomes were abated when revisited at 2 years postoperatively. This study suggests that the direct anterior approach may be associated with greater early postoperative improvements in patient-reported outcomes than the direct lateral approach.

Earlier discharge from hospital may be associated with better pain mitigation after surgery. Goebel and colleagues\(^\text{64}\) retrospectively reviewed pain perception using a visual analogue scale (VAS), consumption of pain medication and length of stay in hospital in 200 patients undergoing either an anterior or lateral approach to THA. There was a significant reduction in perceived pain and consumption of pain medication in the direct anterior group during the first 24 hours postoperatively. The direct anterior group spent an average of 3 fewer days in hospital than the direct lateral group. Again, improved pain mitigation and earlier discharge were attributed to the muscle-sparing properties of the anterior approach. However, the accuracy of these data are limited by the retrospective study design and by pain assessment using a VAS and multiple different assessors.

There may be anatomic pathology that can explain the discrepancy in perceived pain between the groups. Bremer
and colleagues\textsuperscript{65} obtained an MRI 1 year postoperatively in 50 patients who underwent THA through either a direct anterior or lateral approach. The authors noted significant increases in the number of abductor tears or detachments, greater trochanteric fluid collections, gluteus medius tendinosis and fatty atrophy of the abductor muscles in the direct lateral group. The abductor complex is a pain generator following the direct lateral approach and may explain differences in early pain perception between the groups.\textsuperscript{79} However, a limitation of the study by Bremer and colleagues is the absence of a clinical outcome measures assessment. They did not obtain a preoperative MRI, which could have identified patients with evidence of abductor pathology before the procedure, a common finding in patients with hip arthritis.\textsuperscript{13} Future research should compare clinical outcomes and findings on advanced imaging modalities to explain discrepancies in pain and functional outcomes.

**Anterior versus posterior approach**

Several studies have compared the anterior and posterior approaches, with recent literature examining the extent of muscle damage incurred by either approach. A prospective randomized trial by Barrett and colleagues\textsuperscript{66} compared 43 direct anterior and 44 direct posterior approaches to THA. The primary end point was the ability to climb stairs and walk unlimited distances, as assessed with the HHS at 6 weeks, 3 months, 6 months and 12 months postoperatively. The authors also captured intraoperative data, including total duration of surgery, and postoperative data, including length of stay in hospital. The total duration of surgery was on average 23.8 minutes longer in the direct anterior than the direct posterior group. The mean length of stay in hospital was 2.28 days for the direct anterior group and 3.02 days for the direct posterior group. At the 6-week follow-up visit, significantly more patients were walking limitlessly, were able to climb stairs normally and had a higher total HHS in the direct anterior than the direct posterior group. These differences dissipated by the 3-month mark and remained insignificant up to and including 1 year postoperatively. These results support the claim that the direct anterior approach provides earlier restoration of function after THA.

One of the purported benefits of earlier return of function is earlier discharge from hospital. Martin and colleagues\textsuperscript{67} retrospectively reviewed 41 direct anterior and 47 direct posterior approaches to THA. Length of stay in hospital was significantly shorter for the anterior than the posterior group (2.9 d v. 4.0 d). The mean duration of surgery was significantly longer with the anterior than the posterior approach (141 min v. 114 min). Both groups performed similarly on the SF-36 and WOMAC clinical outcome measures at the 6-month follow-up. This study was limited by selection bias, as the mean body mass index (BMI) was significantly higher in the posterior than the anterior group (34.1 v. 28.5). Patients with elevated BMI (> 40) were told that there was a greater risk of wound complications associated with an anterior approach and opted to undergo a posterior approach. Elevated BMI has become a relative contraindication to an anterior approach in our institution. A statistically significant difference in BMI between study cohorts is an important confounder, as obese patients require more assistance with early mobilization, thereby influencing the difference in length of stay between the groups. In the study by Martin and colleagues,\textsuperscript{67} the earlier discharge from hospital was attributed to earlier mobilization owing to the muscle-sparing properties of the anterior approach.

There is considerable interest in the degree of muscle damage sustained during surgical approaches to the hip. An interesting study by Bergin and colleagues\textsuperscript{68} compared various blood markers indicative of muscle damage in patients undergoing THA through either a direct anterior or posterior approach. This methodology has been used previously to justify the use of tissue-sparing techniques, such as laparoscopy in other surgical subspecialties.\textsuperscript{69,70} The investigators measured pre- and postoperative values of various acute phase reactant proteins, such as creatine kinase (CK), C-reactive protein (CRP), interleukin (IL)-6, tumour necrosis factor (TNF)-α and IL-1 in 57 patients undergoing THA. They found a significant increase in CK in the posterior approach group compared with the anterior approach group immediately following the procedure as well as cumulatively 2 days after THA. The other acute phase reactants did not change significantly between the groups.\textsuperscript{68} However, the duration of surgery was longer in the posterior approach than the anterior approach group (mean 118 min v. 78 min). A more prolonged period of immobilization on the operating room table could have contributed to the accumulation of additional serum CK.\textsuperscript{71} Serum CK clearance also depends on renal function,\textsuperscript{72} which was not accounted for in the study by Bergin and colleagues.\textsuperscript{68}

Another study\textsuperscript{73} examined the extent of gluteus medius/minimus, TFL, rectus femoris and short external rotator muscle damage in THAs performed on 12 cadaveric hips (6 direct anterior and 6 direct posterior approaches). Minimal damage was sustained to the gluteus medius muscle with both approaches. The posterior approach caused more damage to the gluteus minimus muscle than the anterior approach (18% v. 8.5% of the mean surface area). The short external rotators were released in all posterior approach specimens and were damaged in 50% of the anterior approach specimens to improve visualization of the proximal femur. Using an anterior approach, 31% and 12% of the mean surface area of the TFL and rectus femoris muscles, respectively, was damaged. No damage to either of these muscles was sustained using a posterior approach.\textsuperscript{73} This study challenges the claim that the anterior approach is truly a muscle-sparing approach. Future studies using gait analysis could elicit the clinical effects of this muscle damage.
CONCLUSION

Surgical approach in THA is an area of debate among orthopedic surgeons. This review has demonstrated that the anterior, lateral and posterior approaches each have unique advantages and disadvantages. High-quality clinical comparisons among the approaches are lacking in the literature; therefore, surgeon preference is likely more a function of training and anecdotal success. The surgical approaches discussed all enable performance of a safe and clinically efficacious THA; therefore, we recommend that surgeons choose the approach with which they have the most experience and ease. Future research should elicit the long-term implications of surgical approach on clinical outcomes, restoration of function (i.e. gait analysis) and health economics.

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Is obesity associated with advanced stage or grade of colon cancer?

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Population-based studies from Europe have suggested that obesity is associated with more advanced stage colorectal cancer on presentation. Obesity is an even more prevalent issue in North America, but comparable data on associations with cancer are lacking. We reviewed the cases of 672 patients with colon cancer diagnosed between 2004 and 2008 in the province of Manitoba who underwent surgical resection at a Winnipeg Regional Health Authority-affiliated hospital. We tested if obesity was associated with more advanced cancer stage or grade. On multivariate analysis, after adjusting for age, sex, tumour location and socioeconomic status, we were unable to show any significant associations between body mass index of 30 or more and advanced stage or grade cancer on presentation. The reasons for the lack of association are likely multifactorial, including the pathophysiology of the disease and process factors, such as screening habits and colonoscopic diagnostic success rates in obese patients.

Colorectal cancer (CRC) is the third most common cancer¹ and the second most frequent cause of cancer-related death among men and women in Western countries.² There appears to be an obesity-related risk associated with many cancers. The strongest associations with obesity observed in men include esophageal, thyroid and colon cancer; in women, the strongest associations include endometrial and gall bladder cancer.³ Several authors have proposed that in patients with colon cancer, obesity may be associated with the formation of advanced adenomatous polyps, its precursor lesion. Siddiqui and colleagues⁴ found that for every 1-unit increase in body mass index (BMI) above 30, there was a corresponding 1% increase in the frequency of finding advanced adenomatous polyps.

More recent literature suggests that obesity may be associated with not only the development of CRC, but also with more advanced cancers on presentation. A prospective population-based study from Sweden by Brändstedt and colleagues,⁵ which included 28 098 patients, demonstrated an association between obesity and increased risk of more advanced-stage CRC (T3/T4, N1, or M1 disease), especially in men. This association was seen in all anthropometric factors, including weight, hip circumference, waist circumference, BMI, and waist:height ratio measurements, except body fat percentage. These authors also found sex-related differences in the association between obesity and expression of various CRC-associated mutations, including catenin, cyclin D1, p53 and microsatellite instability screening status, as well as BRAF and KRAS profiles.⁶,⁷

Obesity is an important issue in Canada that is growing at an alarming rate, with a prevalence of 25%, as reported by the Public Health Agency of Canada and the Canadian Institute for Health Information in 2011. However, comparable data sets examining obesity and risk of more advanced CRC in Canadian populations are lacking. We therefore performed a large-scale review of patients undergoing surgery for colon cancer in Manitoba,
Canada, investigating the association between BMI and colon cancer stage and grade; the primary outcome was the odds of presenting with higher stage (Stage III/IV), and the secondary outcome was the odds of presenting with higher grade (Grade 3) colon cancer. Our study included 687 patients who underwent surgery for colon cancer in Winnipeg Regional Health Authority (WRHA)–affiliated hospitals between 2004 and 2008. Data were abstracted from the Manitoba Cancer Registry and from the patient charts. Two logistic regression models were built, 1 for testing the risk of having a more advanced stage and 1 for having a higher grade of tumour. In our cohort, 358 (53%) patients had stage I-II disease, and 314 (47%) had higher stage (237 Stage III, 77 Stage IV) disease. Lower grade cancer was found in 545 (81%) patients, while high grade cancer was found in 127 (19%) patients.

The mean BMI was 27.9 in the overall cohort (28.1 in those with lower stage and 27.6 in those with higher stage cancers, and 28.0 in those with lower grade and 26.9 in those with higher grade cancers; Fig. 1). On multivariate analysis, after adjusting for age, sex, tumour location and socioeconomic status, we did not find any significant associations between obesity (BMI ≥ 30) and odds of presenting with higher stage (odds ratio [OR] 0.91, 95% confidence interval [CI] 0.64–1.30) or higher grade (OR 0.70, 95% CI 0.43–1.12) disease.

There are several possible reasons for the differences in findings between our study and those of the Swedish study. First, BMI is a labile variable, especially in patients with cancer. It is affected by multiple factors, including individual eating habits, stress, level of physical activity and the biology of the disease itself. It may be difficult to distinguish between risk factors for advanced disease versus the consequences of progressing disease. It is possible that the cancer itself decreases BMI in some patients, owing to factors such as obstruction-related symptoms or cancer-induced cachexia, even before diagnosis. We chose to use patient BMIs recorded just before surgery as a snapshot for each patient in order to achieve some consistency in time points for BMI data collection before the effects of surgery and any adjuvant treatments could play a role. In comparison, the anthropometric factors in the Swedish study were collected prospectively as part of the Malmö Diet and Cancer Study from a nationwide population-based cohort. The data were thereby collected before the diagnosis of cancer, which may be a better representation of the patients’ true BMI before any cancer effects on body mass. A further limitation to our study, considering the data were reviewed retrospectively, was that we could not verify whether all height and weight measurements were made directly by clinic staff in the preoperative anesthesia data forms as per protocol or whether patient estimates were included. A power calculation estimated the need for 400 of each high and low stage, as well as high and low grade cancers to demonstrate a statistically significant association with obesity, thereby rendering our study underpowered, especially for grade. Finally, we reviewed only patients who underwent surgical resection in order to obtain accurate information on tumour stage and grade from the pathology specimens. Other nonsurgical patients with colon cancer, many of whom likely had stage IV disease, were not included, possibly introducing selection bias.

Fig. 1. Mean body mass index of study population based on cancer stage and grade on presentation. Low stage includes Stage I/II. High stage includes Stage III/IV. Low grade includes Grade 1/2. High grade includes Grade 3. Error bars denote standard deviation.
Even if an association between obesity and more advanced colon cancer could have been demonstrated, as in the Swedish study, the question remains as to whether this association is due to the biology of the disease itself, such as invasiveness and proliferative ability, or other factors related to the processes of care in obese patients. The recent discoveries in associations between sex-specific anthropometric factors and biological activity of CRC cancer with respect to gene expression profiles are certainly intriguing.6,7 Another compelling and perhaps equally contributing theory is that the association is due to process variables, such as patient or practitioner-related screening habits or technical diagnostic success rates that may differ in obese patients. Colon cancer stage and grade at the time of diagnosis are likely a result of multiple factors, including biology of the disease; host characteristics, such as BMI; and diagnostic limitations and variability in patient behaviours relating to screening and frequency of health care visits. Further studies are needed to ascertain whether there is an association between obesity and risk of more advanced cancers. If we can unravel the mechanisms behind such an association, there may be areas to target, including process or biological factors, in improving primary or secondary prevention and in the treatment of the disease.

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Supply versus demand: a review of application trends to Canadian surgical training programs

The Royal College of Physicians and Surgeons of Canada recently reported that 16% of newly graduated specialist physicians are unable to find employment, sparking debate over the supply–demand balance of specialist physicians across Canada.1 Though this debate remains unresolved from a societal viewpoint, there is another important, yet rarely discussed perspective, shaping the future of health care in Canada: the graduating medical student entering the workforce.

The supply of Canadian medical graduates has never been higher; there were 2827 graduates in 2014 compared with 1255 graduates in 2002. However, demand for surgical residency positions has declined for more than a decade. Data from the Canadian Resident Matching Service (CaRMS; www.carms.ca/en/data-and-reports) shows that the number of students selecting a surgical specialty as their first choice has dropped to its lowest point since CaRMS began reporting statistics (13.0% in 2014 v. 20.8% in 2002). During the same time period, despite a 260% increase in the number of residency training positions, family medicine experienced an 18.9% average increase in first choice applications. Compare this to urology, which witnessed a 1.2% decrease in first choice applicants, equating to 34 fewer applicants per year in a specialty with only 31 residency training positions nationwide.

Potentially more concerning is that the students currently applying to surgery may be less competitive applicants. The CaRMS data reveal that the average number of unmatched surgical residency positions has been increasing over the past 6 years, peaking in 2009 with 27 unmatched surgical residency positions across Canada. The quality of applicants has dropped to the point where programs would rather leave a position unmatched than accept a candidate.

There has been a decrease in interest in our plastic surgery program at the University of Toronto, which has prompted the question: Does this trend affect only our program, only plastic surgery programs across the country, or is it a phenomenon afflicting all surgical programs?

To examine the current status of Canadian surgical training, we analyzed application trends to the 6 largest surgical specialties (Table 1). We divided the data set
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in half (2002–07 and 2008–13) and compared averages from these 2 periods. Trends were further analyzed based on the academic institution from which applicants graduated (Appendix, Tables S1 and S2, available at canjsurg.ca).

Unfortunately, there is no pervasive and uniform pattern to surgical applications across Canada (Appendix, Table S1); however, of 78 programs examined, 63% experienced a decrease in first choice applicants. Furthermore, 85% experienced a decrease in at least 3 of 6 surgical specialties, and no institution experienced an increase in the number of first choice applicants for all specialties.

Why does this concerning trend exist? How can we improve?

Though one may presume that future employment concerns are the driving force contributing to this ebb in surgical interest, the literature is inconclusive regarding the impact of job opportunities on career selection. Another theory is that medical graduates today are of a generation increasingly opting for lifestyle-centered careers. The current generation (Generation Y, born between 1982 and 2005) has grown up and thrived in a closely supported environment, protected from failure, where teamwork has replaced hierarchy. This differs greatly from traditional surgical training, which may deter the Generation Y student from a surgical career. However, the concept of a generation gap is not new. Rohrich highlighted many of these same challenges in a discussion on the difficulties of training surgeons from Generation X (born between 1961 and 1981). It seems that any time there is a transition between generations, intergenerational conflict rooted in resistance toward change develops. It is how one bridges this gap that determines success moving forward.

Interestingly, our data set overlaps the transition period from Generation X to Generation Y. One can easily conceive that between 2008 and 2013 the proportion of Generation Y students graduating from medical school was increasing as Generation X numbers decreased. Though convenient to blame the mindset of a new generation of physicians, if this were simply a generational effect one would expect minimal variability among geographic locations and academic institutions and a more uniform, pervasive pattern.

Although certainly multifactorial, we believe the key determinant of interest in a surgical career is adequate exposure. Studies have shown that early exposure to surgical specialties has a positive influence on career choice. Unfortunately, in 2010–11 our institution reduced the amount of time that medical students spend on core surgical rotations from 12 to 8 weeks. Alongside duty hour restrictions, call limitations and decreased surgical teaching in medical school, students now receive much less surgical exposure than their predecessors. For example, only 3 hours of teaching is devoted to plastic surgery topics within the current 4-year curriculum at the University of Toronto. It is, therefore, not surprising that plastic surgery at our institution experienced one of the largest overall application decreases nationwide. How can a student become interested in a specialty when the curriculum essentially overlooks it?

Moving forward, the next step would include analyzing surgical teaching curricula at the institutions fostering greater interest in surgical careers to determine what sets them apart. Perhaps there is greater exposure to surgery and more involved surgical role models touting surgery as a rewarding career. Furthermore, we should survey the students themselves to determine their perceived exposure, which can differ from reality if the students lack a thorough understanding of a specialty’s scope of practice. We may also benefit from a better understanding of what students desire from us as surgical educators.

So how can we improve the horizon for surgical training in Canada? While the first step is to admit a problem exists, the next step is for surgeons to develop creative solutions to maintain interest in our specialties. Creativity and progressive thinking is exactly what the fast-paced, multitasking Generation Y student demands. Though seemingly counterintuitive, we must shed the competitive stigma associated with surgical residency before demand drops so low that we become, in essence, obsolete.

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