Canadian benchmarks for acute injury care

Antibiotic use among older adults on an acute care general surgery service

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TAMIS for benign large rectal polyps and early rectal cancers: outcomes from the first Canadian centre to adopt the technique

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Q. WHAT IS HS?
A. Hidradenitis Suppurativa (HS) is a chronic, painful, inflammatory skin disease which affects 1-4% of the general adult population. It is characterized by boils usually occurring where certain sweat glands are located, such as under the breasts, buttocks and inner thighs. The boils can develop and connect, forming draining sinuses which discharge foul-smelling pus.

Q. WHAT CAUSES HS?
A. The cause of HS is unclear. It is thought that certain genetic markers and defects within hair follicles are at the root of the disease. Risk factors include smoking and obesity. About one-third of patients report a family history of HS. HS has been reported to co-occur with several comorbid conditions—mostly, inflammatory bowel disease.

Q. HOW DOES HS IMPACT QUALITY OF LIFE?
A. HS is often undiagnosed or misdiagnosed. It interferes with social interactions, job performance and intimate relationships—often leading to isolation. It is painful and causes embarrassment.

Q. HOW DOES HS IMPACT QUALITY OF LIFE?
A. HS is often undiagnosed or misdiagnosed. It interferes with social interactions, job performance and intimate relationships—often leading to isolation. It is painful and causes embarrassment.

Q. DO PEOPLE SUFFERING FROM HS GO TO THE ER FOR TREATMENT?
A. People with HS come to the emergency room in severe pain and discomfort requiring assistance with the draining of the boils during a flare-up. It's not unusual for patients to go home undiagnosed.

Q. IS THERE A CURE FOR HS?
A. There is currently no cure for HS. Early diagnosis and proper management is important for a patient’s quality of life. The first step for those with HS is to speak to their dermatologist to get an accurate diagnosis.

Q. HOW CAN HS BE TREATED?
A. Medical treatments for HS have included antibacterial washes, topical clindamycin, various systemic antibiotics, hormonal therapies, systemic retinoids, laser treatment, intralesional steroid injections and biologics. Surgical de-roofing or wide excision procedures have long been the definitive treatment for severe HS. There is no guarantee that HS will not recur in the previously excised areas.

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Dr. Louis Kristal at 100: witness to the evolution of surgery in Canada

The views expressed in this editorial are those of the author and do not necessarily reflect the position of the Canadian Medical Association or its subsidiaries.

The lecture, though impromptu, was to be special, but maybe not as special as the medical school realized. Canadian Nobel Prize winner, Major Sir Frederick Banting was on his way to Britain when he took the opportunity to speak to Dalhousie University medical students. Banting had wished to pursue a career in orthopedic surgery, having worked with Professor Clarence Starr at the First World War and in the Hospital for Sick Children, Toronto, Ont., after that. Banting switched to a career in research following the stunning success of his insulin project, which he undertook during a lull in his clinical practice. He became the founding head of the government-funded Banting and Best Research Institute at the University of Toronto. By 1938 Banting had turned his attention to aviation medicine as head of the Royal Canadian Air Force’s Number 1 Clinical Investigation Unit. A week after the Dalhousie lecture, on Feb. 21, 1941, Banting died when the plane that was taking him to Britain crashed close to Musgrave Harbour, Nfld. Dr. Louis Kristal (Dalhousie, 1943), who celebrates his 100th birthday, remembers Banting’s last lecture well. Banting dispensed with platitudes about honour and service even though he had won the Military Cross for gallantry in the previous war and instead explained the physiology of flying to the class and demonstrated the new anti-gravity suit designed by Wilbur Franks in his research unit.

Kristal had planned to enlist upon graduation, but that plan was delayed because he had appendicitis. Upon recovery, he was recalled to his home town of New Waterford, NS, by Dr. David Hartigan. Hartigan, who had been the local member of parliament and had served in the McKenzie King government, used his connections to have Kristal’s job, colliery doctor, declared essential to the war effort, curtailing all further attempts at enlistment. Instead, Hartigan taught Kristal surgery.

In 1944, Richard Goldbloom, the overachieving medical student son of McGill University’s professor of pediatrics, met Ruth Schwartz and his destiny, which lay not in Montreal but in New Waterford, Schwartz’s home town. In pursuit of her, Goldbloom arranged an elective with the town’s medical practice, which provided comprehensive medical care to miners and their families under an insurance scheme known colloquially as the “Check-Off.”

Goldbloom describes Kristal as his “principal mentor” and the town’s “most competent surgeon.” Kristal’s practice included general surgery (appendectomy, perforated peptic ulcers), orthopedics (closed reduction of fractures and amputations), gynecology (curettage, hysterectomy, cesarean section) and surgical treatments of tuberculosis (pneumothorax) and diphtheria (tracheotomy). Goldbloom recalls the locals calling Kristal the “head cutter,” recognizing not only his superior surgical skills, but also his willingness to undertake burr holes to drain epidural hematomas. Anesthesia was provided by another general practitioner (GP) specialist trained on the job, Dr. Joe Roach.

Goldbloom married Schwarz, and they settled in Halifax, where together they had a remarkable effect on the medical community, the Province and Canada. Kristal married Hartigan’s daughter Carmel, who was Schwarz’s best friend. In 1953, the Kristals went to Montreal for a year so that he could upgrade his surgical training at the Royal Victoria Hospital. One of his anecdotes from this period concerns the care of Dr. Wilder Penfield, who Kristal admitted to hospital for a relatively minor operation. In doing so, Kristal undertook the traditional history and physical examination, including a complete assessment of the nervous system. Penfield was kind, complimenting Kristal on his thoroughness. Unlike Dr. Gerald LeBrun, a leading GP surgeon in Halifax, Kristal did not take the certification examination of the Royal College. The Kristals returned to Cape Breton, where he continued as a GP surgeon for another decade until Medicare spelled the end of the Check-Off system and access to Royal College–certified surgeons the end of GP surgery. Interestingly, the Acts to provide universal public medicare in Canada were guided through parliament by the Kristals’ good friend, the late Allan MacEachen, who acknowledged that his personal experience of the Check-Off system motivated his desire for medicare.

After more than 20 years in an unrelenting high-stakes practice in New Waterford, Kristal moved to become a family physician in Brampton, Ont. Interestingly, he was quickly persuaded by his new colleagues to undertake anesthesia training in St. Joseph’s Hospital, Toronto, in order to supplement the Brampton hospital’s anesthesia staff, which Kristal did for another decade until Royal...
College–certified anesthesiologists were available there. Finally, in 1974 Kristal was able to concentrate on family medicine, becoming a much–loved physician who inspired many in the local community to choose medicine as a career. Kristal closed his practice 40 years after graduating, but he continued as a surgical assistant and mentor until age 78.

Roach continued his remarkable career in New Waterford long into old age.6 Goldbloom, the gentle–man leader of pediatrics in Canada, continues to inspire new generations of physicians in Halifax. LeBrun became the doyen of the Dalhousie medical faculty.3 Kristal recalled for me the immense satisfaction he felt when he noticed the tracheotomy scar on a man of whom he was asking directions during a visit home. It was more than 30 years since he had saved the man, who was then a child, from diphtheria.

With this editorial, the Canadian Journal of Surgery pays tribute to these remarkable doctors. The journal recognizes the life and career of Kristal, who is a witness to the evolution of surgical specialties from general practice in Canada. We wish the Kristals happiness and good health in retirement, as they continue to inspire all who encounter them.

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Coeditor, Canadian Journal of Surgery

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son destin, qui l’a arraché à son port d’attaque pour l’amener à New Waterford, la ville natale de Ruth Schwartz, qu’il courtisait alors. Pour atteindre son but, il s’est organisé pour suivre un stage au cabinet du médecin de New Waterford, qui offrait des soins médicaux complets aux mineurs et à leurs familles dans le cadre d’un régime d’assurance familierement appelé « Check-Off »1. Richard Goldbloom a décrit le Dr Kristal comme son « principal mentor » et le « chirurgien le plus compétent » de la ville2. Le Dr Kristal pratiquait la chirurgie générale (appendicetomie, ulcère gastro-duodénal perforé), l’orthopédie (réduction fermée de fractures et amputation), la gynécologie (curetag, hystérectomie, césarienne) et les traitements chirugicaux de la tuberculose (pneumotherax) et de la diphtherie (trachéotomie). Le Dr Goldbloom raconte que les gens surnommaient le Dr Kristal le « coupeur de têtes », non seulement parce qu’il possédait des habiletés supérieures en chirurgie, mais aussi parce qu’il n’hésitait pas à faire des trépanations pour drainer des hématomes épiduraux. Un autre généraliste s’étant spécialisé en cours d’emploi, le Dr Joe Roach, s’occupait de l’anesthésie.

Après leur mariage, Richard Goldbloom et Ruth Schwarz se sont établis à Halifax, où ils ont eu une influence remarquable sur la communauté médicale, la province et le Canada. Pour sa part, le Dr Kristal a épousé Carmel, fille du Dr Hartigan et meilleure amie de Ruth Schwarz. En 1953, le Dr Kristal et sa famille ont passé 1 an à Montréal pour qu’il puisse mettre à jour sa formation chirurgicale à l’Hôpital Royal Victoria. Il raconte que durant cette période, il avait hospitalisé le Dr Wilder Penfield en vue d’une chirurgie relativement mineure. Après avoir procédé à la collecte des antécédents et à l’examen physique habituel, qui comprenait une évaluation complète du système nerveux, il a reçu des compliments pleins de gentillesse du Dr Penfield, qui l’a félicité pour sa rigueur. Le Dr Kristal n’a jamais fait l’examen d’agrément du Collège royal, contrairement au Dr Gerald LeBrun, éminent chirurgien généraliste d’Halifax3. La famille est ensuite revenue au Cap-Breton, où le Dr Kristal a continué d’exercer comme chirurgien généraliste pendant 10 ans, jusqu’à ce que le avènement du régime public d’assurance-maladie entraîne la fin du système de contribution « Check-Off » et que l’accès à des chirurgiens agréés par le Collège royal y fassent leur entrée. À partir de 1974, le Dr Kristal a enfin pu se consacrer entièrement à la médecine de famille. Médecin très aimé, il a inspiré de nombreuses personnes de la région à choisir une carrière en médecine. Le Dr Kristal a fermé son cabinet 40 ans après ses études, mais est demeuré assistant en chirurgie et mentor jusqu’à 78 ans.

Quant au Dr Joe Roach, il a poursuivi sa brillante carrière à New Waterford jusqu’à un âge avancé4. Le Dr Richard Goldbloom, gentleman leader en pédiatrie au Canada, continue d’être une source d’inspiration pour les nouvelles générations de médecins à Halifax. Enfin, le Dr Gerald LeBrun est devenu doyen de la faculté de médecine de l’Université Dalhousie5. Pour terminer, le Dr Kristal s’est remémoré l’immense satisfaction ressentie lors d’une visite dans son vieux coin de pays. Il demandait des directions à un homme lorsqu’il a remarqué une cicatrice de trachéotomie à son cou. Plus de 30 ans auparavant, il avait sauvé la vie de cet homme, qui était alors un enfant atteint de diphtérie.


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Références
Is current preoperative frailty assessment adequate?

As the baby boom population ages, increasing numbers of patients aged 65 years and older are presenting with surgical disease. They are at increased risk for prolonged hospital admission. Although age is commonly used to assess surgical risk, it has been well established that preoperative frailty is more accurate at predicting postoperative outcomes. Frailty is a multisystem syndrome of low physiologic reserves resulting in increased risk for adverse events. It is increasingly recognized as an important determinant of postoperative complications and recovery. Frailty screening and the implementation of early interventions has been associated with preserved autonomy and reduced adverse events. Well-designed studies examining comprehensive geriatric assessment among surgical patients have shown improved outcomes, mostly in orthogeriatric populations. A systematic review by the Cochrane collaboration is ongoing to assess the robustness of these findings. Recommendations developed by the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society suggest the use of multiple preoperative assessments, including preoperative assessment of each patient for frailty. Despite mounting evidence, frailty assessment is not routine surgical practice, and it remains unclear why.

Frailty assessment is not currently well taught to surgeons or surgical nursing staff, and little is known about interdisciplinary surgical health care providers’ perception of frailty or its role in clinical assessment. We have recently undertaken a survey of our surgical staff at the University of Alberta Hospital to assess their beliefs about frailty and the barriers to frailty assessment, and we compared the perspectives across health care professions. The survey was distributed to all health care providers involved in the care of general surgery patients at our institution. It assessed the attitudes of 3 subgroups: surgeons, nurses and allied health professionals.

Previous research has found that frailty assessment and management improves patient outcomes in both medical and surgical patients; however, it continues to have low uptake in most surgical settings. We found the highest...
uptake among allied health practitioners; frailty assessment is less frequent outside of allied health professionals. Specifically, surgeons were less likely than both allied health professionals and nurses to use frailty in guiding patient care. A qualitative investigation by Age UK7 found frailty is viewed as something surgeons “know when they see,” yet numerous studies have reported that perceived frailty varies individually and is an inadequate proxy for measured frailty. This suggests that although health care professionals, particularly surgeons, acknowledge that frailty is an important factor in patients’ outcomes, they are overly reliant on their “gut” impression of a patient’s frailty and do not screen for or manage patients based on their frailty. Furthermore, we identified 4 key barriers to surgical care for frail patients: hospital-specific/institutional, health care system, professional knowledge, and patient/family members. These barriers lead to lack of confidence in conducting frailty assessments and inadequate delivery of elder-friendly surgical care.

A number of authors have identified similar knowledge gaps.7 Successfully addressing these gaps will require awareness of how health care professionals navigate relevant system complexities and constraints in their provision of care. Given that most health care delivery is based on a single problem-oriented diagnostic model and that health care professionals may not be trained to focus on the holistic care of patients, system reorganization around frailty is challenging. Furthermore, frailty is an evolving area of inquiry, and consensus has not yet identified a single optimal tool to identify frailty. That said, the availability of validated and rapidly administered tools permits the use of quick, reliable and easily interpreted frailty assessments in fast-paced surgical environments.

Our survey was limited by a low response rate, which raises the risk of response bias, and was limited by its single-centre design. There was strong agreement, however, for most items across the health professions, and the results were consistent with predicted attitudes of each profession.

It is clear that the use of formal frailty assessment tools has not been widely adopted in practice. Much of this may be due to inadequate education surrounding the effect of frailty on outcomes and tools to permit rapid assessment, particularly for surgeons. Creating a program to educate surgeons about the importance of frailty assessment — such as how it can improve their patients’ care and, most importantly, how to perform a rapid validated assessment — is key to improving uptake. Further research of comprehensive geriatric assessment for surgical patients should also be performed to determine if it is effective outside of orthogeriatric patient populations. Addressing barriers to frailty assessment and high-quality care for frail patients could substantially improve care and postoperative outcomes for this vulnerable population.

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Training Canadian surgeons in oncoplastic breast surgery: Where do we stand?

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SUMMARY

Breast-conserving surgery with adjuvant radiation therapy is widely accepted as a universal standard of care for women with early-stage breast cancer. Oncoplastic breast-conserving surgery (OPS) techniques have emerged in recent years, facilitating the achievement of better cosmetic results while adhering to good oncological principles. Compared with the rest of the international community, Canada has been fairly slow in its clinical uptake of OPS. This commentary discusses how Canada can increase its capacity for OPS.

Breast-conserving surgery with adjuvant radiation therapy is widely accepted as a universal standard of care for women with early-stage breast cancer. Prospective, randomized clinical trials with more than 20 years of follow-up data have reported no difference in mortality and overall survival in women who received breast-conserving surgery compared with women treated with mastectomy.1 The success of breast conservation depends on 2 goals: the surgery must successfully excise the entire cancer, and the cosmetic result needs to be such that the patient retains a cosmetically pleasing breast contour without deformity. Historically, breast conservation has not always achieved a good cosmetic result, leaving 30% of patients with a visible cosmetic deformity2 and resulting in negative patient-reported outcomes (body image and quality of life) and postradiation deformities that are severe and difficult to manage by the plastic surgeon.2

Oncoplastic breast-conserving surgery (OPS) techniques have emerged in recent years, facilitating the achievement of better cosmetic results while adhering to good oncological principles. The term “oncoplastic” first appeared in 1996,1 when Audretsch described the technique of reconstructing a partial mastectomy defect as a further refinement of breast conservation based on a basic principal of breast surgery: that it is much easier to prevent a cosmetic deformity than to repair it later. Since its introduction, OPS has enabled surgeons to remove greater volumes of tissue successfully, thus reducing mastectomy and re-excision rates. For the first time, patients with large-volume and multicentric disease are able to undergo breast conservation with superior cosmesis and long-term oncological safety.4

FORMAL CANADIAN ONCOPLASTIC TRAINING FELLOWSHIPS

Oncoplastic surgical techniques can be divided into 3 levels according to the extent of skill and training required to perform each of these procedures (Table 1), although the amount of training needed for competency has not yet been standardized. With more and more patients requesting and expecting an optimal postoperative appearance, it should be clear to...
breast surgeons that staying relevant in the field must include having an OPS skill set. However, compared with the rest of the international community, Canada has been fairly slow in its clinical uptake of OPS, with a recent study highlighting the lack of available formal training opportunities as a major barrier.1 Oncoplastic surgery has not traditionally been part of a general surgeon’s residency training, nor has it been a formal part of Canadian breast or general surgical oncology fellowship training. These fellowships have traditionally emphasized the development of surgical expertise in the multidisciplinary management of breast disease, with no formal OPS training built into the curriculum. Although fellows do spend time with local plastic surgeons, the scope of training is often limited to postmastectomy breast reconstruction and not methods for performing a cosmetically acceptable breast-conserving surgery while avoiding a mastectomy altogether. As such, Canadian OPS training has traditionally been independent of breast or general surgical oncology training programs.

Recently, owing to increasing demand, Western University and the University of Ottawa developed formal OPS fellowships of 1–2 years with the goal of teaching breast surgical oncology fellows or practising general surgeons to perform a full range of OPS techniques and tips and tricks for effective and efficient collaborations with plastic surgeons, patient selection for OPS, and assessing cosmetic results and patient satisfaction. Workshops are not-for-profit to maximize enrollment and training opportunities. All workshops to date have sold out in 24–72 hours. Further workshops took place in Ottawa and London in October and November, and more are planned throughout Canada (https://oncoplasticpartnershipworkshop.ca).

**CONCLUSION**

Historically, most surgeons felt that a postlumpectomy cosmetic defect or contour deformity was a small price to pay for curing breast cancer while avoiding a mastectomy. Today, with recent advances in modern breast cancer management, women can look forward to a long, healthy life after their breast cancer diagnosis. It is more important than ever to offer them a treatment option that preserves their quality of life and their sense of attractiveness and femininity. Oncoplastic surgery techniques allow the surgeon to not only completely excise the disease, but also maintain excellent cosmetic results. Hopefully there will be a steady rise in general and breast surgeons embracing OPS as they see the benefits reaped by patients who rightly demand better from us.

**Canadian Oncoplastic Courses for the Practising Surgeon**

Practising Canadian surgeons currently performing OPS have generally obtained their skills through courses taken internationally,1 as historically this has been an unmet need in Canada. In partnership with the University of Toronto, University of Ottawa and Western University, the Canadian Breast Surgery Innovations (CBSI) group began offering full-day OPS workshops in late 2016. This group, consisting of expert academic and community OPS surgeons, created the workshop with the goal of raising the standard of breast surgery delivered in Canada. These workshops are currently offered every few months and have been held in conjunction with national or regional general surgery or breast cancer conferences to maximize exposure and enrollment. The workshops include a combination of didactic lectures, comprehensive videos, case discussions and hands-on cadaveric dissections under direct supervision. Participants learn a range of oncoplastic techniques and tips and tricks for effective and efficient collaborations with plastic surgeons, patient selection for OPS, and assessing cosmetic results and patient satisfaction. Workshops are not-for-profit to maximize enrollment and training opportunities. All workshops to date have sold out in 24–72 hours. Further workshops took place in Ottawa and London in October and November, and more are planned throughout Canada (https://oncoplasticpartnershipworkshop.ca).

**Table 1. Classification of oncoplastic breast procedures**

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I</td>
<td>Dual plane undermining, nipple undermining, glandular advancement and lumpectomy defect closure</td>
</tr>
<tr>
<td>Level II</td>
<td>Glandular rotations, skin excision, de-epithelialization and nipple areolar complex recentralization, round block (Binelli) mastopexy, crescent mastopexy, raquet mastopexy, hemibatwing and batwing</td>
</tr>
<tr>
<td>Level III</td>
<td>Reduction mammoplasty procedures with contralateral balancing procedures-wise pattern reduction, vertical mammoplasty, V/J mammoplasty</td>
</tr>
</tbody>
</table>

*Levels I and II can be learned and performed independently by many surgeons; level III techniques involve the contralateral normal breast and are often jointly performed with the plastic surgeon.*
Competing interests: None declared.

Contributors: All authors contributed substantially to the conception, writing and revision of this article and approved the final version for publication.

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**CJS’s top viewed articles***

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The 1917 Halifax Explosion: the first coordinated local civilian medical response to disaster in Canada

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HISTORY OF SURGERY: FIRST WORLD WAR
HISTOIRE DE LA CHIRURGIE : PREMIÈRE GUERRE MONDIALE

In retrospect, the remarkable feature of the Halifax Explosion is that a collision of its kind did not occur earlier, given the volume of military marine traffic entering the Bedford Basin. In 1917, the fourth year of the First World War, hundreds of Allied ships lay protected in the natural harbour by the narrow body of water between the cities of Halifax and Dartmouth, NS. One hundred years ago, on December 6 at 9:04 am, an accidental collision between the SS Imo (Norway) and the SS Mont Blanc (France) detonated in the Halifax Harbour, resulting in the world’s largest man-made, non-nuclear explosion. The immediate casualty toll was 1600 dead and 7500 wounded, and it eventually rose to 1950 dead and 8000 injured. Casualties were mainly on the Halifax side of the harbour because of the location and drift of the munitions-laden SS Mont Blanc, which caught fire, smoke rising 2000 feet into the sky, and exploded 17 minutes later. There was a reflex suspicion of espionage, as would be expected today, and all Germans in the area were arrested. In reality, the accidental collision and secondary explosion destroyed the city of Halifax, leaving unprepared health care providers to respond to a catastrophe of unprecedented proportions.

Two events dominate the retold story of the Halifax Explosion: the heroic messaging by dispatcher Vincent Coleman to halt trains coming to Halifax — “Hold up the train. Ammunition ship afire in harbor making for Pier 6 and will explode. Guess this will be my last message. Good-bye boys.” — and the generous rescue response from the United States. The disaster could not have occurred at a worse time for Halifax, as many medical and nursing staff in the the No. 7 Canadian Stationary Hospital had been deployed to France; all remaining local physicians, nurses and medical students mobilized immediately to treat the injured. Delayed by snow storms, American medical units arrived between Dec. 9 and 12 from the Massachusetts State Guard, Maine National Guard, Red Cross (Boston) and Red Cross (Rhode Island). The immediate care and the bulk of care thereafter was provided by Nova Scotian physicians, nurses and students, supplemented by an extraordinarily fast mobilization of physicians and nurses from the other Maritime provinces. Despite the remarkable local response, a tendency to believe that all the medical care of the wounded was

The 1917 Halifax Explosion was an unfortunate but predictable tragedy, given the sea traffic and munitions cargo, resulting in sudden large-scale damage and catastrophic injuries, with 1950 dead and 8000 injured. Although generous support was received from the United States, the bulk of the medical work was undertaken using local resources through an immediate, massive, centrally coordinated medical response. The incredible care provided 100 years ago by these Canadian physicians, nurses and students is often forgotten, but deserves attention. The local medical response to the 1917 disaster is an early example of coordinated mass casualty relief, the first in Canada, and remains relevant to modern disaster preparedness planning. This commentary has an appendix, available at canjsurg.ca/016317-a1.
provided by the United States started early and has persisted (Appendix 1, available at canjsurg.ca/016317-a1).

The walking wounded went to the nearest point of care. Dr. John Cameron and the patient he was examining in his office were shielded by a large flower pot from the window glass that was blown in by the explosion. His clinic was quickly overwhelmed with patients, as was that of Dr. Lewis Thomas on Brunswick Street. Dr. Thomas was told by patients in the line that Dr. Murdoch Chisholm next door was probably dead. Thomas immediately went to Chisholm and found him alive but unconscious, bleeding from a head wound. He provided first aid and arranged for Chisholm’s transfer to the Victoria General Hospital (VGH). In all, 90 physicians in Halifax and Dartmouth treated the wounded either in their clinics or local hospitals (Appendix 1).

Although the No. 7 Canadian Stationary Hospital (Dalhousie University) had deployed several of its finest staff, VGH responded with skill and resilience. Dr. George Murphy described the VGH entrance as quickly “jammed with autos, wagons, and every conveyance capable of carrying a sufferer. The hallways, offices, and every bit of floor space was littered with human beings suffering with all degrees and manners of wounds and injuries.”

With general surgery colleagues Drs. John MacDougall and Henry MacDonald, ophthalmologists Drs. Everind Kirkpatrick and Evatt Mathers, and anesthetist Dr. Frederick Lessel, Murphy operated for 72 hours without a break. The VGH used its 200 beds to look after 575 injured and burned patients (Appendix 1).

In all, 10 hospitals were used during the emergency: VGH, The Halifax Infirmary, The Children’s Hospital, The Nova Scotia Hospital, The Cogswell Street Military Hospital, Camp Hill Military Hospital, Pier 2 Military Hospital, Dr. Courtenay Ligoure’s Private Hospital, Dr. Anthony Mader’s Private Hospital and Pine Hill Convalescent Hospital. In addition, treatment centres were improvised at the YMCA, Bellevue House, St Mary’s College, Halifax Ladies College, the Waegwoltic Tennis Club and ships in the harbour. Dalhousie medical students were pressed into service at several of these sites, overseen by surgeons, such as Dr. Murphy, who constantly travelled from one site to another.

The Canadian Army Medical Corps supplied 56 doctors and 136 nurses from ships in the harbour. American teams set up in these improvised hospitals, including Dr. Ernest Codman, who though critical of hospitals in his native Boston was complimentary of the medical arrangements in the YMCA. The Halifax Relief Committee was established within hours of

Fig. 1. Unidentified doctor and nurses, in the Nova Scotia Hospital dressing burns on children injured in the 1917 Halifax Explosion. Archives Nova Scotia.

Fig. 2. YMCA where Ernest Codman and a team from Boston set up an emergency hospital as part of the relief effort for the 1917 Halifax Explosion. Nova Scotia Archives and Records Management, Lola Henry Collection, No. 1979–237.8.
the explosion in order to coordinate the complex medical response. Later the committee would oversee reconstruction and compensation of victims (Appendix 1).9

An unintended consequence of Vincent Coleman’s heroic telegraphing was the immediate notification about the disaster to all communities along the railway lines. From around the Maritimes, 153 physicians and 174 nurses immediately made their way to Halifax by train to help. Such an extraordinary mobilization was possible because 90% of medical personnel was still at home, despite the fact that Nova Scotia deployed 2 wartime hospitals, unlike some newer provinces where more than 50% had volunteered for overseas service.10 Many of these volunteers undertook general surgery, including Dr. David Hartigan from New Waterford.11 Others provided specialist care.

Penetrating eye injuries were extraordinarily prevalent in the Halifax Explosion because of flying glass shards.12 The smoke cloud of the ignited SS Mont Blanc rose high in the air, and women, men and children stopped to watch through windows not knowing that minutes later the vessel would explode, shattering every window in the city.13 Dr. George Cox came from New Glasgow and, with 12 other ophthalmologists, operated on 592 eyes, enucleating 249 eyes, with 16 double enucleations.14 Other physicians, such as Dr. Avery DeWitt of Wolfville, were asked to care for patients on hospital trains evacuating wounded out of Halifax (see the film “Halifax Explosion: The Aftermath and Relief Efforts (1917),” available at www.youtube.com/watch?v=5P1mhLMxTXc; caring for the wounded on trains begins at 4:48 of the film). DeWitt, with only the help of his 75-year-old father Dr. George DeWitt and his sister Nurse Nellie Anderson DeWitt, looked after a trainload of dying and injured patients in an improvised hospital in Truro because all of the town’s doctors had gone to Halifax.1

The medical response to the 1917 disaster is the first example of local coordinated civilian mass casualty relief in Canada, and many features of the successful response are echoed in modern disaster preparedness planning. Despite a final death toll of 1950, about 8000 of the injured survived. One hundred years later we pay tribute to the Canadian physicians, nurses and students who successfully coordinated the impressive local medical response so rarely emphasized in reviews of the Halifax Explosion.

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References
Experience with the SynCardia total artificial heart in a Canadian centre

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Background: The SynCardia total artificial heart (TAH) provides complete circulatory support by replacing both native ventricles. Accepted indications include bridge to transplantation and destination therapy. We review our experience with TAH implantation during a period when axial flow pump became available.

Methods: We retrospectively analyzed the demographics, clinical characteristics and survival of all patients receiving the TAH.

Results: From September 2004 to November 2016, 13 patients (12 men, mean age 45 ± 13 yr) received the TAH for refractory cardiogenic shock secondary to idiopathic (56%) or ischemic (17%) cardiomyopathy and to other various causes (33%). Before implantation, mean ejection fraction was 14% ± 4%, 7 (54%) patients had previous cardiac surgery, 4 (31%) were on mechanical ventilation, and 3 (23%) patients were on dialysis. The mean duration of TAH support was 46 ± 40 days. Three (23%) patients died while on support after a mean of 15 days. Actuarial survival on support was 77% ± 12% at 30 days after implantation. Complications on support included stroke (n = 1, 8%), acute respiratory distress syndrome requiring prolonged intubation (n = 5, 38%) and acute renal failure requiring temporary dialysis (n = 5, 38%). Ten (77%) patients survived to be transplanted after a mean of 52 ± 42 days of support. Actuarial survival rates after transplant were 67% ± 16% at 1 month and 56% ± 17% at 1 year after transplantation.

Conclusion: The TAH provides an alternative with low incidence of neurologic events in extremely fragile and complex patients waiting for heart transplantation. Complex and unusual anatomic conditions explained the current use of TAH.


Méthodes : Nous avons analysé de manière rétrospective les caractéristiques démographiques et cliniques et la survie de tous les patients ayant reçu un CAT.

Résultats : De septembre 2004 à novembre 2016, 13 patients (12 hommes, âge moyen 45 ± 13 ans) ont reçu le CAT pour un choc cardiogénique réfractaire dû à la cardiomyopathie idiopathique (50 %) ou ischémique (17 %) ou à d’autres causes (33 %). Avant l’implantation, la fraction d’éjection était en moyenne de 14 % ± 4 %, 7 patients (54 %) avaient déjà subi une chirurgie cardiaque, 4 (31 %) étaient sous ventilation mécanique et 3 (23 %) étaient dialysés. La durée moyenne du soutien par CAT a été de 46 ± 40 jours. Trois patients (23 %) sont décédés malgré l’implantation du dispositif après une moyenne d’utilisation de 15 jours. La survie actuarielle pendant l’utilisation du dispositif a été de 77 % ± 12 % 30 jours suivant l’implantation. Les complications ont inclus : accident vasculaire cérébral (n = 1, 8 %), syndrome de détresse respiratoire aiguë nécessitant une intubation prolongée (n = 5, 38 %) et insuffisance rénale aiguë nécessitant une dialyse temporaire (n = 5, 38 %). Dix patients (77 %) sont survivus jusqu’à leur greffe après une moyenne d’utilisation de 52 ± 42 jours. Les taux de survie actuarielle après la greffe ont été de 67 % ± 16 % après 1 mois et de 56 % ± 17 % après 1 an suivant la greffe.

Conclusion : Le CAT est une solution de rechange qui s’accompagne d’une incidence faible de complications neurologiques chez des patients à l’état extrêmement fragile et complexe en attente d’une greffe cardiaque. Des complications anatomoiques inhabituelles ont expliqué l’utilisation du CAT.
End-stage heart failure is a public health problem affecting an increasing number of patients each year. Although a variety of options exist for its treatment, heart transplantation remains the gold standard. Unfortunately, the lack of donors is now leading to increased use of ventricular assist devices (VAD) as a bridge to transplant (BTT) or as destination therapy (DT). Among patients with advanced heart failure, those with biventricular failure have the worst prognosis and very few available options while waiting for a compatible donor. They are usually more fragile preoperatively, with more comorbidities, including renal and hepatic dysfunction, than patients receiving sole left ventricular support. Implantation of a total artificial heart (TAH) is an alternative to durable biventricular VAD (BiVAD) support.

At the Montreal Heart Institute, we have used the SynCardia TAH since 2004 as a cardiac assist device in patients with critical biventricular failure, patients in whom apical cannulation for left VAD (LVAD) support is contraindicated, and in patients with specific anatomical conditions precluding the use of a standard LVAD (e.g., patients with congenital diseases). We sought to review our experience with TAH implantation during a period when axial flow pump became available.

**Methods**

Between January 2004 and November 2016, 51 durable circulatory assist devices, mostly the HeartMate II device, have been implanted at our institution. Biventricular assistance was required in 13 (24%) patients, all of whom received the SynCardia TAH as a bridge to transplantation. The decision to implant a TAH over a simpler LVAD was made owing to the presence of conditions most often associated with multiorgan failure: severe preoperative right ventricular dysfunction, which was assessed through right heart catheterization, echocardiography and clinical examination; uncontrolled malignant ventricular arrhythmia; massive acute infarction; severe left ventricular hypertrophic cardiomyopathy; and noncompaction left heart and congenital anomalies. Patients with a functional New York Heart Association (NYHA) class IV and a body surface area (BSA) equal to or greater than 1.7 m² or with an anteroposterior diameter greater than 10 cm (measured at T10 from the sternum to the anterior face of the vertebral body on CT of the chest) were eligible for TAH implantation.

**SynCardia TAH**

Implantation of the TAH consists of excision of both ventricles and the 4 native valves. Clinical experience with this device has been described previously. Briefly, it is a pneumatic blood pump with 2 polyurethane ventricles and 4 monodisk mechanical prostheses (Medtronic-Hall, Medtronic Inc.). Each ventricle has a volume of 70 mL and comprises a silicone diaphragm separating blood from the pneumatic chamber. The pulsed injection of compressed air allows the movement of the diaphragm and thus the filling and evacuation of both ventricles. The 2 artificial ventricles are directly sutured to the patient’s native atria and connected to an external console via 2 drivelines. Since 2006, the emergence of new hand-held consoles has made home discharge with TAH possible, but their use has been approved only recently in North America (2011 in Canada, and 2014 in the United States).

**Patient management**

The TAH implantation technique is similar to a usual orthotopic transplant and has been described previously. All patients who received a TAH were systematically anticoagulated with acetylsalicylic acid (ASA; 325 mg/d), warfarin (target international normalized ratio [INR] of 2.5–3.5) and dipyridamole.

**Data collection**

Clinical and laboratory data were collected retrospectively from our transplantation and heart failure database. We obtained informed consent from each patient, and our institution’s ethics committee approved the study. All patients were followed prospectively at the cardiac transplantation and ventricular device clinic at our institution.

**Statistical analysis**

Statistical analyses were performed using the Statistical Package for Social Sciences version 20. Continuous data are presented as means ± standard deviations, and categorical variables are presented as frequencies (%). Survival data were analyzed using Kaplan–Meier estimates. We calculated the estimated survival without including patients at the time of transplantation to assess overall survival after positioning the device.

**Results**

**Baseline characteristics**

Between January 2004 and November 2016, 13 (25%) of our 51 patients receiving long-term mechanical circulatory support received a TAH. Patients’ demographic and clinical characteristics and causes of heart failure are shown in Table 1. Most patients were men (12, 92%), and the patients’ mean age was 45 ± 12 (range 21–68) years. They had a mean BMI of 25.9 ± 2.9 and an average body surface area of 1.93 ± 0.1. Four (31%) patients had prior cardiac surgery, including 2 heart transplantations, 1 mechanical mitral valve replacement and 1 congenital
heart surgery (failed Fontan). One patient was in constant refractory ventricular arrhythmia during the 48 hours preceding TAH implantation, 1 had an aortic aneurysm of the ascending aorta necessitating resection at the time of implantation, 1 had a severe form of hypertrophic cardiomyopathy precluding any trial of an insertion of an LV cannulation for LVAD support, 1 had a massive anteropapical myocardial infarction, and 1 had a nocompaction left ventricular cavity also precluding the insertion of an apical cannula.

Patients with biventricular failure who had a Right Ventricular Stroke Work Index (RVSWI) lower than 300 were evaluated for implantation of the TAH and rejected for a simple LVAD support. All patients had elevated serum creatinine and bilirubin measurements above normal values, suggesting the presence of multorgan failure (Table 1).

**Patient status before implantation**

Five patients (38%) received mechanical respiratory support preoperatively for an average of 0.75 ± 1.3 days before implantation. Those 5 patients also had an intrapleural balloon pump. One (8%) patient was on extracorporeal membrane oxygenation (ECMO) support after primary graft failure following transplantation. Three patients (23%) were on dialysis, initiated 7, 9 and 21 days before TAH implantation, respectively. Four (31%) patients had chronic renal failure before implantation (defined as either kidney damage or estimated glomerular filtration rate [eGFR] < 60 mL/min/1.73 m² for > 3 mo).

**Surgical technique**

The mean duration of clamping and of cardiopulmonary bypass were 85 ± 25 minutes and 103 ± 27 minutes, respectively. One (8%) patient had concomitant atrial septal defect closure, and another patient had a replacement of an aneurysmal dilatation of the ascending aorta.

**Outcomes and complications while on TAH support**

The patients were supported with TAH for a mean duration of 46 ± 40 (range 1–384) days. Three (23%) patients died while on support after an average of 16 ± 0.7 days. Their causes of death were multiple organ failure, acute necrotizing pneumonia and stroke, respectively. The 30-day estimated actuarial survival while on TAH support was 77% ± 12%.

Postoperative complications are listed in Table 2. Eight (62%) patients experienced substantial early postoperative bleeding, requiring multiple blood transfusions, and 5 (38%) patients required reoperation. Seven (54%) patients experienced acute renal failure, requiring temporary hemofiltration, with 1 patient remaining on chronic hemodialysis. Patients were weaned from mechanical ventilatory support after an average of 1.9 ± 1.6 days, and the mean length of stay in the intensive care unit length was 38 ± 32 days. Five (38%) patients required prolonged mechanical ventilator support for respiratory failure.

According to our institutional policy, patients were not allowed to be discharged home with a portable console.

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**Table 1. Preoperative patient characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SD or no. (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at implantation, yr</td>
<td>45 ± 12</td>
</tr>
<tr>
<td>Sex, male:female</td>
<td>12:1</td>
</tr>
<tr>
<td>BSA</td>
<td>1.93 ± 0.1</td>
</tr>
<tr>
<td>BMI</td>
<td>25.9 ± 2.9</td>
</tr>
<tr>
<td>Preoperative support</td>
<td>4 (33)</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>4 (33)</td>
</tr>
<tr>
<td>IABP</td>
<td>11 (91)</td>
</tr>
<tr>
<td>Inotropes</td>
<td>14.6 ± 2.9</td>
</tr>
<tr>
<td>Preoperative LVEF</td>
<td>4 (33)</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>4 (33)</td>
</tr>
<tr>
<td>Preoperative ARF†</td>
<td>2 (16)</td>
</tr>
<tr>
<td>Preoperative dialysis</td>
<td>5 (33)</td>
</tr>
<tr>
<td>INTERMACS status 1 or 2</td>
<td>8 (67)</td>
</tr>
<tr>
<td>Etiology</td>
<td></td>
</tr>
<tr>
<td>DCM (noncompaction of the left heart, uncontrolled VT, multiple LV mural thrombi)</td>
<td>6 (50)</td>
</tr>
<tr>
<td>ICM (acute anteropapical myocardial infarction)</td>
<td>2 (17)</td>
</tr>
<tr>
<td>Other (primary graft failure, mechanical MVR, Failed Fontan, hypertrophic cardiomyopathy)</td>
<td>5 (33)</td>
</tr>
<tr>
<td>Preoperative laboratory data</td>
<td></td>
</tr>
<tr>
<td>Sodium, mmol/L</td>
<td>134 ± 7</td>
</tr>
<tr>
<td>Creatinine, μmol/L</td>
<td>156 ± 79</td>
</tr>
<tr>
<td>eGFR-MDRD, mL/min/1.73 m²</td>
<td>70.6 ± 35.3</td>
</tr>
<tr>
<td>BUN, mmol/L</td>
<td>10.5 ± 0.6</td>
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<tr>
<td>Bilirubin, μmol/L</td>
<td>50.5 ± 9.2</td>
</tr>
<tr>
<td>Lactate, mmol/L</td>
<td>2.8 ± 1.8</td>
</tr>
</tbody>
</table>

*Unless indicated otherwise.
†Delta creatinine > 100 μmol/L or > 50% baseline.

**Table 2. Outcomes of total artificial heart support**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean ± SD or no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of support, d</td>
<td>46 ± 40</td>
</tr>
<tr>
<td>Outcome</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Died on support</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Transplanted</td>
<td>10 (77)</td>
</tr>
<tr>
<td>Neurologic events</td>
<td>TIA (&lt; 24 hr)</td>
</tr>
<tr>
<td>Stroke</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Bleeding requiring reoperation</td>
<td>5 (38)</td>
</tr>
<tr>
<td>Infection</td>
<td>6 (46)</td>
</tr>
<tr>
<td>ARF requiring dialysis*</td>
<td>7 (54)</td>
</tr>
</tbody>
</table>

*Delta creatinine > 100 μmol/L or > 50% baseline.
when these became available in Canada in 2011. While on support, 1 (8%) patient experienced hemorrhagic (ischemic) stroke 15 days after transplantation, and 1 (8%) had a transient ischemic attack (TIA) (< 24 h and without sequelae) 6 days after surgery. Six (46%) patients experienced systemic infections, 1 (8%) a driveline infection, 1 (8%) bacterial mediastinitis, 1 (8%) fungal sepsis possibly related to the device, and 2 (15%) bacterial pneumonias.

**Overall survival after implantation of the TAH**

After a mean follow-up of 807 ± 1230 days, 7 patients (54%) had died. The total estimated actuarial survival after device implantation (patients censored at the time of explant) was 77% ± 12% at 30 days.

**Survival after transplantation**

Ten (77%) patients were successfully transplanted after a mean of 51 ± 42 days of TAH support. Actuarial survival after transplantation was 67% ± 16% at 1 month and 56% ± 17% 1 year after transplantation.

**Discussion**

Replacing 2 native ventricles and 4 cardiac valves, the TAH provides a flow rate of 7–9 L/min, improving systemic perfusion and decreasing filling pressures. Although the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) reported only 301 TAH implantations for the period June 2006 to December 2014, TAH remains a valid option for patients with irreversible biventricular failure and in those with specific anatomical conditions. Indications for TAH include extensive acute anteroapical myocardial infarction, acute or chronic cardiac rejection, left ventricular insufficiency with previous mechanical valves in place, acquired inoperable left ventricular mural thrombi, intractable ventricular arrhythmia, failure of Fontan correction, end-stage hypertrophic cardiomyopathy, and noncompaction of the left heart.

In this report, we reviewed our experience using the SynCardia TAH in BTT patients. This device was used in extremely sick patients (all patients were in INTERMACS I or II) with biventricular failure awaiting transplantation or with special conditions precluding the use of simpler axial flow pump LVAD. The posttransplant survival of this sicker population is expected to be lower than in our usual patients. The need for a TAH in our program was 24% (n = 13), which is higher than data reported by INTERMACS (4%, n = 697 of 15 743), possibly because of the limited availability of this technology compared with the widespread availability of more traditional LVADs.

Survival to transplantation varies greatly, ranging between 26% and 79%, as reported by the CardioWest TAH investigators. Moreover, in a recent report on more than 100 patients who received TAH, Copeland and colleagues reported a survival to transplantation of 68% and a posttransplant survival of 77%, for a global survival from implantation of 52%. La Pitié-Salpêtrière Hospital reported a similar success rate of BTT of 61% after a mean support duration of 97 ± 97 days.

At our institution, the TAH is the preferred device for durable biventricular support in eligible patients awaiting transplantation. The BTT rate compares favourably with those reported in the literature. Those results are mainly owing to rigorous patient selection and decision to proceed to temporary circulatory support, although these patients were at high risk of immediate death. Kirsch and colleagues identified older age and preoperative mechanical ventilation as major risk factors while on support. Others have also reported perioperative mechanical ventilation as a risk factor for death while on support. Indeed, the need for perioperative mechanical ventilation reflects the magnitude of cardiogenic shock and the patient’s critical preoperative condition.

One (8%) patient had a stroke while on support. This incidence of neurologic events was similar to those reported around the world. However, most of these studies are retrospective by nature and could have underestimated the incidence of stroke, because not all patients underwent systematic brain imaging. In the present study, we performed brain imaging on a clinical basis only. Furthermore, the TAH compares favourably with BiVAD devices in terms of early/mid-term survival or stroke. This is likely because of the complete removal of both ventricles, the absence of residual thrombi and the use of shorter drivelines with large-diameter cannula. Also, local antithrombotic management could be associated with those low rates of neurologic events.

Our institutional policy is to keep the TAH recipients in the hospital until transplantation. However, the recent emergence of mobile consoles allows home discharge. Only a few centres have reported their experience with these portable drivers. Demondion and colleagues described 12 (44%) patients discharged home over a 4-year period, with an average wait of 88 days from TAH implantation to transplant. Hence, the high costs associated with ICU stay and the economic burden on the hospital could be limited with an earlier home discharge for these patients. Furthermore, the authorization by the US Food and Drug Administration for implantation of a TAH as DT in 2014 as well as the development of a 50 mL pump for small adults or children (< 40 kg) could extend the indications for TAH beyond a BTT strategy.

The average survival of 57% 1 year after transplantation among patients who received a TAH is lower than that in patients who received the HeartMate II device in our experience. A policy of routine discharge home with a hand-held console after TAH implantation may allow for
complete patient recovery before transplantation and better survival at 1 year.

CONCLUSION

Although the increasing dominance of LVAD continuous-flow pumps is now well established, the TAH remains a viable option in our strategy to support patients with biventricular failure and with special clinical or anatomical conditions. This device offers an effective means of bridging critically ill patients to heart transplantation by replacing all native ventricles. The current availability of the hand-held consoles could improve the patient’s condition at the time of transplantation, allowing out of the hospital care for patients during mechanical support with the TAH.

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Competing interests: None declared.

Contributors: A. Nguyen and M. Carrier designed the study, acquired and analyzed the data, which M. Pellerin, L. Perrault, A. Ducharme and N. Racine also analyzed. A. Nguyen and M. Carrier wrote the article, which all authors reviewed and approved for publication.

References

Canadian benchmarks for acute injury care

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Background: Acute care injury outcomes vary substantially across Canadian provinces and trauma centres. Our aim was to develop Canadian benchmarks to monitor mortality and hospital length of stay (LOS) for injury admissions.

Methods: Benchmarks were derived using data from the Canadian National Trauma Registry on patients with major trauma admitted to any level I or II trauma centre in Canada and from the following patient subgroups: isolated traumatic brain injury (TBI), isolated thoracoabdominal injury, multisystem blunt injury, age 65 years or older. We assessed predictive validity using measures of discrimination and calibration, and performed sensitivity analyses to assess the impact of replacing analytically complex methods (multiple imputation, shrinkage estimates and flexible modelling) with simple models that can be implemented locally.

Results: The mortality risk adjustment model had excellent discrimination and calibration (area under the receiver operating characteristic curve 0.886, Hosmer–Lemeshow 36). The LOS risk-adjustment model predicted 29% of the variation in LOS. Overall, observed:expected ratios of mortality and mean LOS generated by an analytically simple model correlated strongly with those generated by analytically complex models ($r > 0.95$, $κ$ on outliers > 0.90).

Conclusion: We propose Canadian benchmarks that can be used to monitor quality of care in Canadian trauma centres using Excel (see the appendices, available at canjsurg.ca). The program can be implemented using local trauma registries, providing that at least 100 patients are available for analysis.

Contexte : L'issue des traitements dispensés dans les services de traumatologie d'urgence varie substanriellement d'une province canadienne et d'un centre de traumatologie à l'autre. Notre but était d'établir des valeurs de référence pour suivre la mortalité et la durée des séjours hospitaliers en traumatologie au Canada.

Méthodes : Les paramètres ont été sélectionnés à partir des données du Registre national des traumatismes concernant les grands polytraumatisés admis dans tout centre de traumatologie de niveau I ou II au Canada et selon les catégories de patients suivantes : traumatisme crânien isolé (TCI), traumatisme thoraco-abdominal isolé, traumatisme plurisystémique fermé, âge de 65 ans ou plus. Nous avons évalué la validité prédictive à l'aide de critères discriminants et de paramètres d'étalonnage et nous avons procédé à des analyses de sensibilité pour évaluer l'impact du remplacement de méthodes analytiques complexes (imputation multiple, estimations par contraction des coefficients et modélisation flexible) par des modèles simples applicables à l'échelle locale.

Résultats : Le modèle d'ajustement du risque de mortalité s’est révélé doté d’un pouvoir discriminant et d’un étalonnage excellents (aire sous la courbe de la fonction d’efficacité du récepteur [ROC] 0,886, test de Hosmer–Lemeshow 36). Le modèle d’ajustement du risque pour la durée des séjour hospitaliers a permis de prédire 29 % de sa variation. De plus, les rapports observés:attendus pour la mortalité et la durée moyenne des séjours hospitaliers générés par un modèle analytique simple ont été en étruite corrélation avec les rapports générés par les modèles analytiques complexes ($r > 0.95$, $κ$ pour valeurs aberrantes > 0.90).

Conclusion : Nous proposons des valeurs de référence canadiennes qui peuvent être utilisées pour faire le suivi de la qualité des soins dans les centres de traumatologie canadiens à l’aide d’un simple programme Excel (voir les annexes, accessible à l’adresse canjsurg.ca). Le programme peut être appliqué à l’aide des données des registres de traumatologie locaux à la condition qu’au moins 100 patients y soient accessibles pour analyse.
Important improvements in mortality and morbidity associated with injury have been achieved with the introduction of trauma systems. However, variations in patient outcomes have been observed even among level I trauma centres in the United States and Canada, and suboptimal quality of care has been documented in up to 50% of trauma system admissions. Research has suggested that benchmarking activities stimulate quality improvement, which in turn improves patient outcomes.

Institutional evaluation of injury care is often limited to preventable morbidity and mortality case conferences or observed:expected (O:E) mortality ratios derived using the outdated Trauma Injury Severity (TRISS) model. Hospitals worldwide now have the opportunity to participate in the Trauma Quality Improvement Program (TQIP) of the American College of Surgeons, which produces quality reports, including indicators of mortality and major complications. However, TQIP costs preclude participation among low-volume or budget-constrained centres. Furthermore, while international comparisons are certainly informative, given the differences in patient populations and health care systems, there is also a need to compare injury outcomes nationally. In order to drive national, provincial, and institutional efforts to improve the quality of injury care in Canada, there is a need to develop Canadian benchmarks that will enable trauma centres nationwide to evaluate their injury outcomes using routinely collected data.

The objective of this study was to develop Canadian benchmarks to evaluate acute injury care in terms of mortality and hospital length of stay (LOS).

Methods

Study setting, population and data

Benchmarks were based on injury admissions to level I and II trauma centres across Canada between Apr. 1, 2006, and Mar. 31, 2012. Patient-level data were extracted from the National Trauma Registry comprehensive data set, which contains information on sociodemographic characteristics, circumstances of injury, anatomic injury descriptions, physiologic parameters, interventions, and outcomes for patients admitted with major trauma to level I and II trauma centres across Canada. Data are abstracted from patient files by trained data coders in each hospital according to a standardized data dictionary. Anatomic injury is coded using the Abbreviated Injury Scale (AIS) according to guidelines published by the Association for the Advancement of Automotive Medicine (AAAM). The registry was centralized at the Canadian Institute of Health Information (CIHI), where data quality was managed.

Patients

All adults (age ≥ 16 yr) with major trauma, defined as an injury severity score (ISS) greater than 12, were included in the study. Patients coded as dead on arrival and patients who arrived with no vital signs and died within 30 minutes were excluded. For benchmarking LOS, only live discharges were included. Previous analyses of the same data showed no significant changes in benchmarking results when deaths were included in a competitive risks framework. The research ethics board of the CHU de Québec approved our study.

Outcomes

Mortality was defined as any deaths occurring between arrival at the emergency department and hospital discharge. Length of stay in the index hospital was calculated as the number of days between admission and discharge, truncated at 90 days; any LOS longer than 90 days was attributed 90 days to minimize the influence of extreme values. Length of stay has a right-skewed distribution and was therefore modelled using a natural log transformation. The natural log transformation generates geometric means that are approximately equivalent to the median.

Previous research has suggested that additional acute care days owing to interfacility transfer do not influence benchmarking results.

Derivation of risk-adjustment models

Mortality was modelled using logistic regression and LOS using a log-linear model. Candidate risk-adjustment variables (i.e., baseline patient demographic and clinical characteristics) were determined a priori using previous work by our research team. Variable selection was based on bootstrap resampling. Variables that were statistically significant in more than 70% of 500 bootstrap samples of size n were included in the final risk-adjustment model. Models were derived for the whole patient population (all injury) and for 4 injury subgroups:

- isolated traumatic brain injury (TBI), defined as patients with any of the AIS codes 115299.9, 115999.9, 115099.9, 113000.6, 116002.3, 116004.5, 100999.9, 100999.9, 113000.6, 116000.3, 116002.3, 116004.5, 120099.3–22899.3, 130202.2–132699.2, 140202.5–140799.3, 150000.2–150408.4, 161000.1–161013.5 and no injury in another body region with an AIS of 3 or higher;
- isolated thoracoabdominal injury, defined as an injury to the thorax or abdomen with an AIS of 3 or higher and no injury in another body region with an AIS of 3 or higher;
- blunt multisystem injury, defined as injuries in at least 2 body regions with an AIS of 3 or higher; and
- patients aged 65 years or older.
In the database used to produce risk-adjustment models (Canadian National Trauma Registry, 2006–2012), injury coding was based on AIS90 (updated to 98). Most trauma registries across Canada converted to AIS05 shortly after 2012. We therefore produced risk-adjustment models for AIS90 and for AIS05. For the latter we converted AIS90 codes to AIS05 codes using validated conversion algorithms recommended by the AAAM.

Validation of models

The predictive performance of mortality risk–adjustment models derived with 2006–2011 data (derivation sample) was evaluated with 2012 data (validation sample). We assessed discrimination with the area under the receiver operating characteristic curve (AUC) and calibration with the Hosmer–Lemeshow statistic and Cox’s calibration intercept and slope. We evaluated overall model fit with Nagelkerke’s $R^2$. Risk-adjustment models for mortality were considered to have excellent discrimination if $0.8 \leq \text{AUC} < 0.9$ and outstanding discrimination if AUC $\geq 0.9$. We evaluated risk-adjustment models for LOS with $r^2$ statistics.

Benchmarking

Benchmarking is based on Agency for Healthcare Research and Quality (AHRQ) methodology. For mortality, we calculated the O:E ratio by applying coefficients from the risk-adjustment models described previously (derived using 2006–2011 data) to hospital-specific patient characteristics (2012 data). Benchmarking on LOS was based on the ratio of the sum of observed hospital days to expected hospital days.

Sensitivity analyses

Our goal was to derive an analytically simple benchmarking method that would enable trauma centres to calculate their own benchmarking statistics locally. We therefore performed extensive sensitivity analyses to evaluate the impact of analytically complex methods, considered to be the gold standard in benchmarking methodology. We performed multiple imputations for missing data, shrinkage estimates to handle unstable estimates for low-volume centres and used flexible modelling techniques for continuous covariates.

Handling missing data

Glasgow Coma Scale (GCS) scores were missing for 20% of data observations. In most benchmarking analyses, observations with missing GCS are excluded. This may introduce bias, as the GCS is not missing completely at random; rather, it is frequently missing for patients with minor extracranial injury and for patients who are sedated and intubated on arrival. An alternative method is to attribute a GCS value based on the value of variables highly correlated to the GCS, such as maximum head AIS (single imputation). However, this method does not account for the complex covariance structure of the analysis or the uncertainty surrounding the missing value and, therefore, tends to underestimate variance (too many outliers). The current gold standard for handling missing data in benchmarking analysis is multiple imputation. However, this method requires complex analytical skills. We compared O:E ratios generated using single imputation to those generated using multiple imputation. The former was based on the mean GCS observed for maximum head AIS categories. The latter was based on the Markov Chain Monte Carlo method with a noninformative prior and a single chain used to generate 5 imputations for each missing data value. Each multiple imputation model (1 per outcome) included all independent and dependent variables used in the respective analysis model. In total 3% of observations had missing data on systolic blood pressure. These observations were attributed a “normal” blood pressure (i.e., $\geq 90$ mm Hg).

Handling unstable estimates for low-volume centres

For low-volume centres, O:E estimates may be subject to regression to the mean bias, whereby punctual estimates based on few observations are too far from the mean and too often declared outliers. To address this bias, multi-level modelling can be used to generate shrinkage estimates, whereby O:E ratios are multiplied by a shrinkage factor based on the inverse of their variance. We compared O:E ratio estimates to which a shrinkage factor was applied (random intercept in a multilevel model) to those with no shrinkage factor (fixed effect in a single-level model).

Flexible modelling continuous covariates

Continuous covariates, such as age, systolic blood pressure (SBP), GCS score and the new injury severity score (NISS), may not have linear associations with the outcome of interest. For example, the risk of death in injury populations is generally stable until 55 years of age and increases exponentially thereafter. A simple technique for handling nonlinear associations is to model categories of continuous covariates using dummy variables (e.g., model age 16–54, 55–64, 65–74, 75–84 and $\geq 85$ yr). However, this approach leads to the difficulty of choosing appropriate cut-points and to unintuitive step increases in risk that assume constant risk within categories (e.g., all patients in the 75–84 yr age group are assumed to have the same risk of death).
Flexible modelling strategies, such as splines and fractional polynomials, can be used to address the limitations of categories. However, they are computationally complex. We compared O:E ratios generated by a model based on categories of continuous covariates to those generated by a model based on fractional polynomials.

Additional sensitivity analyses

Information on comorbidities is often unavailable in trauma registries and is subject to underreporting and variable coding across centres. In addition, previous research has shown that with robust adjustment for age, information on comorbidities does not significantly improve injury mortality prediction models. We evaluated the impact of adjustment for comorbidities in observations that could be matched to hospital discharge data. Finally, mortality should theoretically be evaluated over a fixed period of time, and the proportion of injury-related deaths occurring after 30 days varies substantially across Canadian trauma centres (0%–15% in our sample). However, time to death among patients admitted for injuries may be influenced by factors that are unrelated to injury severity and quality of care, such as do-not-resuscitate directives.

We evaluated the impact of using 30-day in-hospital mortality rather than mortality evaluated over the whole hospital stay.

To evaluate the agreement on benchmarking results under each sensitivity analysis, we calculated Pearson correlation coefficients on O:E ratios and weighted \( \kappa \) coefficients on outliers. We considered correlation coefficients greater than 0.95 and \( \kappa \) coefficients greater than 0.7 to convey acceptable agreement.

All analyses were performed using SAS software version 9.4 for Windows (SAS Institute Inc.). We created a series of Excel spreadsheets to calculate O:E ratios for mortality (Appendix 1, canjsurg.ca/002817-a1 for AIS-1998 and Appendix 2, canjsurg.ca/002817-a2 for AIS-2005) and LOS (Appendix 3, canjsurg.ca/002817-a3 for AIS-1998 and Appendix 4, canjsurg.ca/002817-a4 for AIS-2005) along with detailed instructions (Appendix 5, canjsurg.ca/002817-a5). The algorithm is based on coefficients derived from 2006–2012 data and has been tested on hospital registry data by Trauma Services BC (J.T.).

RESULTS

Study population

Between 2006 and 2012, 80 353 major adult trauma admissions to level I and II trauma centres across Canada were included in the NTR. After exclusion of 968 patients who were dead on arrival (1.2%) and 578 patients admitted for observation with undetermined injuries (0.7%), 78 807 (98.1% of those eligible) patients were included in the final study sample and used for analyses on in-hospital mortality. Of these 70 425 (87.6%) patients were discharged alive and were included in analyses on LOS.

In the whole study population (all years, all types of injury), the mean age was 51 years, and 71% of patients were men. One-third of the study population had isolated TBI, one-third injuries to multiple body regions and one-sixth isolated thoracoabdominal injuries (Table 1).

Globally, 8382 (10.6%) patients died during their hospital stay. Crude mortality increased with age and injury severity and was highest among patients with severe isolated TBI (Table 1). Crude mortality varied little over the study period but did vary across provinces.

Mean (geometric) LOS was 16.7 ± 18.1 (median 10) days. Mean LOS increased with age and injury severity and was longer for women than men and for patients with TBI than those with other injuries. Crude LOS decreased over the study period and varied across provinces.

Risk-adjustment models

Risk-adjustment models for mortality had an AUC greater than 0.8 in the whole validation sample and in every injury subgroup, indicating excellent discrimination (Table 2). Calibration intercepts close to 0 and slopes close to 1 also indicate excellent agreement between observed and predicted mortality probabilities, and high \( R^2 \) values indicated good overall model fit. The risk-adjustment model for LOS predicted 29% of the variation in hospital stay in the whole validation sample, 26% in multiple blunt injury, 22% in isolated TBI, 20% in patients aged 65 years or older, and 18% in isolated thoracoabdominal injury.

Benchmarking results

The O:E mortality ratios varied between 0.19 and 1.55 across Canadian trauma centres for the whole sample (Fig. 1). Three centres had observed mortality significantly higher than expected and 4 lower than expected according to the average mortality experience across Canada. The O:E ratios for hospital stay varied between 0.91 and 1.10 across trauma centres (Fig. 2). Two hospitals had a mean LOS significantly higher than expected according to their case mix and 2 had significantly lower mean LOS.

Sensitivity analyses

In the whole sample and in all injury subgroups, O:E ratios of mortality and LOS generated under multiple imputation, fractional polynomial modelling and with shrinkage estimates correlated strongly with analytically simple estimates (Table 2). The only exception was a weak agreement on outliers with the model derived under multiple imputation for isolated TBI (\( \kappa = 0.32 \)).
The O:E mortality ratios calculated with adjustment for comorbidities had very strong agreement with those calculated using no adjustment for comorbidities in the whole sample and in all injury subgroups. Again, the only exception was a weak agreement on outliers for isolated TBI ($\kappa = 0.49$). However, O:E ratios on LOS with adjustment for comorbidities had low agreement with those generated by a model without comorbidities in the whole sample and in all subgroups.

**DISCUSSION**

We have developed Canadian benchmarks for mortality and hospital LOS for acute injury care. These benchmarks

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**Table 1. Characteristics of the study population**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)</th>
<th>Mortality, %</th>
<th>Mean LOS, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>78,807 (100)</td>
<td>10.6</td>
<td>16.7</td>
</tr>
<tr>
<td>Age, yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;55</td>
<td>44,773 (56.8)</td>
<td>6.5</td>
<td>15.6</td>
</tr>
<tr>
<td>55–64</td>
<td>10,190 (12.9)</td>
<td>9.3</td>
<td>17.0</td>
</tr>
<tr>
<td>65–74</td>
<td>8,778 (11.1)</td>
<td>13.1</td>
<td>18.5</td>
</tr>
<tr>
<td>75–84</td>
<td>9,803 (12.4)</td>
<td>19.8</td>
<td>19.1</td>
</tr>
<tr>
<td>≥ 85</td>
<td>5,263 (6.7)</td>
<td>27.3</td>
<td>20.2</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>56,267 (71.4)</td>
<td>10.2</td>
<td>16.5</td>
</tr>
<tr>
<td>Female</td>
<td>22,540 (28.6)</td>
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<td>17.5</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVC</td>
<td>32,476 (41.2)</td>
<td>8.2</td>
<td>17.4</td>
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<tr>
<td>Fall from height</td>
<td>12,709 (16.1)</td>
<td>15.4</td>
<td>16.2</td>
</tr>
<tr>
<td>Fall from own height</td>
<td>17,378 (22.1)</td>
<td>13.3</td>
<td>16.9</td>
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<tr>
<td>Penetrating</td>
<td>3,320 (4.2)</td>
<td>11.3</td>
<td>14.5</td>
</tr>
<tr>
<td>Other</td>
<td>12,924 (16.4)</td>
<td>8.5</td>
<td>16.0</td>
</tr>
<tr>
<td>Type of injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple blunt</td>
<td>25,126 (31.9)</td>
<td>11.9</td>
<td>22.4</td>
</tr>
<tr>
<td>Isolated TBI</td>
<td>29,395 (37.3)</td>
<td>14.7</td>
<td>14.5</td>
</tr>
<tr>
<td>Isolated thoracoabdominal</td>
<td>13,178 (16.7)</td>
<td>3.6</td>
<td>10.5</td>
</tr>
<tr>
<td>Other</td>
<td>10,612 (13.5)</td>
<td>5.3</td>
<td>18.2</td>
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<tr>
<td>Transfer</td>
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<tr>
<td>Alberta</td>
<td>15,689 (19.9)</td>
<td>8.3</td>
<td>15.3</td>
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<td>Manitoba</td>
<td>3,024 (3.8)</td>
<td>10.3</td>
<td>16.2</td>
</tr>
<tr>
<td>Ontario</td>
<td>26,888 (34.1)</td>
<td>11.6</td>
<td>16.2</td>
</tr>
<tr>
<td>Quebec</td>
<td>18,229 (23.1)</td>
<td>11.1</td>
<td>17.7</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>2,665 (3.4)</td>
<td>12.1</td>
<td>17.3</td>
</tr>
<tr>
<td>Newfoundland &amp; Labrador</td>
<td>649 (0.8)</td>
<td>9.7</td>
<td>24.3</td>
</tr>
<tr>
<td>Missing</td>
<td>2,816 (3.6)</td>
<td>10.4</td>
<td>—</td>
</tr>
</tbody>
</table>

**Table 2. Characteristics of the study population**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)</th>
<th>Mortality, %</th>
<th>Mean LOS, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS score*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3–8</td>
<td>6,383 (8.0)</td>
<td>37.0</td>
<td>31.5</td>
</tr>
<tr>
<td>9–12</td>
<td>3,908 (5.0)</td>
<td>16.3</td>
<td>22.1</td>
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<tr>
<td>13–15</td>
<td>52,528 (66.7)</td>
<td>4.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Missing</td>
<td>15,988 (20.3)</td>
<td>20.4</td>
<td>—</td>
</tr>
<tr>
<td>NISS ≥ 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12–24</td>
<td>24,529 (31.1)</td>
<td>3.2</td>
<td>11.8</td>
</tr>
<tr>
<td>41–49</td>
<td>9,979 (12.7)</td>
<td>11.5</td>
<td>21.4</td>
</tr>
<tr>
<td>50–66</td>
<td>10,171 (12.9)</td>
<td>30.0</td>
<td>30.3</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2006</td>
<td>10,779 (13.7)</td>
<td>11.0</td>
<td>17.3</td>
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<tr>
<td>2007</td>
<td>11,345 (14.4)</td>
<td>10.4</td>
<td>17.4</td>
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<tr>
<td>2008</td>
<td>11,192 (14.2)</td>
<td>10.9</td>
<td>16.9</td>
</tr>
<tr>
<td>2009</td>
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<td>2010</td>
<td>11,353 (14.4)</td>
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<td>16.3</td>
</tr>
<tr>
<td>2011</td>
<td>12,156 (15.4)</td>
<td>10.3</td>
<td>16.4</td>
</tr>
<tr>
<td>2012</td>
<td>10,844 (13.8)</td>
<td>10.8</td>
<td>16.6</td>
</tr>
<tr>
<td>Province</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>11,663 (14.8)</td>
<td>10.5</td>
<td>18.1</td>
</tr>
<tr>
<td>Manitoba</td>
<td>15,689 (19.9)</td>
<td>8.3</td>
<td>15.3</td>
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<tr>
<td>Ontario</td>
<td>26,888 (34.1)</td>
<td>11.6</td>
<td>16.2</td>
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<tr>
<td>Quebec</td>
<td>18,229 (23.1)</td>
<td>11.1</td>
<td>17.7</td>
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<tr>
<td>Nova Scotia</td>
<td>2,665 (3.4)</td>
<td>12.1</td>
<td>17.3</td>
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<tr>
<td>Newfoundland &amp; Labrador</td>
<td>649 (0.8)</td>
<td>9.7</td>
<td>24.3</td>
</tr>
<tr>
<td>Missing</td>
<td>2,816 (3.6)</td>
<td>10.4</td>
<td>—</td>
</tr>
</tbody>
</table>

**Table 2. Accuracy of risk adjustment models for predicting mortality in the whole study population and injury subgroups**

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of patients</th>
<th>AUC (95% CI)</th>
<th>Hosmer–Lemeshow statistic</th>
<th>Calibration intercept; slope</th>
<th>Nagelkerke’s R²</th>
<th>Length of stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole sample</td>
<td>10,671</td>
<td>0.886 (0.876–0.895)</td>
<td>36.3</td>
<td>0.00253; 0.97645</td>
<td>0.4008</td>
<td>0.2888</td>
</tr>
<tr>
<td>Isolated TBI</td>
<td>4257</td>
<td>0.842 (0.827–0.857)</td>
<td>18.9</td>
<td>0.00635; 0.995829</td>
<td>0.3410</td>
<td>0.2204</td>
</tr>
<tr>
<td>Isolated thoracoabdominal</td>
<td>1849</td>
<td>0.854 (0.794–0.915)</td>
<td>7.6</td>
<td>−0.00242; 1.08462</td>
<td>0.2708</td>
<td>0.1780</td>
</tr>
<tr>
<td>Multiple blunt injuries</td>
<td>3205</td>
<td>0.878 (0.861–0.896)</td>
<td>17.3</td>
<td>0.00253; 0.97921</td>
<td>0.3893</td>
<td>0.2611</td>
</tr>
<tr>
<td>Age ≥ 65 yr</td>
<td>3612</td>
<td>0.817 (0.799–0.835)</td>
<td>12.1</td>
<td>0.00194; 0.98949</td>
<td>0.3197</td>
<td>0.2088</td>
</tr>
</tbody>
</table>

AUC = area under the receiver operating characteristic curve; CI = confidence interval.

*Measured on arrival in the emergency department.
Fig. 1. Observed:expected (O:E) ratios of mortality with 95% confidence intervals for Canadian trauma centres.

Fig. 2. Observed:expected (O:E) ratios of mean (geometric) length of stay (LOS) with 95% confidence intervals for Canadian trauma centres.
will enable Canadian trauma centres to evaluate quality using a simple Excel algorithm that can be easily applied using trauma registry data (see the appendices for algorithms and detailed instructions). This information can be used by local trauma programs to inform quality-improvement activities. The benchmarks could also be used in trauma systems outside Canada for international comparisons. They may be particularly useful in countries with similar health care systems (e.g., United Kingdom, Australia).

**Interpretation**

The O:E mortality ratio is the ratio of the number of deaths observed in a trauma centre to the number that would be expected if that centre had the mortality experience of the average Canadian trauma centre. Centres with a lower O:E 95% confidence limit above the national average have higher mortality than expected according to their patient case mix. Local trauma committees can look into reasons behind the observed difference in terms of structures and processes. Although the risk-adjustment models derived here cannot be used to pass judgment on the appropriateness of care for individual patients, they can be used to identify patients with unexpected outcomes for discussion (e.g., deaths with an expected mortality probability < 20%). Similarly, patients with a large difference between observed and expected LOS may be targeted for review by the trauma committee. Centres with a lower O:E 95% confidence limit below the national average have lower mortality than expected according to their patient case mix and can be used for emulation. The possibility that high or low outliers are due to data quality problems, such as underestimation of injury severity, should also be considered and may stimulate improvements in trauma registry data quality. Hospitals can use O:E ratios plotted over time to monitor trends in outcomes within their centres.

**Limitations**

We used analytically simple O:E ratios because their calculation does not require specialized expertise or data analysis tools. However, they must be used in consideration of their limits. First, O:E ratios should be used only to compare each hospital to the benchmark. They are not, in theory, suitable for comparisons across hospitals with different patient case mixes, as they are standardized to the case mix of the hospital under evaluation rather than to a common case mix pattern. Second, like in many trauma registries, a high percentage of GCS data was missing. Although our sensitivity analyses suggest that simple imputation generates results similar to those obtained under multiple imputation, neither are a substitute for real data. Furthermore, agreement on outliers for isolated TBI was low between models with simple and multiple imputation strategies. Trauma centres should therefore make efforts to optimize the collection of these data in their trauma registries. Third, because shrinkage estimates were not used, we do not recommend calculating O:E ratios when fewer than 100 observations are available. Low-volume centres should accumulate 2 or more years of data for benchmarking analysis. Fourth, sensitivity analyses indicate that comorbidities may play a role in risk adjustment when benchmarking LOS. However, underreporting of comorbidities is a widespread problem, and the low agreement in O:E ratios with and without adjustment for comorbidities may be associated with differences in reporting standards across trauma centres. Nevertheless, we should aim for standardized collection of comorbidity data in all trauma registries to improve risk adjustment of LOS models. Fifth, the validity of benchmarking results depends on the quality of data used to derive them. Each trauma centre is responsible for the quality of its data, and CIHI promotes uniform data collection across Canadian centres using a standardized data dictionary and data quality checks. Data quality is central to the benchmarking process. Finally, to be timely, coefficients should be updated by recalibrating models in new data at least every 5 years. This study shows the potential of a Canadian trauma centre benchmarking system, but a sustainable source of national injury data is essential to its viability.

**Conclusion**

The benchmarks proposed in this study provide trauma centres with the opportunity to evaluate quality of care in terms of mortality and LOS locally. This information should be used to inform local quality-improvement initiatives, not for accountability. Users should be aware that the validity and precision of O:E estimates rely on the availability of large sample sizes (at least 100 observations) and on the quality of data in the trauma registry.

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**Contributors:** All authors designed the study. L. Moore acquired the data, which all authors analyzed. L. Moore wrote the article, which all authors reviewed and approved for publication.
References


Antibiotic use among older adults on an acute care general surgery service

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Background: Antibiotics play an important role in the treatment of many surgical diseases that affect older adults, and the potential for inappropriate use of these drugs is high. Our objective was to describe antibiotic use among older adults admitted to an acute care surgery service at a tertiary care teaching hospital.

Methods: Detailed data regarding diagnosis, comorbidities, surgery and antibiotic use were retrospectively collected for patients 70 years and older admitted to an acute care surgery service. We evaluated antibiotic use (perioperative prophylaxis and treatment) for appropriateness based on published guidelines.

Results: During the study period 453 patients were admitted to the acute care surgery service, and 229 underwent surgery. The most common diagnoses were small bowel obstruction (27.2%) and acute cholecystitis (11.0%). In total 251 nonselective abdominal operations were performed, and perioperative antibiotic prophylaxis was appropriate in 49.5% of cases. The most common prophylaxis errors were incorrect timing (15.5%) and incorrect dose (12.4%). Overall 206 patients received treatment with antibiotics for their underlying disease process, and 44.2% received appropriate first-line drug therapy. The most common therapeutic errors were administration of second- or third-line antibiotics without indication (37.9%) and use of antibiotics when not indicated (12.1%). There was considerable variation in the duration of treatment for patients with the same diagnoses.

Conclusion: Inappropriate antibiotic use was common among older patients admitted to an acute care surgery service. Quality improvement initiatives are needed to ensure patients receive optimal care in this complex hospital environment.
Antibiotics are one of the most highly used drug classes in hospitals, and it is estimated that more than half of all patients admitted to acute care services receive antibiotics.\textsuperscript{1,2} They are used to treat both community- and hospital-acquired infections and as prophylaxis before invasive procedures, including surgery. However, research suggests that in up to 50\% of cases antibiotics are unnecessary or inappropriately selected for treatment.\textsuperscript{3–4} This may contribute to the development of antibiotic-resistant bacteria, increased health care expenditures, longer hospital stays and unnecessary adverse events.\textsuperscript{5} Similarly, inappropriate perioperative antibiotic prophylaxis is associated with increased risk of wound infections. Despite interventions and the use of surgical checklists, full adherence to antibiotic guidelines in the operating room continues to be suboptimal.\textsuperscript{6–8}

As the population ages, older adults make up an increasing proportion of patients admitted to hospitals, and antibiotics play an important role in the management of many diseases. This is especially true of older patients who are admitted to acute care general surgery services, where antibiotics are routinely used for both treatment and prophylactic purposes. However, very little research has specifically examined antibiotic use in this patient population. This is important to study, given that older patients are among those who are most susceptible to the consequences of inappropriate antibiotic use.\textsuperscript{9–12} Additionally, patients on acute care surgery services may be at increased risk for antibiotic errors, given the high volume of heterogeneous patients, frequent handovers, rotating surgeon coverage and the prominent role of trainees in treatment decisions. Therefore, the purpose of this research was to describe antibiotic use among older adults admitted to an acute care surgical service at a tertiary care teaching hospital.

\textbf{METHODS}

All patients aged 70 years and older who were admitted to an acute care general surgery service with intra-abdominal or abdominal wall conditions between July 1, 2011, and Sept. 30, 2012, were included in this study. Patients were identified prospectively at the time of admission to hospital, and we obtained their consent for participation. We retrospectively collected detailed data regarding demographic characteristics, admission diagnosis, allergies, comorbidities, treatments, surgery and antibiotic therapies from medical records after the patients were discharged. Detailed data were collected for antibiotics given in the emergency department (ED), the general surgery ward, the intermediate care unit (IMCU), the intensive care unit (ICU) and in the operating room (OR). We recorded information regarding antibiotic type, dose, frequency and route of administration (oral v. intravenous). Procedure start times in the OR and antibiotic administration times were collected to evaluate prophylactic antibiotic use.

Appropriate prophylactic antibiotic use was also examined according to the time of day when the procedure occurred: daytime (7:30 am to 4:59 pm), evening (5:00 pm to 11:59 pm) or nighttime (midnight to 7:29 am).

Antibiotic use was categorized as appropriate or inappropriate based on centre-specific antibiotic guidelines for surgical prophylaxis and treatment of common infectious diseases, including those associated with general surgery. These were available online and in handbook format during the study period.\textsuperscript{13} They were consistent with other published guidelines taking into account local resistance patterns.\textsuperscript{14–16} No specific educational initiatives were undertaken to influence prescriber adherence to local guidelines. We assessed each antibiotic prescription independently and then used them to categorize the antibiotic treatment of each patient as appropriate or inappropriate overall; if inappropriate, the reason was recorded. In cases where there was uncertainty regarding the appropriateness of antibiotic use, the case was discussed and clarified with an infectious disease physician at our institution.

We considered antibiotic prophylaxis (perioperative antibiotics to prevent infection associated with surgery) to be appropriate if the correct antibiotics and dose were administered within the 60 minutes before the incision time recorded in the operative record,\textsuperscript{16} or if antibiotics given for therapeutic purposes before surgery provided adequate prophylactic coverage. Therapeutic antibiotic decisions (for treatment of surgical diseases or intra-abdominal septic complications) were deemed appropriate if the condition required antibiotic treatment and the patient received the recommended agent and dose, or if the condition did not require antibiotics and none were given. We took documented patient allergies into account when determining appropriate antibiotic prescriptions, and the alternative guideline-recommended antibiotic was considered to be the correct one. Otherwise we categorized antibiotic use as inappropriate, and the reasons were described. Instances of antibiotic use for indications other than prophylaxis or treatment of surgical diseases, such as urinary tract or respiratory infections, were not evaluated for appropriateness. Our institutional research ethics board approved our study protocol.

\textbf{RESULTS}

During the study period 453 patients aged 70 years or older were admitted to the acute care general surgery service. The most common admission diagnoses were small bowel obstruction and acute cholecystitis, and the median length of stay in hospital was 6 days (Table 1). Overall 224 (49\%) patients were managed nonoperatively, and 229 (51\%) underwent surgery. One hundred patients spent time in the IMCU, and 62 were admitted to the ICU during their stay in hospital. During their admission, 339 (74.8\%) patients received antibiotics for any reason.
perioperative prophylaxis or therapeutic). Most patients ($n = 361$) did not have antibiotic allergies or intolerances recorded. Among the remaining patients, penicillins ($n = 33$), sulfonamides ($n = 42$) and macrolides ($n = 8$) were the most common antibiotic classes with documented sensitivities. Twenty patients had intolerances documented to multiple antibiotic agents. There were no instances of patients receiving antibiotics that were contraindicated owing to allergies.

**Perioperative antibiotic prophylaxis**

A total of 251 nonelective abdominal operations were performed on 229 patients. The most common procedures were large bowel resection (20.3%), laparoscopic cholecystectomy (19.5%), small bowel resection (13.5%) and lysis of adhesions (13.1%). Most surgeries were classified as clean-contaminated (54.2%), followed by clean (20.7%), dirty (19.9%) and contaminated (5.2%).

Prophylactic antibiotics were indicated for all surgeries performed and were given in 223 of 251 cases (89%). In 188 cases prophylactic antibiotics were given in the OR, and in 35 cases antibiotics used preoperatively for therapeutic indications provided adequate prophylaxis. Overall, perioperative prophylactic antibiotic coverage was appropriate in 49.5% of cases. The most common error was timing of antibiotic administration (Table 2). In 78% of these cases the antibiotics were given after surgical incision, and in 22% of cases they were given too early (> 60 min before the procedure). More than 1 error occurred in 25 cases.

Operations that were performed at nighttime had lower rates of appropriate prophylactic antibiotic use (35.5%) than those performed during the daytime and evening (52.9% and 48.8%, respectively); however, this finding was not statistically significant.

**Therapeutic antibiotic use**

Therapeutic antibiotic treatment decisions were appropriate (antibiotics indicated and appropriate antibiotics given, or antibiotics not indicated and not given) in 336 of 453 (74.2%) admitted patients. Of the 117 categorized as inappropriate, 78 involved administration of non–first line antibiotics when a first-line antibiotic would have been appropriate, 25 involved the use of antibiotics when not indicated, and in 14 cases additional antibiotic therapy was required but not given. We did not observe any antibiotic errors owing to patient factors, such as allergies or drug interactions.

Overall 206 of 453 (45.5%) patients received therapeutic antibiotics for treatment of their surgical disease or intra-abdominal complication. A total of 576 antibiotic prescriptions were ordered for these patients. The most common indications for therapeutic antibiotics were intra-abdominal septic complications (15.5%), acute cholecyst-itis (15.5%), diverticulitis (12.6%), ischemic colitis (10.7%) and cholangitis (8.3%). The median total duration of therapeutic antibiotic treatment was 8 (interquartile range [IQR] 3–15) days, and 68 (15.0%) admitted patients were discharged with an antibiotic prescription. There was considerable variation in the nature and duration of antibiotic therapy for many common surgical problems (Table 3).

Analysis of individual prescriptions showed that 449 of all 576 (78.0%) therapeutic antibiotic prescriptions were appropriate for the treatment of underlying surgical disease ($n = 463$) or intra-abdominal complications ($n = 113$). For antibiotic treatment associated with the admission diagnosis, an alternate antibiotic was available for 98 of 463 prescriptions. Cefazolin was the antibiotic most frequently identified as an alternative (11.2% of prescriptions), followed by amoxicillin-clavulanate (5.4%). In 25 cases of ciprofloxacin use and 24 cases of ceftriaxone use, cefazolin was the guideline-recommended first-line antibiotic. For 9 ciprofloxacin and 18 metronidazole
prescriptions, amoxicillin-clavulanate was the preferred alternative. In 5.6% of prescriptions associated with the surgical disease, the antibiotic was unnecessary either because there was sufficient coverage by other antibiotics, or because there was no indication.

**DISCUSSION**

In the present study, therapeutic and prophylactic antibiotic use was examined to give a comprehensive view of use and errors on an acute care general surgery service. Although acute care surgery services are designed to reduce morbidity and mortality, they are prone to errors owing to complex system factors. Care may be compromised by frequent suboptimal transfers of care and a high turnover of busy nursing staff, surgeons and trainees. Older adults cared for on these services commonly have evolving medical needs and multiple comorbidities. If undergoing urgent surgery, their health status often cannot feasibly be optimized preoperatively as would be done for patients undergoing elective operations. The presence of these factors in acute care services renders patients vulnerable to medical errors, including inappropriate prophylactic and therapeutic antibiotic use.

Although surgeons commonly must make antibiotic therapy decisions in the absence of definitive evidence for infection, optimizing antibiotic use in hospitals is important for 2 key reasons. First, inappropriate antibiotic therapy is associated with several adverse outcomes, such as increased postoperative complications, resulting in longer hospital stays and higher care costs. Second, adherence to empiric antibiotic prescribing guidelines and stewardship programs helps to reduce the prevalence and avoid emergence of antibiotic-resistant bacteria.

Research investigating antibiotic use is extensive, and recent studies continue to show disappointing rates of prophylactic antibiotic use across various patient populations. We found that prophylactic antibiotic errors were common in the acute care general surgery setting. This is disappointing, given that surgical “time outs” before incision were in use at the time of this study. The most frequent error was inappropriate timing, particularly the delayed administration of antibiotics after incision, which has been a common trend in prior studies. Circumstances surrounding acute surgical care, including communication between surgical staff and anesthesiologists, compliance with checklists, competing care priorities and quick transitions from the ED to the OR may be factors involved in such errors. Barriers to provision of appropriate prophylaxis identified in the literature include a perceived low importance and inconvenience, impaired workflow, and organizational communication. Besides timing, administration of incorrect doses and omission of antibiotics were common errors, both potentially attributable to lack of awareness or availability of prescribing guidelines in the OR.

Strategies evaluated to optimize antibiotic prescribing in surgical settings have largely targeted prophylactic antibiotic use in elective operations. Effective interventions are often multifaceted and have included interdisciplinary guideline development, prescriber feedback, educational initiatives, posters, checklists, and forced functions. In the acute surgical setting, Weiser and colleagues showed that the use of a surgical checklist is feasible, effectively improves adherence to antibiotic prophylaxis guidelines and reduces surgery-associated complications and mortality. A 3-phase surgical safety checklist (surgical briefing, surgical time out and surgical debriefing) has recently been implemented at our institution and may address some of these issues. A review by Gagliardi and colleagues found improved antibiotic prophylaxis adherence with the implementation of institutional guidelines, individualized performance feedback and multidisciplinary strategies involving education and reminders.

Compared with prophylactic antibiotic use, therapeutic antibiotic use was more often in accordance with guidelines.

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Table 3. Therapeutic antibiotic use for common surgical diseases among patients aged 70 years or older admitted to an acute care general surgery service

<table>
<thead>
<tr>
<th>Primary admission diagnosis</th>
<th>Antibiotics indicated, %</th>
<th>Antibiotics received, %</th>
<th>Appropriate treatment, %</th>
<th>Discharged with antibiotic, %</th>
<th>Median [IQR] duration, d*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute cholecystitis (n = 50)</td>
<td>64.0</td>
<td>64.0</td>
<td>54.0</td>
<td>10.0</td>
<td>3 [1–69]</td>
</tr>
<tr>
<td>Ischemic colitis (n = 22)</td>
<td>100</td>
<td>100</td>
<td>63.6</td>
<td>54.5</td>
<td>13 [1–21]</td>
</tr>
<tr>
<td>Pancreatitis, gallstone (n = 21)</td>
<td>28.6</td>
<td>28.6</td>
<td>90.5</td>
<td>0.0</td>
<td>5 [4–15]</td>
</tr>
<tr>
<td>Cholangitis (n = 19)</td>
<td>100</td>
<td>89.5</td>
<td>42.1</td>
<td>36.8</td>
<td>5 [1–20]</td>
</tr>
<tr>
<td>Intra-abdominal abscess (n = 13)</td>
<td>100</td>
<td>100</td>
<td>53.8</td>
<td>69.2</td>
<td>18 [4–47]</td>
</tr>
<tr>
<td>Perforated ulcer (n = 10)</td>
<td>100</td>
<td>100</td>
<td>50.0</td>
<td>10.0</td>
<td>8 [1–44]</td>
</tr>
<tr>
<td>Diverticulitis, simple (n = 9)</td>
<td>100</td>
<td>100</td>
<td>11.1</td>
<td>66.7</td>
<td>11 [3–17]</td>
</tr>
<tr>
<td>Diverticulitis, abscess (n = 9)</td>
<td>100</td>
<td>100</td>
<td>33.3</td>
<td>66.7</td>
<td>17 [1–77]</td>
</tr>
<tr>
<td>Diverticulitis, perforation (n = 8)</td>
<td>100</td>
<td>100</td>
<td>62.5</td>
<td>12.5</td>
<td>9 [1–22]</td>
</tr>
<tr>
<td>Acute appendicitis (n = 8)</td>
<td>50.0</td>
<td>50.0</td>
<td>75.0</td>
<td>12.5</td>
<td>7 [3–22]</td>
</tr>
</tbody>
</table>

IQR = interquartile range.

* Treatment duration includes in-hospital and outpatient prescriptions.
This is comparable across other studies, where therapeutic antibiotic use has been reported to be correct in 49%–87% of patients across various surgical settings.\textsuperscript{21,22,31–45} Our study showed that older patients received therapeutic antibiotics when indicated, although there was significant variability in how patients with the same diagnosis were treated in the acute care setting, specifically with respect to the choice of antibiotic and the duration of treatment prescribed. Although some of the variability in duration of treatment certainly reflects differences in disease severity, other factors, such as lack of evidence or guidelines on the duration of treatment, or individual surgeon preference, are likely important. The extended duration of antibiotic therapy in some patients may present substantial overtreatment without added benefit. A recent large trial showed no significant difference in infectious outcomes when duration of antibiotic use was shortened to 4 days.\textsuperscript{46} The use of second- or third-line antibiotics instead of first-line empiric antibiotics, as recommended by hospital guidelines, was common. A lack of awareness of prescribing guidelines, limited accessibility to guidelines on the surgical ward and managing a heterogeneous population with different antibiotic needs may contribute to this finding.\textsuperscript{47}

Research has been done to evaluate persuasive, restrictive and structural interventions aimed at mitigating the consequences of antibiotic misuse and overcoming barriers to improved prescribing in patients admitted to hospital.\textsuperscript{45} Both persuasive (e.g., education, prescribing feedback) and restrictive interventions (e.g., limiting access to certain antibiotics, policy changes) can improve antibiotic use. However, it is unclear which interventions are best at improving use long-term, as direct comparisons of interventions have not been done and study methods and settings are heterogeneous.\textsuperscript{45} In general surgery specifically, studies of education and guideline-based antibiotic stewardship programs have shown improved prescribing and reduced antibiotic use.\textsuperscript{48,49} Moving forward, surgeons will need to be engaged in antibiotic stewardship initiatives and should be involved in the development of local guidelines.\textsuperscript{30,51}

Limitations

Our research adds to the literature in an area that has been largely unstudied and requires intervention. Our audit of antibiotic use identifies important gaps in use and can serve to inform and benchmark quality-improvement initiatives in acute care surgical settings, especially in the care of older adults. However, there are several limitations with this research that should be considered. The descriptive aim of this study limits the inferences that can be made regarding associations between antibiotic treatment and patient outcomes. We did not examine factors associated with inappropriate antibiotic use. Although we examined older adults who were likely typical of those managed on an acute care surgical service, the study population was heterogeneous, having various diagnoses and procedures. The retrospective nature of this study made it difficult to determine the need for therapeutic antibiotics for some conditions, such as acute cholecystitis. Our institutional guidelines provided direction in the majority of cases, yet we acknowledge that antibiotic treatment decisions are not always clear-cut. Finally, our study was performed in a tertiary care academic teaching hospital and may not be applicable to other settings.

Conclusion

Seventy-five percent of older adults who were admitted to an acute care general surgery service received antibiotics. Perioperative antibiotic prophylaxis errors were common despite established evidence to support their benefit and the use surgical “time outs.” There was considerable variation in the therapeutic antibiotic treatment among patients with the same diagnoses. Alongside hospital guidelines and education, quality-improvement and quality-assurance initiatives are required to ensure patients receive optimal care in this complex treatment environment. It is unclear which strategies will lead to sustainable improvements in antibiotic use in the acute care setting.

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References

Tattooing or not? A review of current practice and outcomes for laparoscopic colonic resection following endoscopy at a tertiary care centre

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Background: Because small colonic tumours may not be visualized or palpated during laparoscopy, location of the lesion must be identified before surgery. The aim of this study was to evaluate the effectiveness of the current recommendation of endoscopic tattooing of lesions prior to laparoscopic colonic resections.

Methods: All consecutive patients who underwent elective laparoscopic resection for a colonic lesion at a single tertiary institution between 2013 and 2015 were identified for chart review.

Results: In total, 224 patients underwent laparoscopic resection for a benign or malignant colonic lesion during the study period. All patients had a complete colonoscopy preoperatively. In all, 148 patients (66%) had their lesion tattooed at endoscopy. Most lesions were tattooed distally, but 15% were tattooed either proximally, both proximally and distally, or tattooed without specifying location as proximal or distal. Tattoo localization was accurate in 69% of cases. Tattooed lesions were not visible during surgery 21.5% of time; 2 cases were converted to open surgery to identify the lesion. Inaccuracy in endoscopic localization led to change in surgical plan in 16% of surgeries. In the nontattooed group, 1 case was converted to open surgery to localize the lesion, 3 required intraoperative colonoscopy and 1 had positive margins on final pathology.

Conclusion: To improve surgical planning, we recommend the practice of endoscopic tattooing of all colon lesions at a location just distal to the lesion using multiple injections to cover the circumference of the bowel wall.

Contexte : Comme il n’est pas toujours possible de voir ou de palper les petites tumeurs du côlon durant la laparoscopie, le siège de la lésion doit être localisé avant la chirurgie. Le but de cette étude était d’évaluer l’efficacité de la recommandation actuelle, qui consiste à tatouer les lésions au cours de l’endoscopie, avant les colectomies laparoscopiques.

Méthodes : Nous avons recensé tous les patients consécutifs ayant subi une résection laparoscopique non urgente d’une lésion du côlon dans un même établissement de soins tertiaires entre 2013 et 2015 afin d’analyser leurs dossiers.

Résultats : En tout, 224 patients ont subi la résection laparoscopique d’une lésion bénigne ou maligne du côlon durant la période visée. Tous les patients ont passé une coloscopie totale avant la chirurgie. Le tatouage endoscopique de la lésion a été effectué pour 148 patients (66 %). La plupart des lésions ont été tatouées au point distal, mais 15 % l’ont été soit au point proximal, soit au point proximal et au point distal, soit sans précision quant à l’emplacement. La localisation par tatouage était exacte dans 69 % des cas. Les lésions tatouées n’étaient pas visibles durant la chirurgie dans 21,5 % des cas; 2 cas ont été convertis en chirurgies effectives afin qu’on puisse repérer la lésion. L’inexactitude de la localisation endoscopique a entraîné la modification du plan chirurgical dans 16 % des chirurgies. Dans le groupe non tatoué, 1 cas a été converti en chirurgie effective afin qu’on puisse repérer la lésion, 3 cas ont nécessité une coloscopie peropératoire et 1 cas présentait des marges positives à l’examen pathologique final.

Conclusion : Afin d’améliorer la planification chirurgicale, nous recommandons le tatouage endoscopique de toutes les lésions du côlon, au point distal de la lésion, et de procéder par injections multiples en vue de couvrir la circonférence de la paroi intestinale.
A bout 100 000 cases of colon cancer are now diagnosed each year in the United States, and most are amenable to resection with curative intent. In the past decade, there has been a dramatic shift in practice toward minimally invasive surgery, with an increasing number of laparoscopic colon resections being performed. Since laparoscopic surgery is associated with decreased tactile feedback, small colonic lesions may not be detectable intraoperatively. Failure to accurately localize a tumour may lead to adverse outcomes, including resection of a wrong segment of bowel, positive resection margins, conversion to open surgery, on-table colonoscopy, or on-table alteration in planned surgical resection. In fact, according to a survey conducted by the American Society of Colon and Rectal Surgeons, 6.5% of surgeons who perform routine laparoscopic colonic resection have admitted to removing the wrong segment of bowel at least once.3

Colonoscopy is firmly established as the gold standard both for diagnosis and preoperative localization of malignant colonic lesions. However, even colonscopic tumour localization is inaccurate in 11.3%–21% of cases.4–6 As such, colonscopic tattooing is now considered to be standard practice for tumour localization before laparoscopic colorectal excision.7,8 Several medical and surgical associations and societies recommend tattooing of suspicious-looking lesions without reference to their size.9,10 However, there is no established guideline as to when and how to tattoo colonic lesions, resulting in varied practices among physicians and hospitals.

The aim of the present study was to evaluate the effectiveness of the current practice of endoscopic tattooing of lesions before laparoscopic colonic resection at a tertiary care centre.

METHODS

We performed a retrospective cohort study on all consecutive patients who underwent elective laparoscopic resection for a colonic tumour in the period January 2013 to January 2015 at St. Paul’s hospital, Vancouver, which is affiliated with the University of British Columbia. We excluded patients with rectal lesions below the peritoneal reflection, as they would be accurately localized by routine magnetic resonance imaging scan. Also excluded were patients who had more than 1 lesion in the colon or who had emergency surgery. No institutional guideline or protocol regarding tattooing existed at the time of the study.

Data on baseline patient demographic and clinical characteristics were obtained. We collected details regarding endoscopic localization of the tumour, tattooing and endoscopic documentation. Charts were reviewed to collect data on operative visualization and localization of lesions and tattoos, planned and performed surgical procedures, changes in surgical plan and operative and postoperative outcomes. We compared patients with and without tattooed lesions. Visibility and accuracy of the position of the tattoo at surgery was compared with the position stated in the endoscopy report. The research ethics boards of St. Paul’s Hospital and the University of British Columbia approved our study.

Statistical analysis

Descriptive statistics are reported, including means, medians, standard deviations and ranges. We used the Student t test or the Mann–Whitney U test to compare means. Categorical variables were compared using the χ2 test. All statistics were 2-tailed, and we considered results to be significant at p < 0.05. Statistical analysis was done with the software package R Studio.

RESULTS

During the study period, 276 patients underwent laparoscopic colonic resection for malignant lesions. We excluded 41 patients because the lesion was localized in the rectum, and we excluded 11 patients because they had more than 1 lesion. Of the 224 patients included in the study analysis, 148 (66.1%) had their lesion tattooed preoperatively and 76 (33.9%) did not. Patients’ baseline demographic and clinical characteristics are shown in Table 1.

Table 2 summarizes differences associated with tattooing. The greatest proportion of tattooed lesions (45.5%) was in the left colon, whereas most nontattooed lesions (82.9%) were in the right colon. Most preoperative endoscopies were performed by gastroenterologists (86.6%), of which 88.7% were done by staff at our tertiary care centre. The remaining endoscopies were performed by surgeons (13.4%). Surgeons were more likely to tattoo the lesion than gastroenterologists (80% v. 63.9%, p = 0.10). There was no statistically significant difference in the tattoo rate between local gastroenterologists and referring gastroenterologists (62.8% v. 72.7%, p = 0.48). For 8 patients,
tattoos were carried out during a second endoscopy, as they had not been tattooed on the first endoscopy and it was deemed necessary by the surgeon preoperatively. The endoscopy reports of 44 (19.6%) patients were missing information regarding tattooing and localization of the lesion. There was no difference in the percentage of lesions seen on computed tomography (CT) scan between the 2 groups. Twenty-three (15.5%) patients had their lesions tattooed at a site other than distal to the lesion; 16 were tattooed proximally, and 7 were tattooed both proximally and distally.

Table 3 shows the operative outcomes. Overall, endoscopic localization was accurate in 68.8% of tumours. Of the 70 lesions inaccurately localized by endoscopy, 8 were in the upper rectum (described as sigmoid), 8 were in the sigmoid (described as descending colon), 7 were in the descending colon (described as sigmoid), 6 were in the splenic flexure (described as hepatic flexure), 16 were in the transverse colon (4 described as right colon, 4 as descending colon and 8 as splenic flexure), 12 were at the hepatic flexure (described as cecum) and 13 were in the cecum (described as hepatic flexure). Endoscopic localization was more accurate in the nontattooed group than in the tattooed group (82.9% vs. 61.5%, \( p = 0.002 \)). Of the tattooed lesions, 116 (78.5%) were visualized intraoperatively. Of the 32 tattoos that were not visualized, 16 were in the right colon, 1 in the hepatic flexure, 2 in the transverse colon, 3 in the splenic flexure, 3 in the descending colon, 5 in the sigmoid and 2 in the rectosigmoid.

These inaccurate endoscopic localizations led to intraoperative changes in surgical plan in 15.2% of patients. The majority of these occurred in the tattooed group (19.6% vs. 6.6%, \( p = 0.018 \)). Of the 34 patients with an on-table alteration in surgical plan, 8 had an anterior resection instead of a planned left hemicolectomy, 1 had an anterior resection instead of a planned low anterior resection, 11 had a left hemicolectomy instead of a planned anterior resection, 5 had a right hemicolectomy instead of a planned extended right hemicolectomy, 7 had an extended right hemicolectomy instead of a planned right hemicolectomy and 2 had a subtotal colectomy instead of a right hemicolectomy \((n = 1)\) or left hemicolectomy \((n = 1)\).

Conversion to open surgery owing to inability to locate or feel the lesion occurred in 3 patients. One patient had a hepatic flexure lesion that was not tattooed and was described as localized in the transverse colon at endoscopy. Two patients had tattooed lesions that were not visualized at surgery: 1 in the descending colon and 1 in the sigmoid. Intraoperative endoscopy was needed in 7 patients, including 5 patients whose tattoos could not be

### Table 2. Endoscopic localization, tattooing and imaging data

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Overall ( n = 224 )</th>
<th>Tattooed ( n = 148 )</th>
<th>Nontattooed ( n = 76 )</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localization at endoscopy</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Right colon</td>
<td>121 (53.9)</td>
<td>58 (39.3)</td>
<td>63 (82.9)</td>
<td></td>
</tr>
<tr>
<td>Transverse colon</td>
<td>17 (7.6)</td>
<td>15 (10.1)</td>
<td>2 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Left colon</td>
<td>77 (34.5)</td>
<td>67 (45.5)</td>
<td>9 (11.9)</td>
<td></td>
</tr>
<tr>
<td>Rectosigmoid</td>
<td>9 (4.0)</td>
<td>7 (4.9)</td>
<td>2 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Endoscopy performed by</td>
<td></td>
<td></td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>Gastroenterologist</td>
<td>194 (86.6)</td>
<td>124 (63.9)</td>
<td>70 (36.1)</td>
<td></td>
</tr>
<tr>
<td>Surgeon</td>
<td>30 (13.4)</td>
<td>24 (80)</td>
<td>6 (20)</td>
<td></td>
</tr>
<tr>
<td>Second endoscopy necessary</td>
<td>—</td>
<td>8 (5.4)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Missing information on tattooing in report</td>
<td>44 (19.6)</td>
<td>15 (10.1)</td>
<td>29 (38.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lesion seen on CT</td>
<td>115 (51.3)</td>
<td>74 (50.0)</td>
<td>41 (63.9)</td>
<td>0.14</td>
</tr>
<tr>
<td>Tattoo site other than distal</td>
<td>—</td>
<td>23 (15.5)</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

CT = computed tomography.

### Table 3. Perioperative outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Overall ( n = 224 )</th>
<th>Tattooed ( n = 148 )</th>
<th>Nontattooed ( n = 76 )</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate endoscopic localization</td>
<td>154 (68.8)</td>
<td>91 (61.5)</td>
<td>63 (82.9)</td>
<td>0.002</td>
</tr>
<tr>
<td>Tattoo visualized at surgery</td>
<td>—</td>
<td>116 (78.5)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>On-table change in surgical plan</td>
<td>34 (15.2)</td>
<td>29 (19.6)</td>
<td>5 (6.6)</td>
<td>0.018</td>
</tr>
<tr>
<td>Conversion to open surgery or need for intraoperative endoscopy</td>
<td>10 (4.5)</td>
<td>6 (4.1)</td>
<td>4 (5.3)</td>
<td>0.94</td>
</tr>
</tbody>
</table>
seen and 2 patients who did not have their lesions tattooed. All 7 lesions were located in the sigmoid, and the 2 lesions not tattooed were described as being in the descending colon at endoscopy. Only 1 patient had a microscopic positive distal margin. The lesion was located in the sigmoid and had not been tattooed before surgery.

There was no significant difference between the tattooed and nontattooed groups in intraoperative complications (1.4% v. 1.3%, \( p > 0.99 \)), median estimated blood loss (100 mL v. 100 mL, \( p > 0.99 \)), mean lymph nodes retrieved (20.4 v. 20.0, \( p = 0.96 \)) and median length of hospital stay (5 d v. 5 d, \( p > 0.99 \)). However, the median duration of surgery was significantly longer in the tattooed than in the nontattooed group (120 min v. 97.5 min, \( p = 0.002 \)).

**DISCUSSION**

Colorectal cancer screening has led to a decrease in colorectal cancer mortality and has been adopted in most economically developed countries. Increased use of fecal occult blood testing (FOBT) and fecal immunochemical tests for hemoglobin (FIT) has led to the detection of early and smaller lesions.\(^{11,12}\) In our series, just 50% of the lesions were visible on CT scan. With laparoscopic surgery for colonic resection, accurate preoperative and intraoperative localization of the tumour is mandatory. Tattooing is an appropriate way to assure accurate localization for small lesions not identified on CT scan. Although a few studies have recommended tattooing the lesion distally and at multiple circumferential sites,\(^{13,14}\) no universal guideline has been adopted to ensure standardized and effective tattooing.

Our study reports an inaccuracy rate of endoscopic localization of lesions of 31.2%. This rate exceeds others reported in the literature (11%–21%).\(^{4,6}\) Our higher inaccuracy may be explained by our categorical distinction of the hepatic flexure, ascending colon and cecum as different segments rather than including them all as the right colon. Also, we excluded distal rectal lesions that are accurately localized preoperatively by digital rectal examination and rigid sigmoidoscopy.

Additionally, there is variability in the way tattooing is performed: single versus multiple circumferential, and proximal versus distal versus both. In our study, 72.4% of tattoos were placed at a single spot. There was a significant difference in tattoo visibility rate if the tattoo was placed at a single spot versus multiple spots (70.8% v. 88.6%, \( p = 0.030 \)). The high rate of single-spot tattoos can, in part, account for the large proportion of tattoos (21.5%) that were not visible at surgery. Also, 23 patients had lesions tattooed at a site other than distally, which could lead to confusion as to lesion location during surgery, with potential removal of the wrong segment of bowel or positive margin. Furthermore, in our study there was missing information in regards to tattooing for 43 patients, indicating the need for standardized documentation of tattooing.

Adverse outcomes resulted from inaccurate lesion localization in 45 of 224 (20%) patients in our study: 34 patients had an on-table alteration in surgical plan, 3 patients needed conversion to open surgery to localize the lesion, 7 patients required intraoperative endoscopy to confirm location of the tumour and 1 patient whose lesion was not tattooed had a positive microscopic margin. Adverse outcomes may be avoidable with accurate tattooing at the preoperative endoscopy.

In our study, 33.9% of the tumours were not tattooed. This number is similar to rates of tattooing reported in the literature.\(^{15}\) In our study, 80% of the lesions that were not tattooed were localized in the right colon at endoscopy. Likely, endoscopists did not feel that tattooing was needed if the lesion was visualized in proximity to the landmarks of the ileoceleal valve and appendiceal orifice. However, in our study, 25 of the 70 inaccurately localized lesions were described as being in the right colon at endoscopy. We recommend that all potentially significant lesions are tattooed, even those located in the right colon or rectum. Also, if the lesion is not tattooed, we recommend a second colonoscopy be performed to tattoo the lesion if it is not visible on CT scan.

Arguments supporting the recommendation of tattooing all cancers and suspicious polyps include safety and low cost.\(^{16}\) In our series, no complications resulted from endoscopic tattooing. There was also no difference in the number of lymph nodes retrieved or in intraoperative complication rates from tattooing. Shorter duration of surgery in our nontattooed group was explained by the higher number of right-sided lesions that were not tattooed.

**Limitations**

Our study was limited by its retrospective design and single-institution experience. The decision to tattoo or not tattoo the lesion was at the discretion of the endoscopist, which introduced potential selection bias. Additionally, absence of standardized endoscopy reporting on tattooing resulted in missing or incomplete data. Finally, there were no data on the use of a scope guide, which can help with localization of the lesion.

**CONCLUSION**

To improve surgical planning and outcomes, we recommend endoscopic tattooing of all cancers and suspicious polyps just distal to the lesion using multiple injections to cover the circumference of the bowel wall as well as recording all pertinent information in the endoscopy report. Every institution should establish clear guidelines to ensure standard practice among endoscopists and to increase accuracy rates.
RECHERCHE

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Competing interests: P.T. Phang is a consultant with Servier. No other competing interests declared.

Contributors: F. Letarte, M. Raval, A. Karimuddin, C. Brown and P.T. Phang designed the study. F. Letarte, M. Webb and P.T. Phang acquired the data, which F. Letarte, M. Raval, A. Karimuddin, C. Brown and P.T. Phang analyzed. F. Letarte, A. Karimuddin and P.T. Phang wrote the article, which all authors reviewed and approved for publication.

References


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Comparison of retroperitoneal liposarcoma extending into the inguinal canal and inguinoscrotal liposarcoma

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Background: This study was designed to analyze differences between retroperitoneal liposarcoma (RLPS) extending into the inguinal canal and inguinoscrotal liposarcoma.

Methods: We retrospectively reviewed the records for patients who were managed for inguinal liposarcoma at Samsung Medical Center, a tertiary hospital, between January 1998 and December 2016. Patient data on demographics, tumour location, surgery, adjuvant therapy, histology, recurrence and death were collected. We used Mann–Whitney, Fisher exact and Kaplan–Meier log-rank tests to analyze differences between groups.

Results: Seven of 179 (3.9%) patients with abdominal liposarcoma had inguinoscrotal liposarcoma, and 6 of 168 (3.6%) patients with RLPS had extension to the inguinal canal. No differences were observed between groups in sex (p > 0.99), mean age (49.7 ± 6.4 yr v. 52.1 ± 12.5 yr, p = 0.37), laterality (p > 0.99) or scrotal involvement (40.0% v. 66.7%, p = 0.57). The RLPS group had significantly larger tumours than the inguinoscrotal group (27.9 ± 6.8 cm v. 7.8 ± 4.2 cm, p = 0.001). Postoperative complications were significantly more common in the RLPS group (n = 4, 83.3%); patients in the inguinoscrotal group experienced no postoperative complications (p = 0.021). Log-rank tests showed that the groups had no statistical differences in disease-free survival (p = 0.94) or overall survival (p = 0.10). However, inoperable disease-free survival was significantly poorer in the RLPS group (p = 0.010).

Conclusion: Although initial signs and symptoms can be similar, RLPS extending into the inguinal canal was associated with significantly higher morbidity and mortality than inguinoscrotal liposarcoma.

Contexte : Cette étude visait à examiner les différences entre le liposarcome rétro-peritonéal s’étendant au canal inguinal et le liposarcome inguino-scrotal.

Méthodes : Nous avons procédé à une analyse rétrospective des dossiers de patients traités pour un liposarcome inguinal au Samsung Medical Center, un hôpital de soins tertiaires, entre janvier 1998 et décembre 2016. Nous avons recueilli les données des patients en ce qui a trait aux caractéristiques démographiques, au siège de la tumeur, à la chirurgie, au traitement adjuvant, à l’histologie, à la récidive et au décès. Nous avons utilisé le test de Mann–Whitney, la méthode exacte de Fisher et les tests logarithmiques par rangs de Kaplan–Meier pour analyser les différences entre les 2 groupes.

Résultats : Sept des 179 (3.9 %) patients atteints de liposarcome abdominal avaient un liposarcome inguino-scrotal, et 6 des 168 (3.6 %) patients atteints de liposarcome rétropéritonéal présentaient une extension au canal inguinal. Aucune différence n’a été observée entre les groupes pour le sexe (p > 0.99), l’âge moyen (49,7 ± 6,4 ans c. 52,1 ± 12,5 ans, p = 0,37), la latéralité (p > 0,99) ou l’atteinte scrotale (40 % c. 66,7 %, p = 0,37). La taille de la tumeur était significativement plus grande dans le groupe du liposarcome rétropéritonéal que dans celui du liposarcome inguino-scrotal (27,9 ± 6,8 cm c. 7,8 ± 4,2 cm, p = 0,001). De même, les complications postopératoires étaient significativement plus courantes dans le groupe du liposarcome rétropéritonéal (n = 4, 83,3 %), les patients du groupe du liposarcome inguino-scrotal n’en ayant pratiquement pas présenté (p = 0,021). Les tests logarithmiques par rangs ont révélé l’absence de différences statistiques entre les groupes pour la survie sans récidive (p = 0,94) et la survie globale (p = 0,10). Cependant, la survie sans récidive du patient inopérable était significativement plus faible dans le groupe du liposarcome rétropéritonéal (p = 0,010).

Conclusion : Malgré la similarité des premiers signes et symptômes, le liposarcome rétropéritonéal s’étendant au canal inguinal était associé à des taux de morbidité et de mortalité significativement plus élevés que le liposarcome inguino-scrotal.
Liposarcoma (LPS) is one of the most common soft tissue sarcomas that arises where fat is present. The retroperitoneum and extremities are the most common sites of origin, and up to 40% of liposarcomas are found in the retroperitoneum.1

Although relatively uncommon, retroperitoneal liposarcoma (RLPS) can cause substantial morbidity and mortality.2 Similar to other retroperitoneal soft tissue sarcomas, RLPS is frequently discovered as a giant tumour, often occupying the entire abdominal cavity. Although surgical resection is considered the most effective treatment, RLPS often has a high rate of incomplete resection and local recurrence due to its aggressive growth into vital structures.3 Detecting signs or symptoms before tumours become enlarged is difficult because the most common symptom is palpating mass, which occurs only when the tumour is large.

Retroperitoneal liposarcoma is usually confined to the retroperitoneum. However, in rare cases, RLPS extends to the inguinal canal, which communicates with the retroperitoneal space. Only a few case reports describe RLPS presenting as an inguinal hernia.1,4-9 Sometimes, a protruding mass in the inguinal region is the only symptom, resulting in a misdiagnosis of ordinary inguinal hernia.

Not every inguinal LPS is an RLPS. Similar to RLPS, inguinoscrotal LPS, which arises along the spermatic cord and testis, is an uncommon soft tissue sarcoma.10 Inguinoscrotal LPS can be isolated in this area without extending into the retroperitoneal space.

The present study summarizes data on LPS of the inguinal region from a high-volume sarcoma centre. We reviewed our experience with inguinal LPS, both RLPS extending into the inguinal region and isolated inguinoscrotal LPS. By comparing these 2 different entities of LPS with the same presenting symptom, we contribute new insights to the understanding of inguinal sarcoma presenting as an inguinal hernia.

METHODS

Patients

Data on patients who underwent surgery for LPS located in the inguinal canal between January 1998 and December 2016 at Samsung Medical Center were retrospectively collected from our institution’s sarcoma database. Patients were categorized as having RLPS extending into the inguinal region or isolated inguinoscrotal LPS based on tumour location. Only patients with an inguinal LPS on initial presentation were included. Patients with RLPS extending into the thigh region through the femoral canal were also excluded.

Data collection

Demographic data and treatment history from other hospitals were collected by chart review. Anatomic locations of tumours were determined by reviewing preoperative computed tomography (CT) or magnetic resonance imaging (MRI) scans. We assessed laterality, location and size. With respect to surgery, we collected data on resected organs, margin status of the specimen and invasion of adjacent organs. Data on tumour characteristics were histological differentiation and Fédération Nationale des Centres de Lutte Contre le Cancer (FNCLCC) grade, based on the pathology report. Data on adjuvant therapy, such as radiotherapy or chemotherapy, were also collected. The Institutional Review Board of Samsung Medical Center approved our study protocol.

Statistical analysis

We used the Mann–Whitney test to compare continuous variables and the Fisher exact test to compare categorical variables. Kaplan–Meier survival analysis was used to analyze disease-free, overall and inoperable disease-free survival between groups. The date of the operation when curative complete resection was performed was the starting point, and the end point was set as time of interest, recurrence, death, or inoperable progression of the tumour. In cases of inoperable progression, the end point was the time when the team decided that the tumour was inoperable and required only palliative treatment.

We performed all statistical analyses using SPSS software version 18.0 (SPSS Inc.).

RESULTS

During the study period, 179 patients underwent surgery for abdominal LPS at our centre (Fig. 1). Among these patients, 168 (93.9%) had RLPS, 7 patients (3.9%) had inguinal LPS isolated to the area, and 4 patients (2.2%) had LPS in the abdominal wall. Whereas 161 (95.8%) patients with RLPS had a tumour only in the retroperitoneal space, 6 (3.6%) had an RLPS extending into the inguinal canal, and 1 (0.6%) had an RLPS extending into the femoral canal. The 6 patients with RLPS extending into the inguinal canal and the 7 patients with an inguinal LPS isolated to the inguinoscrotal region were included.

Case summary: retroperitoneal liposarcoma extending into the inguinal canal

The 6 patients with RLPS extending into the inguinal canal are described in Table 1. The male/female ratio was 5:1 and the right/left ratio was 1:1. Four patients (66.7%) reported a palpable mass on initial presentation, and 1 had dyspepsia. Patients had a mean tumour size of 27.9 ± 6.8 (range 18–37) cm. The tumour of retroperitoneal origin extended to the scrotum in 2 of 5 patients (40.0% excluding the female patient). Tumour histology was well differentiated in 2 cases (33.3%) and de-differentiated in 4 cases.
(66.7%). The CT findings of patients are presented in Figure 2.

Half of these patients (patients 1, 2, and 3) received incorrect diagnoses and had operations for simple inguinal hernia at other hospitals. Curative complete excision of the hidden tumour was delayed for 20, 12 or 62 months, respectively, from the hernia repair. Patient 1 underwent inguinal hernia repair at another hospital. Two cord lipomas, 9 cm and 5 cm, were discovered during the operation. Pathological review was not performed at that time. Patient 2 underwent inguinal mass excision at another hospital. The patient remembered that she was told that the mass was a lipoma. Pathology slides were not reviewed at our hospital. The retroperitoneal mass was discovered after symptoms reappeared 12 months later. Patient 3 underwent hernia repair 5 years before mass excision. Because of a lack of information about the first operation, we could not identify suspicious signs for patient 3. Only patient 2 is currently disease-free, surviving 89 months after excision with no recurrence. Patient 1 and patient 3 died 39 months and 12 months, respectively, after the operation. Patient 3 experienced metastasis to the liver and underwent liver resection.

Three patients underwent mass excision on initial presentation. Patient 5 underwent combined organ resection, including kidney, adrenal and testis resection. The patient did not experience recurrence during the 11-month postoperative period. Patient 4 and patient 6 are currently in an inoperable progression status, even after numerous operations for recurrent tumours.

Case summary: liposarcoma isolated in the inguinoscrotal region

Seven patients with inguinoscrotal LPS are described in Table 2. The male:female ratio was 6:1 and the right:left ratio was 4:3. Five patients (71.4%) sensed a palpable mass and 1 (14.2%) sensed a swelling in the inguinal region. Patient 8 had pain in the scrotal area. Four of 7 patients (57.1%) had tumour involvement in the scrotum. The mean tumour size was 7.8 ± 4.2 cm (range 3–14 cm). Six patients had a first operation in another hospital; 4 came to our centre after recurrence and 2 underwent complete excision in our centre for remnant sarcoma. Two patients (patient 10 and patient 11) underwent combined and mass resection. Five of 7 patients (71.4%) had de-differentiated LPS, 1 (14.2%) had well-differentiated LPS and 1 (14.2%) had myxoid/round cell LPS. Although 5 of 7 patients (71.4%) experienced recurrence, all 7 patients currently have disease-free status. Patient 9 had a lung metastasis that was operated with video-assisted thoracoscopic lobectomy, and was followed up for 173 months. Figure 3 shows initial image findings for patients.

Comparison between RLPS and inguinoscrotal LPS

Comparisons of demographic, clinical and pathological characteristics of patients are shown in Table 3. The RLPS group had significantly larger tumours than the inguinoscrotal group (27.9 ± 6.8 cm v. 7.8 ± 4.2 cm, p =...
Postoperative complications were significantly more common in the RLPS group ($n = 4$, 83.3%). Patients in the inguinoscrotal group experienced no postoperative complications ($p = 0.021$). The median comprehensive complication index was 8.7 (interquartile range 0–21.72) in the RLPS group, showing a trend that approached statistical significance ($p = 0.05$). No differences were observed in sex ($p > 0.99$), mean age (49.7 ± 6.4 yr v. 52.1 ± 12.5 yr, $p = 0.37$), laterality ($p > 0.99$), scrotal involvement (40.0% v. 66.7%, $p = 0.57$), histology ($p = 0.52$), grades ($p = 0.35$), positive margin (100% v. 66.7%, $p > 0.99$), adjuvant therapy (66.7% v. 85.7%, $p = 0.56$), recurrence (66.7% v. 71.4%, $p > 0.99$), median recurrence-free duration (12.5 mo v. 18 mo, $p = 0.73$), or mean survival duration (44.3 ± 36.4 mo v. 71.4 ± 68.2 mo, $p = 0.35$). Combined organ resection was performed on 83.3% of patients with RLPS, whereas 28.6% of inguinoscrotal patients underwent combined organ resection ($p = 0.10$). Although 2 patients (33.3%) in the RLPS group died, this was not significantly different from the inguinoscrotal LPS group, in which no patients died ($p = 0.19$). The proportion of patients who had inoperable tumours was significantly higher in the RLPS group than in the inguinoscrotal group ($n = 4$, 66.7% v. $n = 0$, $p = 0.021$). Inoperable status was defined as death or tumour progression that was considered inoperable.

**Disease-free, overall, and inoperable disease-free survival**

We performed Kaplan–Meier survival analysis with log-rank tests to compare survival between the 2 groups for recurrence, inoperable progression and death. Disease-free survival in the RLPS group was 66.7% at 1 year and

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hernia repair as initial operation</th>
<th>Mass excision as initial operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1</td>
<td>Patient 2</td>
<td>Patient 3</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Age, yr</td>
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<td>52</td>
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<td>Symptom</td>
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<td>Palpable mass</td>
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<td>Right</td>
<td>Right</td>
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<tr>
<td>Location</td>
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<tr>
<td>Turnover size, cm</td>
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<td>30</td>
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<tr>
<td>Scrotal involvement</td>
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<tr>
<td>Delay of excision, mo</td>
<td>20</td>
<td>12</td>
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<tr>
<td>No. of operations before excision</td>
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<td>Organ invasion</td>
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<td>Negative</td>
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<td>Postoperative complication (classification)*</td>
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<td>No</td>
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<td>89</td>
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<tr>
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</table>

DDLPS = de-differentiated liposarcoma; N/A = not applicable; SMC = Samsung Medical Center; WDLPS = well-differentiated liposarcoma.

*Clavien–Dindo classification.
22.2% at 5 years; in the inguinoscrotal group it was 57.1% at 1 year and 42.9% at 5 years. Log-rank tests showed that the groups did not differ significantly ($p = 0.94$).

Overall survival in the RLPS group was 80.0% at 1 year and 53.3% at 5 years; in the inguinoscrotal group it was 100% throughout the study period. Log-rank tests showed that overall survival differences were not significant between the groups ($p = 0.10$).

Inoperable disease-free survival in the RLPS group was 83.3% at 1 year and 41.7% at 5 years; in the inguinoscrotal LPS group it was 100% throughout the study period. Log-rank tests showed significant differences between the groups for inoperable disease-free survival ($p = 0.010$). The 3 survival curves for each group are presented in Figure 4.

**DISCUSSION**

Retroperitoneal liposarcoma is an uncommon disease that most surgeons do not have much experience managing. Even less common is RLPS extending into the inguinal canal, occurring in 3.6% of patients with the condition, based on our data. In contrast, inguinal hernia is a prevalent condition that all surgeons encounter in clinical practice. The possibility of inguinal hernia being misdiagnosed as LPS is low. Montgomery and Buras reported that the rate of incidental liposarcoma identified during a hernia operation was lower than 0.1% (2 of 1736 inguinal hernias); however, misdiagnosis of uncommon cases can lead to a poor prognosis.

The present study included 6 patients with RLPS extending into the inguinal canal. Previously, only a few published case reports of inguinal hernia were available, and they discussed an LPS protruding from the retroperitoneum. Although 6 is a small number for reliable statistical analysis, we showed that RLPS protruding into the inguinal canal has poor prognosis compared with inguinoscrotal LPS.

One of the important findings of this study was the presenting features of both diseases. First, RLPS extending into the inguinal canal (5 of 6 patients, 83.3%) and inguinoscrotal LPS (6 of 7 patients, 85.7%) were predominant in men. Initial presentation can be similar. Retroperitoneal liposarcoma can remain hidden without signs or symptoms before it becomes large. Extension through the inguinal canal may be the only symptom, and 4 of 6 patients (66.7%) felt a palpable mass in the inguinal region. Three of 6 patients (50.0%) underwent inguinal hernia repair without further checkup (e.g., by CT). One patient had an associated cord lipoma of 9 cm; however, pathology was not reviewed. Another patient underwent associated mass excision and was given a diagnosis of lipoma. Similarly, LPS confined to the inguinoscrotal region presented with a palpable mass or swelling of the inguinal region (6 of 7 patients, 85.7%). Scrotal involvement also occurred in patients with RLPS. Although scrotal involvement was more frequent with inguinoscrotal LPS than RLPS (> of 6 patients, 66.7% vs. 2 of 5 patients, 40.0%), scrotal enlargement with a palpable mass did not
guarantee exclusion of retroperitoneal origin. Based on these presenting features, it was impossible to determine if tumours originated from fat tissue beside the spermatic cord and testis or deep underlying fat tissue of the retroperitoneum. Therefore, imaging studies, such as CT or MRI, can be useful, whereas ultrasonography can be of limited use in scanning the retroperitoneum.

Another finding from this study was the differing prognoses for morbidity and mortality. Based on basic knowledge that RLPS has a poor prognosis, we were not surprised to find that only 2 patients achieved disease-free status (33.3%). Four (66.7%) patients experienced recurrence, 2 (33.3%) patients died, and another 2 patients (33.3%) progressed to inoperable status. The inguinoscrotal LPS group also showed a high recurrence rate (5 of 7 patients, 71.4%). However, patients were all disease-free without progression to inoperable status. Differences yielded by the Kaplan–Meier log-rank test were significant ($p = 0.010$). The RLPS group showed a high rate of postoperative complications (4 of 6 patients, 66.7%), whereas no patients in the inguinoscrotal

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Patient 7</th>
<th>Patient 8</th>
<th>Patient 9</th>
<th>Patient 10</th>
<th>Patient 11</th>
<th>Patient 12</th>
<th>Patient 13</th>
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<td>Swelling</td>
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<td>29</td>
<td>173</td>
<td>32</td>
<td>167</td>
<td>13</td>
<td>47</td>
</tr>
</tbody>
</table>

DDLPS = de-differentiated liposarcoma; N/A = not applicable; SMC = Samsung Medical Center; VATS = video-assisted thoracoscopic surgery; WDLPS = well-differentiated liposarcoma.
**Fig. 3:** Image findings of patients with inguinoscrotal liposarcoma. A) Patient 7 had a 4.5 cm mass in the inguinal canal. B) Patient 8 had a 4 cm mass in the inguinoscrotal region. C) Patient 9 had recurrence in the left inguinal canal after previous excision of an 8 cm mass. D) Patient 10 had a 12 cm mass in the inguinoscrotal region. E) Patient 11 had a 3 cm mass in the right inguinoscrotal region. F) Patient 12 had a 9 cm mass in the left inguinoscrotal region. Patient 13 had G) a 14 cm mass in the right inguinal canal on magnetic resonance imaging, with H) hypermetabolic features on positron emission tomography. Arrowheads indicate a mass in the inguinal canal.

| Table 3. Comparison of baseline characteristics and clinical outcomes between patients with retroperitoneal liposarcoma extending to inguinal canal and patients with inguinoscrotal liposarcoma. |
|-----------------------------|-----------------------------|-----------------------------|
| Characteristic              | Retroperitoneal LPS (n = 6)  | Inguinoscrotal LPS (n = 7)  | p value    |
| Male sex                    | 5 (83.3)                    | 6 (85.7)                    | > 0.99     |
| Age, yr                     | 49.7 ± 6.4                  | 52.1 ± 12.5                 | 0.37       |
| Laterality, right:left      | 3:3                         | 4:3                         | > 0.99     |
| Scrotal involvement         | 2 (40.0)                    | 4 (66.7)                    | 0.57       |
| Tumour size, cm             | 27.9 ± 6.8                  | 7.8 ± 4.2                   | 0.001      |
| Combined organ resection    | 5 (83.3)                    | 2 (28.6)                    | 0.10       |
| Histology                   | 0.52                        |                             |            |
| Well-differentiated liposarcoma | 2 (33.3)                  | 1 (14.3)                    |            |
| De-differentiated liposarcoma | 4 (66.7)                  | 5 (71.4)                    |            |
| Round/myxoid liposarcoma    | 0 (0)                       | 1 (14.3)                    |            |
| Grade (I:II:III)            | 1:1:1                       | 4:2:0                       | 0.35       |
| Margin positive, %          | 100                         | 66.7                        | > 0.99     |
| Postoperative complications | 4 (66.7)                    | 0 (0)                       | 0.021      |
| Comprehensive complication index, median (IQR) | 8.7 [0–21.72] | — | 0.05 |
| Adjuvant therapy            | 4 (66.7)                    | 6 (85.7)                    | 0.56       |
| Recurrence                  | 4 (66.7)                    | 5 (71.4)                    | > 0.99     |
| Recurrence-free duration, mo, median (IQR) | 12.5 [1.75–37.25] | 18.0 [7.0–47.0] | 0.73 |
| No. of recurrences, median (IQR) | 2.0 [0–4.25] | 1.0 [0–5.0] | 0.74 |
| Local/distant recurrence    | 3:1                         | 4:1                         | > 0.99     |
| Death                       | 2 (33.3)                    | 0 (0)                       | 0.19       |
| Survival, mo                | 44.3 ± 36.4                 | 71.4 ± 68.2                 | 0.35       |
| Progression to inoperable status | 4 (66.7) | 0 (0) | 0.021 |
| Death                       | 2 (33.3)                    | 0 (0)                       | 0.19       |
| Inoperable progression      | 2 (33.3)                    | 0 (0)                       | 0.19       |
| Disease-free status         | 2 (33.3)                    | 7 (100)                     | 0.021      |

IQR = interquartile range; LPS = liposarcoma; SD = standard deviation.

*Unless indicated otherwise.
LPS group experienced complications ($p = 0.021$). Based on these findings, checking for hidden tumours within the retroperitoneal space when inguinal masses are suspected to be soft tissue sarcomas is crucial.

**Limitations**

A limitation of this study was the small number of patients. However, by discussing a rare circumstance of an uncommon disease, we believe that we can caution general surgeons worldwide who routinely perform inguinal hernia repair. We presented significant findings on tumour size, postoperative complications, inoperable disease progression and inoperable disease-free survival. However, more valuable data could be analyzed if more patients were available for analysis. For example, no significant differences in overall survival ($p = 0.10$) were observed; these are expected to be different when more patients are included.

Another shortcoming is that we could not perform statistical analysis comparing patients with RLPS who underwent inguinal hernia repair initially and patients with RLPS who underwent complete excision as the first treatment. The importance of not delaying surgical removal of tumours is common sense for surgeons. However, accumulating evidence-based data is still important, even for uncommon conditions.

**CONCLUSION**

Retroperitoneal liposarcoma extending into the inguinal canal should be managed with caution. A tumour protruding through the inguinal canal requires high pressure, especially for patients who have already undergone hernia repair. Although no data support this hypothesis, this condition could be associated with worse outcomes, even when RLPS is confined to the retroperitoneum. When a moderate amount of data is collected, comparison of RLPS and RLPS extending into the inguinal canal can be performed.

In our study, half the patients with RLPS extending into the inguinal canal underwent inguinal hernia repair before mass excision. However, the possibility of finding hidden tumours was lost by not performing pathological review in 1 patient’s case. Pathological review of every specimen from surgery can provide clues about uncommon diseases. If a mass is large or extends to the retroperitoneal or intraperitoneal space, further imaging workup is mandatory. Protrusion in an already repaired inguinal canal can be a sign of late RLPS. If a mass is detected on imaging, or if pathology shows unusual features, referring the patient to a tertiary sarcoma-specialized centre is important. Retroperitoneal liposarcoma should be resected by an experienced surgeon, and inguinoscrotal liposarcoma can recur if sufficient margins are not achieved during the first operation. We hope our experience and findings provide guidance for general surgeons who frequently operate on patients with inguinal hernias. Furthermore, we hope sarcoma surgeons worldwide present their cases of RLPS extending into the inguinal canal to help researchers generate systematic guidance for this rare condition.

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Competing interests: None declared.

Contributors: All authors designed the study. J. Rhu, Y-L. Choi and S. Kim acquired the data, which J. Rhu, H. Park, J. Park and S. Kim analyzed. J. Rhu and S. Kim wrote the article, which all authors reviewed and approved for publication.

References

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Optimizing associated liver partition and portal vein ligation for staged hepatectomy outcomes: Surgical experience or appropriate patient selection?

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Carlos Garcia-Ochoa, MD  
Mark A. Levstik, MD  
Bandar Al-Judaibi, MBBS  
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Background: Early reports of associated liver partition and portal vein ligation for staged hepatectomy (ALPPS) outcomes have been suboptimal. The literature has confirmed that learning curves influence surgical outcomes. We have 54 months of continuous experience performing ALPPS with strict selection criteria. This study aimed to evaluate the impact of the learning curve on ALPPS outcomes.

Methods: We retrospectively compared patients who underwent ALPPS between April 2012 and March 2016. Patients were grouped into 2 24-month (early and late) periods. All candidates had a high tumour load requiring staged hepatectomy after chemotherapy response, a predicted future liver remnant (FLR) less than 30% and good performance status.

Results: Thirty-three patients underwent ALPPS during the study period: 16 in the early group (median age 65 yr, mean body mass index [BMI] 27) and 17 in the late group (median age 60 yr, mean BMI 25). Bilobar disease was comparable in both groups (94% v. 88%, \( p > 0.99 \)). Duration of surgery was not statistically different. Intraoperative blood loss and need for transfusion were significantly lower in the late group (200 ± 109 mL v. 100 ± 43 mL, \( p < 0.05 \)). The late group had a higher proportion of monosegment ALPPS (4:1). There were no deaths within 90 days in either cohort. Rates of postoperative complications were not statistically significant between groups. The R0 resection rate was similar. The entire 1-year disease-free and overall survival were 52% and 84%, respectively.

Conclusion: Excellent results can be obtained in innovative complex surgery with careful patient selection and good technical skills. Additionally, the learning curve brought confidence to perform more complex procedures while maintaining good outcomes.

Contexte : Les premiers résultats sur l’association de la partition hépatique et de la ligature portale pour l’hépatectomie en 2 temps (ALPPS) sont sous-optimaux. La littérature a confirmé que les courbes d’apprentissage influencent les résultats des interventions chirurgicales. Notre étude reposait sur 54 mois consécutifs d’utilisation de la technique ALPPS selon des critères de sélection rigoureux. Elle visait à évaluer l’effet de la courbe d’apprentissage sur les résultats liés à l’ALPPS.

Méthodes : Nous avons procédé à une comparaison rétrospective des patients traités par l’ALPPS entre avril 2012 et mars 2016. Nous avons divisé les patients en 2 groupes de 24 mois (précoces et tardifs). Tous les candidats avaient une charge tumorielle élevée nécessitant une hépatectomie en 2 temps après une réponse à la chimiothérapie, un volume estimé de futur foie résiduel (FFR) inférieur à 30 % et un indice fonctionnel favorable.

Résultats : Trente-trois patients ont été traités par l’ALPPS pendant la période de l’étude : 16 dans le groupe précoce (âge médian 65 ans, indice de masse corporelle [IMC] moyen 27) et 17 dans le groupe tardif (âge médian 60 ans, IMC moyen 25). Le taux de maladie bilobaire était comparable entre les 2 groupes (94 % c. 88 %, \( p > 0.99 \)). La durée de la chirurgie n’était pas statistiquement différente. Les pertes de sang peropératoires et le besoin de transfusion étaient significativement inférieurs dans le groupe tardif (200 ± 109 mL c. 100 ± 43 mL, \( p < 0.05 \)). Le groupe tardif avait une proportion plus élevée d’ALPPS mono-segmentaires (4:1). Il n’y a eu aucun décès dans les 90 jours parmi les 2 cohortes. Les taux de complications postopératoires n’étaient pas statistiquement significatifs entre les groupes. Le taux de résection R0 était similaire. Les taux de survie sans récidive après une année complète et de survie globale étaient de 52 % et de 84 %, respectivement.
A associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) has been reported recently as a novel variant of 2-stage hepatectomy.¹ ² It aims to increase the proportion of patients deemed operable by removing the tumour load in a shorter period of time than with other techniques.³ The first stage is performed by clearing the future liver remnant (FLR) from metastasis, ligating the portal vein and physically separating the FLR from the “deportalized” liver with an in situ split. The second stage follows with removal of the deportalized part of the liver after rapid hypertrophy of the FLR.⁴ The mechanism behind the accelerated hypertrophy in ALPPS is yet to be fully understood. Schlegel and colleagues⁵ described an elegant rodent study suggesting that the rapid hypertrophy of liver parenchyma may be associated with a systemic increase of circulating factors released as part of an inflammatory reaction to the parenchymal split in conjunction with portal vein ligation (PVL) and increased blood flow to the FLR.

An initially reported major complication rate (Clavien–Dindo grade III and higher) of 44% and mortality of 12% for ALPPS⁶ led to concerns among the surgical community and raised questions regarding its role and indications.⁷ Recently published data from the international ALPPS registry indicate a perioperative 90-day mortality of 9% and a severe complication rate (Clavien–Dindo grade IIIb or higher) of 27%. The high morbidity associated with ALPPS is lower when treating patients younger than 60 years of age and those with colorectal liver metastases (CRLM).⁸ Patients who experience liver failure according to the International Study Group for Liver Surgery (ISGLS) criteria after stage 1 ALPPS and those with a model of end-stage liver disease (MELD) score of more than 10 before stage 2 ALPPS are at significantly greater risk of death within 90 days after stage 2 ALPPS.⁹ Nevertheless, few centres have documented initial good outcomes with ALPPS. We reported our initial experience with ALPPS, which had an overall complication rate of 36%, a severe complication rate of 14% and no deaths within 90 days.¹⁰ Recently, Alvarez and colleagues¹¹ reported high oncological feasibility with adequate patient safety. The morbidity in their series according to the Clavien–Dindo classification was 53% (43% for grade IIIa or higher and 31% for grade IIIb or higher) and mortality was 6.6%.

The learning curve effect describes practical improvement that comes with experience.¹² In hepato-pancreato-biliary (HPB) practice, this effect had been shown for pancreaticoduodenectomy/Whipple procedure, with improvements reported in duration of surgery and, more importantly, in patient outcomes, including blood loss, complications and length of stay in hospital.¹³,¹⁴ However, data regarding centre-specific experience in ALPPS have yet to be established.

At our centre, we adopted ALPPS in April 2012 as a salvage procedure after failed portal vein embolization (PVE). The present study evaluates the impact of the learning curve on ALPPS complications and outcomes at our centre.

**METHODS**

Data from patients who underwent ALPPS at the London Health Sciences Centre (LHSC) in London, Ont., between April 2012 and March 2016 were recovered from a database established prospectively. All patients were reviewed by a multidisciplinary tumour board consisting of HPB and colorectal surgeons, medical oncologists, radiation oncologists, interventional radiologists, pathologists and radiologists and were deemed unresectable by a single-staged operation owing to high tumour load, bilobar disease and FLR less than 30%. Most of our patients had CRLM, for which careful patient selection has been established at our centre; we have developed specific inclusion and exclusion criteria. Inclusion criteria for CRLM are summarized in Box 1. The presence of 1 or more of the following was considered a contraindication for ALPPS: unresectable primary tumours, unresectable tumour in the FLR or extrahepatic metastases other than localized resectable CRLM, presence of clinical, laboratory or radiological signs of elevated pressures in the portal venous system, and/or poor functional capacity (Eastern Cooperative Oncology Group [ECOG] score ≥ 2).

Before surgery, routine blood tests, including serum tumour marker levels (carcinoembryonic antigen [CEA], cancer antigen [CA] 19.9, and/or α-fetoprotein [AFP]) were assessed. Preoperative radiologic investigations

**Box 1: Associating liver partition and portal vein ligation for staged hepatectomy indication for colorectal liver metastases at London Health Sciences Centre**

- Extensive bilobar CRLM necessitating an extended hepatectomy
- Predicted FLR < 30%
- Technically feasible resection (planned R0)
- No evidence of extrahepatic disease (except localized resectable lung metastasis)
- Good functional capacity (ECOG score of 0 or 1)
- Complete or partial morphologic response, or absence of progression, after systemic chemotherapy (4–6 cycles)
- Biological response evident by CEA reduction

CEA = carcinoembryonic antigen; CRLM = colorectal liver metastases; ECOG = Eastern Cooperative Oncology Group; FLR = future liver remnant.

**Conclusion**: L’innovation dans le domaine des chirurgies complexes peut donner d’excellents résultats lorsqu’on sélectionne attentivement les patients et que l’on possède de bonnes habiletés techniques. De plus, la courbe d’apprentissage a eu pour effet d’accroître la confiance dans la capacité de réaliser des interventions complexes tout en produisant de bons résultats.
included thoracoabdominal computed tomography (CT) or magnetic resonance imaging (MRI). Selected patients with high tumour load also underwent positron emission tomography (PET) to evaluate the presence of extrahepatic disease.

We evaluated the following volumetric parameters: standardized total liver volume (sTLV) calculated according to the method used by Vauthey and colleagues,15 using the estimated body surface area (BSA) as described by Mosteller,16 future (remnant) liver volume (FLV), and future liver volume to total liver volume ratio (FLV:TLV). Volumetric measurements were performed preoperatively and after stage 1 of the procedure in order to plan stage 2. The percentage of FLR hypertrophy was calculated according to the following formula: \([(FLV2–FLV1)÷FLV1]×100\).

We divided our patients into 2 groups: the early group consisted of patients who underwent the procedure in the first 2 years, and the late group consisted of those who underwent the procedure in the last 2 years. We collected the following data for each patient: demographic characteristics, site of the primary tumour, number of intrahepatic tumours and their distribution, timing of CRLM (synchronous or metachronous), presence of extrahepatic disease, use of perioperative chemotherapy and use of previous PVE. Operative details included duration of surgery, type of liver resection, rate of intraoperative blood transfusions and radiological liver resection. When the surgical free margin was 0 mm or there was exposed tumour along the transection plane, liver resection was classified as R1. The following liver biochemistries were measured: international normalized ratio (INR), bilirubin, alkaline phosphatase (ALP) and transaminases (aspartate aminotransferase [AST] and alanine aminotransferase [ALT]). Blood samples were taken before surgery, after stage 1 on postoperative days (POD) 1, 3, 5 and 7 and again after stage 2 on POD 1, 3, 5 and 7.

Primary outcomes for each group included postoperative morbidity and 90-day mortality. Secondary outcomes for the whole patient group included overall (OS) and disease-free survival (DFS) rates. The types of liver resections performed were defined using the Brisbane 2000 nomenclature.17 Complications were scored according to the Clavien–Dindo grading system;18 we considered grade IIIa a major complication and grade IIIb or higher a severe complication. Mortality included deaths that occurred during the hospital stay or within 90 days after stage 2 ALPPS. Postoperative liver failure was defined according to the “50–50” criteria (prothrombin time [PT] < 50%, INR > 1.7 and a serum bilirubin level > 50 mmol/L on POD-519) and the definition established by the International Study Group of Liver Surgery (ISGLS).20

Procedure

The technical aspects of the procedure have been described previously.2,4,10 Overall, we distinguish the procedure into 2 major surgical stages and 1 interval phase. The key steps of stage 1 are as follows: 1) exploration and formal laparotomy to rule out any extrahepatic disease; 2) complete liver mobilization, including ligation and division of the retrohepatic veins draining into the inferior vena cava (IVC) and isolating and encircling both the right hepatic vein (RHV) and the middle hepatic vein with vessel loops; 3) intraoperative ultrasonography to determine resectability and mark the partition plane; 4) cholecystectomy; 5) complete tumour wedge resection (clearing) of the FLR if bilateral disease is present; and 6) isolation of the right portal vein behind the common hepatic duct followed by division of the portal supply of the diseased hemiliver. The hepatoduodenal ligament remains intact with no isolation of the main hilar structures, preserving the blood supply to segment 4.

In classical ALPPS, the in situ split of the parenchyma is achieved between the FLR and deportalized liver (between the left lateral sector and segment 4) using a vessel sealing device (Enseal, Ethicon Endo-Surgery Inc., Johnson & Johnson Medical Ltd.). The partition of the liver is continued until the retrohepatic IVC is visualized and the right hilar plate is identified and encircled with a vessel loop. Special attention is made to preserve the middle hepatic vein (MHV) to avoid congestion of segments 4, 5 and 8 of the deportalized right hemiliver. We believe this prevents congestion and subsequent ischemia during the interval phase between stage 1 and stage 2. A vessel loop is left around the MHV and RHV to avoid the need for dissection at the time of the second stage, which facilitates ALPPS completion. The right hepatic arterial inflow and biliary drainage to the deportalized hemiliver are maintained during this first stage to preserve the liver synthetic function. We place 2 round silicone drains (BLAKE, Ethicon Endo-Surgery Inc., Johnson & Johnson Medical Ltd.) in the surgical field: 1 in the partition plane and 1 in the retrohepatic area.

During our initial 4 cases, we used a bag on the deportalized hemiliver in an attempt to prevent adhesions for the stage 2 ALPPS and as a precaution of bile leak based on the initial ALPPS description.2 We abandoned using the bag after our fourth case because no bile leak was noticed and this step might have increased a potential risk of infection. Furthermore, leaving a foreign body in situ necessitated a second operation to remove the plastic bag, regardless of the outcomes of stage 1. Vessel loops are to be able to be left in the abdomen with no evident long-term consequences.21

During the interval phase, the patients are transferred to the high-acuity surgical unit for 24 h and then to the regular ward according to their postoperative course. To avoid overhydration and liver congestion, patients are placed on IV fluid for a day, followed by a clear liquid diet and finally a full diet advancement once oral intake is tolerated. We encourage early ambulation out of bed to a chair on POD-1 and ambulation at least 4 times daily. Blood work is repeated as previously mentioned. Within 7–10 days...
after the operation, a contrast-enhanced abdominal CT scan is obtained. If adequate hypertrophy (FLR > 30%) is observed, stage 2 of the procedure is scheduled for the next available operative day, provided the patient is in stable condition (Fig. 1).

In stage 2, the diseased deportalized liver is usually removed by stapling through the hilar plate followed by stapling the right hepatic vein and then the middle hepatic vein. These sequences control the inflow first and allow rotating the diseased liver for better MHV visualization.

In 3 patients, we used a segment 4 modification of the above ALPPS technique. In these cases, the patients had a high tumour load in the left lateral sector and in the right lobe. In stage 1, a left lateral sectionectomy preserving the segment 4 branch of the left portal vein, clean-up of the FLR, and right PVL were performed along with division of the parenchyma through the Cantile line. Stage 2 consisted of removal of the deportalized right lobe (Fig. 2). One patient had “segment 6 ALPPS,” where we preserved the inflow from the right posterior hepatic artery and right posterior portal vein as well as the outflow through the right inferior hepatic vein (Makuuchi vein). This was followed by ligation of the right anterior and left portal veins. Partition was then performed between segment 6 and 7 and across segment 5 to the hilar plate in stage 1. Stage 2 involved division of all 3 hepatic veins and completion of hepatectomy with resection of segments 1, 2, 3, 4, 5, 7 and 8.

**Statistical analysis**

Statistical analyses were performed using SPSS software version 21.0 (IBM Corp.). Categorical variables are described using percentages and compared using the $\chi^2$ test or Fisher exact test, as appropriate. Continuous variables are expressed as means and standard deviations for symmetrically distributed data, as medians and interquartile ranges (IQR) for nonsymmetrically distributed data and compared using an unpaired t test or the Mann–Whitney U test, as appropriate. Actual OS and DS at 1 year is reported. We defined OS as the time from the first stage to death (all causes) and DFS as the time from the second stage to the first recorded evidence of recurrence on imaging (local or distant).

**RESULTS**

During the study period, a total of 39 patients were explored for ALPPS. The procedure was feasible in 33 patients (16 in the early and 17 in the late group). These procedures were performed in 2 patients with primary and 31 patients with secondary liver tumours. Six patients were deemed inoperable, and resection was abandoned before attempting stage 1 ALPPS. Of these, 2 patients were deemed technically unresectable after intraoperative ultrasonography, 2 patients had tumours abutting the left portal vein near the bifurcation, 1 had an unresectable primary tumour and 1 had severe steatohepatitis with 60% macrosteatosis in the FLR. The demographic and clinical characteristics of patients are summarized in Table 1. There were no significant differences in age, sex, body mass index (BMI) and American Society of Anesthesiologists (ASA) classification between the groups. A total of 31 (94%) patients had CRLM, and the remaining 2 patients had hepatocellular carcinoma (HCC) and cholangiocarcinoma. There were no significant differences in the indications for surgery between the groups. Bilobar disease was comparable (94% v. 88%, $p > 0.99$).
Thirty-two patients successfully underwent both stages of ALPPS (97% feasibility) during a single hospital stay. One patient in the early group experienced left portal vein thrombosis after stage 1 and did not reach the second stage. The metastasis was lying on and abutting the left portal vein; this was cleared from the vein and moved toward the right side during stage 1. The partition was completed as usual. Follow-up CT scan of the abdomen did not show evidence of hypertrophy of the left lateral segment owing to the presence of a partial clot in the left portal vein.

Intraoperative data are presented in Table 2. The median duration of surgery in the second stage decreased from 127 min in the early group to 90 min in the late group, but this decrease was not statistically significant. Intraoperative clinically estimated blood loss and blood transfusion were similar in stage 1 and significantly lower in stage 2 in the late group (200 ± 109 mL v. 100 ± 43 mL, p = 0.045). The late group had a higher proportion of Monosegment ALPPS (4:1). There were no statistically significant differences between the groups in the number of extrahepatic simultaneous procedures, including abdomino-perineal resection.

Thirty-two patients achieved a sufficient hypertrophy within 10 days (97% efficacy) after the stage 1. No patients had delayed hypertrophy. In the early experience, the mean ratio of FLR volume to TLV before ALPPS was 19.3% ± 4.7%. At 1 week after the procedure, the mean ratio increased to 36% ± 8.4%, with a median FLR hypertrophy of 90% (IQR 27%–107%). In the late group, the mean ratio of FLR volume to TLV before ALPPS was 21.9% ± 3.7%. At 1 week after the procedure, the mean ratio was 37.5% ± 6.6%, with a median FLR hypertrophy of 80% median (IQR 41%–140%).

Considering both groups, the overall morbidity of the study population was 58% (19 patients). Major complications (grade IIIa) occurred in 4 (25%) patients in the early group and 8 (47%) patients in the late group (p = 0.70). Two patients in each cohort had grade IIIb or higher complications. Four (25%) patients in the early group and 1 (6%) in the late group met the 50–50 criteria of postoperative liver failure (p = 0.17). Two of them required endoscopic retrograde cholangiopancreatography (ERCP) under general anesthesia. One patient in each group had

<table>
<thead>
<tr>
<th>Table 1. Patient demographic and baseline clinical and tumor characteristics</th>
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<tbody>
<tr>
<td>Characteristic</td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>Age, yr</td>
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<tr>
<td>Sex</td>
</tr>
<tr>
<td>Male</td>
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<tr>
<td>Female</td>
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<tr>
<td>BMI</td>
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<tr>
<td>ASA class</td>
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<tr>
<td>&lt; 3</td>
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<tr>
<td>≥ 3</td>
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<tr>
<td>Primary disease</td>
</tr>
<tr>
<td>CRC</td>
</tr>
<tr>
<td>HCC</td>
</tr>
<tr>
<td>Cholangiocarcinoma</td>
</tr>
<tr>
<td>Tumorex (CRLM)</td>
</tr>
<tr>
<td>Synchronous</td>
</tr>
<tr>
<td>Metachronous</td>
</tr>
<tr>
<td>Bilobar distribution</td>
</tr>
<tr>
<td>PVE</td>
</tr>
<tr>
<td>Preoperative chemotherapy</td>
</tr>
<tr>
<td>≥ 6 cycles of chemotherapy</td>
</tr>
</tbody>
</table>

ASA = American Society of Anesthesiologists; BMI = body mass index; CRC = colorectal cancer; CRLM = colorectal liver metastasis; HCC = hepatocellular cancer; IQR = interquartile range; PVE = portal vein embolization.
abdominal wall dehiscence after stage 2 ALPPS that required repair. One patient with simultaneous ALPPS and colon resection in the early group had percutaneous drainage for an intra-abdominal abscess. Another patient in the late group had segment 6 ALPPS requiring diaphragmatic resection and mesh repair; a subphrenic abscess developed, and the patient was managed with IV antibiotics and percutaneous drainage. The remaining complications were postoperative wound infections. Rates of major and severe postoperative complications did not differ significantly between the groups (Table 1). There were no deaths within 90 days in either cohort.

The median interval between both surgeries was significantly shorter in the early than in the late group (8 d v. 10 d, \(p = 0.010\)). Negative resection margins (R0) were achieved in 14 of 15 patients in the early group and 15 of 17 patients in the late group \((p > 0.99)\) who completed both stages. At 1-year follow-up, 14 of 15 patients in the early group and 12 of 16 patients in the late group were alive (93% v. 75%, \(p = 0.33\)). The 1-year DS was 53% in the early group and 50% in the late group \((p > 0.99)\).

**DISCUSSION**

Our single-centre experience with ALPPS showed consistently acceptable morbidity and no perioperative mortality throughout the study period for 2-stage hepatectomy, with improvements in intraoperative blood loss and transfusion. We performed monosegment ALPPS in more patients in the late group, without any compromise in perioperative outcomes apart from a nonsignificant increase in major complications.

The ALPPS procedure has gained popularity for the treatment of patients requiring liver resection, with a very low predicted FLR. The ALPPS approach provides 2 perceived advantages. First, as a result of rapid liver kinetic growth, surgical resection of all disease can be achieved more promptly with ALPPS than with conventional 2-staged hepatectomy with portal vein embolization. Second, the completion rate of ALPPS significantly eclipses that of conventional 2-staged hepatectomy, with few patients failing to reach stage 2 of the procedure due to tumour progression. Our results support the previous evidence of high feasibility of ALPPS. We found minimal interstage dropout, excellent FLR hypertrophy and a reduction in blood transfusion between stages in the late group without any compromise in perioperative outcomes.

These proposed advantages of ALPPS have been counterbalanced by reports of high perioperative morbidity and mortality. The first published cohort described a 12% perioperative mortality, with other studies reporting similarly high perioperative mortality as well as severe morbidity in up to two-thirds of patients. Our group has previously reported an early experience with ALPPS, showing no deaths within 90 days in a pilot series of 14 patients. In the present series, we again report no deaths within 90 days in 32 patients, which to our knowledge makes this study the largest single-centre cohort with no perioperative mortality. The largest available studies reporting on short-term outcomes of ALPPS are analyses of the International ALPPS Registry, with a published 90-day mortality of 9% and a severe complication (Clavien–Dindo ≥ IIIb) rate of 27%. This morbidity and mortality is further attenuated in patients with CRLM and in those older than 60 years. This finding supports our centre’s recommendation that selection criteria for ALPPS are the cornerstone of successfully improving perioperative outcomes, and, in addition to age and CRLM, we reiterate the importance of good functional status.

In addition to careful patient selection, we believe that several important technical considerations exist. Preservation

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**Table 2. Intraoperative data and short-term outcomes**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group; median (IQR), no. (%) or mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of surgery, min</td>
<td>Early, (n = 16) Late, (n = 17) (p) value</td>
</tr>
<tr>
<td>Stage 1</td>
<td>388 [294–480] 440 [335–540] 0.70</td>
</tr>
<tr>
<td>Stage 2</td>
<td>127 [50–204] 90 [60–215] 0.13</td>
</tr>
<tr>
<td>Estimated blood loss, mL</td>
<td></td>
</tr>
<tr>
<td>Stage 1</td>
<td>800 [500–2000] 1000 [400–2500] 0.17</td>
</tr>
<tr>
<td>Stage 2</td>
<td>200 [50–400] 100 [50–200] 0.045</td>
</tr>
<tr>
<td>RBC transfusion</td>
<td>9 [66] 4 [24] 0.15</td>
</tr>
<tr>
<td>No. RBC packs per patient</td>
<td></td>
</tr>
<tr>
<td>Stage 1</td>
<td>0.75 [0–3] 0.7 [0–4] 0.43</td>
</tr>
<tr>
<td>Stage 2</td>
<td>0.67 [0–3] 0 0.044</td>
</tr>
<tr>
<td>Type of liver resection</td>
<td></td>
</tr>
<tr>
<td>Right trisectionectomy</td>
<td>15 [94] 13 [76] 0.042</td>
</tr>
<tr>
<td>Monosegment ALPPS</td>
<td>1 [6] 4 [24] 0.042</td>
</tr>
<tr>
<td>Reversed approach</td>
<td>2 [12] 0 0.16</td>
</tr>
<tr>
<td>Extrahepatic simultaneous procedures</td>
<td>4 [25] 5 [29] 0.16</td>
</tr>
<tr>
<td>Colon resection</td>
<td>2 1 —</td>
</tr>
<tr>
<td>LAR</td>
<td>2 3 —</td>
</tr>
<tr>
<td>APR</td>
<td>0 1 —</td>
</tr>
<tr>
<td>Plastic bag used</td>
<td>4 [25] 0 0.021</td>
</tr>
<tr>
<td>Interval phase, d</td>
<td>8 [7–10] 10 [7–12] 0.010</td>
</tr>
<tr>
<td>%FLR/TLV</td>
<td>19.27 ± 4.7 21.94 ± 3.7 0.11</td>
</tr>
<tr>
<td>%FLR/TLV after stage 1</td>
<td>36 ± 8.4 37.5 ± 6.6 0.84</td>
</tr>
<tr>
<td>Complications</td>
<td></td>
</tr>
<tr>
<td>Any complication</td>
<td>6 [37] 13 [76] 0.44</td>
</tr>
<tr>
<td>Major (IIa)</td>
<td>4 [25] 8 [47] 0.70</td>
</tr>
<tr>
<td>90-d mortality</td>
<td>0 0 &gt; 0.99</td>
</tr>
<tr>
<td>LOS, d</td>
<td>17 [13–49] 16 [14–33] 0.35</td>
</tr>
<tr>
<td>Curability</td>
<td></td>
</tr>
<tr>
<td>R0</td>
<td>15 [94] 15 [88] &gt; 0.99</td>
</tr>
</tbody>
</table>

ALPPS = associated liver partition and portal vein ligation for staged hepatectomy; APR = abdominopercineal resection; FLR = future liver remnant; IQR = interquartile range; LAR = low anterior resection; LOS = length of stay; RBC = red blood cells; SD = standard deviation; TLV = total liver volume.
of the middle hepatic vein in order to reduce the incidence of segment 4 venous congestion and subsequent necrosis should be mandatory. 23 Although some centres have adopted variations of the initial technique, 26,27,28 we continue to perform complete parenchymal transection and show that this can be performed with acceptable perioperative morbidity and a 90-day mortality of 0%. Complete parenchymal transection during stage I facilitates a quicker and more straightforward stage 2. Finally, we recommend minimizing dissection of the hepatoduodenal ligament to reduce the risk of biliary or arterial complications. Refinements in these aspects of the surgical technique are underscored by a reduction in intraoperative blood loss and the need for blood transfusion in our cohort’s later group.

Limitations

Some limitations arise as a consequence of the study design. As a single-centre series with a small sample size (despite being relatively large when compared with the existing literature), the conclusions reached by our group may not be generalizable to other centres. Furthermore, potential biases and confounders arise from the retrospective nature of the study. Although unrecognized confounding variables may be the underlying cause of the improved intraoperative characteristics and interstage interval in the later experience, we performed more monosegment ALPPS in the later stage, which should bias the analysis against the later group.

Conclusion

The ALPPS technique continues to generate considerable controversy in the hepatobiliary community. We have previously hypothesized that the morbidity and mortality associated with ALPPS can be reduced with careful patient selection and surgical technique. 7 In the present study, we showed that acceptable morbidity and mortality can be sustained over a larger cohort of 32 patients, despite the inclusion of more patients requiring monosegment ALPPS. Improvements in intraoperative blood loss and reduction in interstage interval suggest refinement in surgical technique and perioperative, multidisciplinary care. Surgical team experience, in conjunction with greater understanding and participation from medical oncologists, radiation oncologists, radiologists, nurses and other members of the patient care team has contributed to the learning curve shown at our centre. We acknowledge that further data are necessary before any conclusions can be drawn regarding the safety of ALPPS and that few data exist on long-term oncological outcomes and quality of life. Based on our results, we continue to believe that with careful patient selection and refinement in surgical technique, the initial concerns regarding poor perioperative outcomes can be assuaged and the ALPPS can gain greater acceptance as a surgical option for patients with extensive, bilobar disease and a very small predicted FLR.

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Transanal minimally invasive surgery for benign large rectal polyps and early malignant rectal cancers: experience and outcomes from the first Canadian centre to adopt the technique

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Background: Transanal minimally invasive surgery (TAMIS) has emerged as a relatively new technique in treating early cancer and benign lesion of the rectum. The technique is likely to be widely adopted, surpassing other comparable techniques owing to its simple setup and cost-effectiveness. We assessed the outcomes of TAMIS at our centre.

Methods: We retrospectively reviewed prospectively collected data on 50 patients who underwent TAMIS for benign, malignant T1 or T2 cancers that were unfit for radical surgery over a 4-year period. Outcomes, including 30-day complications and recurrence, as well as our ability to implement and integrate this technique at our centre were assessed.

Results: All 50 TAMIS procedures were successful. The average lesion was 7 cm from the anal verge, the average tumour size was 2.5 cm, the average duration of surgery was 73 minutes, the average length of stay was 1.1 days, and the margin negativity was 84%. Major indications in our series included 25 lesions that were too large for endoscopic resection, 14 early cancers or high-grade dysplasia, 10 margin checks postpolypectomy, 6 cases of recurrent polyposis, and 4 medically unfit patients. There were no deaths. The rate of short-term complications, including rectal bleeding, reoperation and urinary retention, was 16%. The rate of long-term complications, including anal incontinence and stenosis, was 4%. Benign and malignant recurrence rates were 2% and 6%, respectively. Overall long-term requirement for invasive procedures, low anterior resection or abdominoperineal resection, was 12%.

Conclusion: To our knowledge, this is the first Canadian study showing TAMIS to be an efficient and safe procedure for the treatment of well-selected patients with rectal lesions. Outcomes from our centre are comparable with those found in the literature.
Despite advances in endoscopic techniques and technology, surgical excision remains the cornerstone for treatment with a curative intent for colorectal lesions. A multitude of surgical interventions for mid to low rectal lesions have been developed over the last 30 years. The degree of radical resection directly affects disease-free survival, yet aggressive surgical options often negatively impact the quality of life (QOL) thereafter. Hence, there is a need for a surgical technique that is oncologically equivalent to radical surgery but that is safer and functionally superior.

From a historical point of view, transanal endoscopic microsurgery (TEM) was first described by Buess and colleagues in 1983. It is an effective modality for treating benign and early-stage rectal tumours. TEM has been shown to be effective and safe, with low morbidity and with good QOL postoperatively for patients with early rectal cancer and adenomas of the mid and distal rectum. Furthermore, TEM is associated with substantially lower cost at US$800 per single use. It is disposable and requires fewer pieces of equipment to achieve the same or even better exposure than TEM. Also, setup for TEM is easier and more manoeuvrable than TEM. The TAMIS platform allows regular laparoscopic instruments to be used.

Despite its versatility and increasing adoption, there is little evidence in the literature that examined the clinical outcomes of TAMIS. Our centre adopted the TAMIS procedure for treating benign and early-stage rectal tumours in 2012 — the first in Canada. To date, we have successfully completed more than 50 rectal excisions using the TAMIS platform. Here we describe our technique, experience and outcomes with TAMIS as well as any challenges currently associated with it.

**METHODS**

We conducted a retrospective review of prospectively collected data on patients who underwent TAMIS for benign or early malignant rectal lesions between May 2012 and August 2016 at Health Sciences North, Sudbury, Ont., a tertiary care centre. The study was approved by our institutional review board. All procedures were performed by a single colorectal surgeon (A. C.-M.). The TAMIS procedure considered for this study included local excision and fistulas involving the rectum. Patients with benign lesions, T1 lesions, or T2 lesions that were unfit for radical surgery were also considered for TAMIS local excision after staging confirmed no metastatic disease.

Staging was accomplished using endoscopic biopsy, computed tomography (CT), pelvic magnetic resonance imaging (MRI) and endoscopic ultrasonography (EUS). Patients with nonmalignant polyps and T1 lesions were offered the TAMIS procedure with the understanding that intraoperative findings or final pathology analysis may precipitate further and more invasive operations, such as low anterior resection (LAR) or abdominoperineal resection (APR). Patients with T2 lesions who were unsuitable surgical candidates for invasive pelvic resections were also offered the TAMIS procedure.

We examined the following outcomes: procedure feasibility, margin negativity, length of stay in hospital (LOS) and early complications. Histological outcome was assessed through microscopic resection margin status.

**Surgical technique**

Our technique is based on that described by Attalah and colleagues in 2010 (Fig. 1). The patient is placed in a lithotomy, prone, Sim left lateral decubitus or right lateral decubitus position such that the lesion is at 6 o’clock. Use of the lone star retractor is optional. We used the GelPOINT Path Transanal Access Platform for all procedures. Three working ports are placed into the GelCap: 2 regular ports, including a camera port, are inserted at the 11 o’clock and at the 6 o’clock positions, and 1 AirSeal port is inserted at the 2 o’clock position. The GelCap is then mounted onto the platform. Pneumorectum is achieved at a pressure of 15 mm Hg with carbon dioxide gas. An Endo-Eye Laparoscope (Olympus) with a multiangulation camera is introduced. The rectal lesion is identified and marked with hook electrocautery circumferentially, taking care to leave adequate margins in all directions. We often strive to achieve full thickness resection, avoiding dissection down to the plane of the mesorectal fat. In most cases, we reapproximate the defect with 3–0 Vicryl (polyglactin) sutures without narrowing the rectal lumen; use of a piece of GelFoam is optional. The specimen is carefully pinned to a soft board and sent to pathology.

**RESULTS**

**Demographic characteristics and indications**

A total of 50 patients (31 men and 19 women, mean age 67 ± 1 yr) underwent TAMIS at our centre between May 2012 and August 2016. The average BMI was 30 ± 1. The demographic and clinical characteristics of the patients are shown in Table 1.
The major indications for TAMIS were benign rectal lesions that were too large for endoscopic resection (EMR) \((n = 25)\), followed by early rectal cancers and high-grade dysplasia (HGD; \(n = 14\)), lesions with inadequate or unknown margin postendoscopic excision or polypectomy \((n = 10)\) and recurrent polyps following previous excision of any kind \((n = 6;\) Table 1). Two patients with T2 lesions and 2 patients with T1 lesions on preoperative workup.

Fig. 1. Transanal minimally invasive surgery (TAMIS) setup and surgical specimens. **(A–C)** The patient is usually placed in the lithotomy with steep Trendelenburg position for posterior rectal wall lesions. **(D)** Positioning of patients should also take into account the location of the lesion. Though some reports suggest that through the TAMIS platform any lesion in the rectum can be accessed in a 360° circumferential manner, we have always positioned the patient such that the lesion is at 6 o'clock. **(E)** The lone star retractor is placed. **(F)** The TAMIS platform is placed. **(G)** Positioning of the surgeon, first assistant and scrub nurse in relation to the viewing screen and the patient. **(H)** Once the lesion is identified, it is demarcated with a hook electrocautery to mark its boundary with adequate margins in all directions. **(I–M)** Careful and deliberate dissection from the mucosa onto the plane of the mesorectal fat. **(N–O)** Once the lesion is removed, the defect is usually reapproximated. **(P)** The specimen is pinned on a soft board and sent to pathology for analysis.
were offered TAMIS owing to advanced age and medical comorbidities. Two patients underwent redo-TAMIS (Table 1).

**Technical success rate**

The average lesion distance from the anal verge was 7 ± 1 cm, and the lesions were present in all aspects of the rectal circumference in equal proportions. This was reflected in patient positioning (Table 2).

The average duration of surgery was 73 ± 5 min; stratified by year, the average durations were 99 ± 6 min, 85 ± 13 min, 59 ± 7 min, 71 ± 16 min and 52 ± 7 min. Yearly case load was 6 cases in 2012, 13 in 2013, 7 in 2014, 15 in 2015 and 9 cases in 2016 (Fig. 2). Full thickness resection, including partial mesorectum, was performed in 34 (68%) patients. When the lesion was close to the vaginal plexus or prostate/urethra (4 patients, 8%), we were careful with the depth. When the lesion was too close to the sphincter (12 patients, 24%), only full thickness wall resection was done. We successfully completed TAMIS in all 50 patients. Of these, 47 cases were completed with the TAMIS platform alone, and 3 cases required a hybrid technique using the transanal excision (TAE) and colonoscopic-assisted localization of the lesions. No intraoperative conversion through LAR, APR, or TAE was required.

The average volume of the specimen was 17.8 ± 2.3 cm³ and the volume of tumour resected was 5.5 ± 1.0 cm³. The average tumour diameter was 2.5 ± 0.2 cm. In 43 (86%) patients, the excision defect was closed.

### Resection margins and pathology

On final pathology, 16 patients had adenocarcinomas, 1 had a neuroendocrine tumour, 23 had adenomas of various subtypes, and 10 had nonmalignant or benign lesions.

All specimens had grossly negative margins at the time of excision, and care was taken intraoperatively to avoid fragmentation. We achieved an R0 negative resection margin in 42 (84%) patients, a microscopically positive margin in 4 (8%) patients and indeterminate margins in 4 (8%) patients. Two of these patients were followed up with flexible sigmoidoscopy (FSIG) every 6 months. One of these patients experienced a recurrence at 16-month follow-up

### Table 1. Patient demographic and clinical characteristics and TAMIS indications

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (range) or no. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>67 (45–87)</td>
</tr>
<tr>
<td>Sex, male:female</td>
<td>31:19</td>
</tr>
<tr>
<td>ASA classification</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Unavailable*</td>
<td>19</td>
</tr>
<tr>
<td>BMI</td>
<td>30 (17–56)</td>
</tr>
<tr>
<td>TAMIS indications†</td>
<td></td>
</tr>
<tr>
<td>Lesions not amendable to EMR</td>
<td>25</td>
</tr>
<tr>
<td>Early adenocarcinoma appropriate for TAMIS</td>
<td>13</td>
</tr>
<tr>
<td>High-grade dysplasia</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate or indeterminate margin post-EMR</td>
<td>10</td>
</tr>
<tr>
<td>Recurrent polypsis</td>
<td>6</td>
</tr>
<tr>
<td>Medically unfit for radical resection</td>
<td>4</td>
</tr>
<tr>
<td>≥ 2 indications</td>
<td>9</td>
</tr>
</tbody>
</table>

ASA = American Society of Anesthesiologists; BMI = body mass index; EMR = endoscopic mucosal resection; TAMIS = transanal minimally invasive surgery.

ASA documentation in operative records was not mandatory at our center prior to 2013.

Some patients fall under multiple categories.

### Table 2. Quality of excision and postoperative findings

<table>
<thead>
<tr>
<th>Finding</th>
<th>Mean (range) or no. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion distance from anal verge, cm</td>
<td>7 (2–15)</td>
</tr>
<tr>
<td>Lesion location</td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>13</td>
</tr>
<tr>
<td>Anterior</td>
<td>12</td>
</tr>
<tr>
<td>Left</td>
<td>17</td>
</tr>
<tr>
<td>Right</td>
<td>8</td>
</tr>
<tr>
<td>Patient positioning</td>
<td></td>
</tr>
<tr>
<td>Lithotomy</td>
<td>15</td>
</tr>
<tr>
<td>Prone jackknife</td>
<td>14</td>
</tr>
<tr>
<td>Sim left lateral decubitus</td>
<td>15</td>
</tr>
<tr>
<td>Right lateral decubitus</td>
<td>6</td>
</tr>
<tr>
<td>Resection depth</td>
<td></td>
</tr>
<tr>
<td>Mucosa</td>
<td>12</td>
</tr>
<tr>
<td>Rectal wall</td>
<td>4</td>
</tr>
<tr>
<td>Rectal wall with partial thickness mesorectum</td>
<td>34</td>
</tr>
<tr>
<td>Volume of specimen resected, cm³</td>
<td>17.8 (1.4–66.7)</td>
</tr>
<tr>
<td>Volume of tumour resected, cm³†</td>
<td>5.5 (0.012–27.6)</td>
</tr>
<tr>
<td>Tumour size along greatest dimension, cm</td>
<td>2.5 (1–4.9)</td>
</tr>
<tr>
<td>Defect closure, yes:no</td>
<td>43:7</td>
</tr>
<tr>
<td>Technique</td>
<td></td>
</tr>
<tr>
<td>TAMIS only</td>
<td>47</td>
</tr>
<tr>
<td>Hybrid technique</td>
<td>3</td>
</tr>
<tr>
<td>Intraoperative conversion (LAR/TAE)</td>
<td>0</td>
</tr>
<tr>
<td>Final pathology</td>
<td></td>
</tr>
<tr>
<td>Adenocarcinoma and neuroendocrine tumour</td>
<td>17</td>
</tr>
<tr>
<td>Villous adenoma</td>
<td>5</td>
</tr>
<tr>
<td>Tubulovillous adenoma</td>
<td>15</td>
</tr>
<tr>
<td>Tubular adenoma</td>
<td>2</td>
</tr>
<tr>
<td>Serrated adenoma</td>
<td>1</td>
</tr>
<tr>
<td>Submucosal lipoma</td>
<td>1</td>
</tr>
<tr>
<td>No malignancy</td>
<td>9</td>
</tr>
<tr>
<td>Resection margins</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>42</td>
</tr>
<tr>
<td>Positive</td>
<td>4</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>4</td>
</tr>
</tbody>
</table>

LAR = low anterior resection; TAE = transanal excision; TAMIS = transanal minimally invasive surgery.

Table reports do not always include 3-dimensional measurements of the resected specimen.

Some specimens, especially the ones to rule out positive margin, do not contain tumour for measurements.
and subsequently underwent re-excision. Histology on the redo-TAMIS specimen returned as a T2 lesion, and the microscopic margins were positive. Owing to advanced age, medical comorbidities and the patient’s unwillingness to undergo a third operation, palliative chemotherapy was prescribed. The other patient had HGD involving the resection margin of the adenoma specimen and was followed with FSIG every 6 months, with no recurrence to date. Two of these 4 patients had no recurrence on follow-up. In the 4 patients in whom the margin was indeterminate, the lesions were fragmented during the operations, hence their margins could not be assessed on pathological analysis. As a routine, these patients also underwent surveillance FSIG every 6 months and were found to have no recurrence of their diseases 3 years after TAMIS.

Of the 15 malignant cases on preoperative diagnosis, only 9 were confirmed to be malignant on final pathology, and of the 35 benign preoperative cases, 8 were found to be malignant on final pathology (Fig. 3).

Recurrence

The median duration of follow-up was 21 (range 2–53) months. There were 4 adenocarcinoma recurrences (8%) in our series: 1 benign and 3 malignant (Table 3). These patients were followed clinically with regular FSIG until local recurrence was identified. The patient with benign recurrence experienced a local recurrence at 13 months on FSIG surveillance. He underwent TAMIS re-excision and has been disease-free since. One patient with a malignant recurrence was found to have multiple liver metastases and a presacral mass at 35 months. He was referred to oncology for medical management. Two patients with cancer had local recurrence. One recurred at 16 months, and the patient underwent re-excision, but pathology returned as pT2 with a positive margin (see the Resection margins and pathology section). The patient was referred for palliative chemotherapy because of poor surgical candidacy. The other patient also had a local recurrence and was clinically staged as T2N0M0 and was considered for APR.

Morbidity and mortality

The average LOS was 1.1 ± 0.2 days. Most (42 of 50, 84%) patients went home on the same day or on postoperative day (POD) 1. The remainder went home on POD-2 or POD-3 and were kept for observation owing to medical comorbidities, urinary retention and reoperation. One patient experienced hospital-acquired pneumonia and pleural effusion with no intra-abdominal or rectal issues; this extended his LOS to 10 days, as he required medical management.

The overall 30-day morbidity was 16% (8 of 50) A breakdown of complications is listed in Table 3. Mortality was 0%. Short-term complications included 1 small suture line perforation requiring laparoscopic repair on POD-1. We had 4 cases of postoperative rectal bleeds; the patients were admitted for observation. One of them required transfusion. One patient had a urinary tract infection. Long-term complications included 1 rectal stenosis that resolved after 4 endoscopic dilatations during the first year after surgery. The patient has remained asymptomatic.

Discussion

The treatment of benign and early tumours hinges on a balance between curative intent and functional preservation. The TAMIS technique is safe and effective for removing rectal lesions with good functional and oncological
outcomes. It exceeds TAE and TEM with several advantages. The rapid setup for TAMIS is more efficient than the setup for TEM. It can be completed in about 5 min. The platform does not need to be fixed to the operating table and is therefore mobile and manoeuvrable. In addition, TAMIS allows the use of any laparoscopic instruments, making the procedure universal. This translates into greater familiarity or transferability of existing skills for the surgeon, increased cost-effectiveness, and better and safer care for patients. These benefits have been widely reported in the literature.\textsuperscript{4,5,13} Compared with TAE, TAMIS allows for better exposure and visualization of lesions along the entire length of the rectum. Contrary to previous indications for TAMIS, we found that excision of high rectal lesions were feasible with this technique; albeit slightly more challenging to perform, the surgery was less invasive and required shorter LOS.

Despite these advantages, there are still a few challenges commonly encountered with TAMIS. First, lesions behind a valve of Houston are difficult to excise on a TAMIS platform. In one such case, our initial dissection was delayed owing to an inability to identify the lesion. The platform had to be taken down, and an intraoperative flexible endoscope was introduced to finally identify the lesion behind a fold 10 cm above the anal verge. The dissection itself was difficult, as the surgeon struggled to expose the lesion and provide adequate traction. The closure of the defect was equally challenging, and it was left open after hemostasis was achieved. Second, TAMIS is challenging in obese patients with abundant adiposity in the gluteal region. To overcome this problem, we place stay sutures to efface the anal canal. Once pneumorectum is achieved, then the adenoma can be visualized and excised. This was achieved in 42 patients. To achieve a full thickness resection for T1 adeno carcinoma or large polyps, we deliberately entered the plane of the mesorectum and resected portions of it; the advantage was the achievement of R0 negative margins, but the disadvantages were longer duration of surgery and inadvertent peritoneal entry, especially in patients with mid to high rectal lesions. We have not needed to convert to laparoscopic repair for peritoneal violation. However, it may be necessary, as suggested previously by others.\textsuperscript{11}

One caveat with aggressive resection to achieve R0 margin is peritoneal violation. These cases were often associated with lesions that were relatively large, occupying up to 40%–50% rectal circumference, and located anteriorly or left anterolaterally in the rectum at 7–10 cm from the anal verge. We had a total of 5 peritoneal violations. They were suture-repaired in all 5 patients, who were admitted overnight for observation. One patient was kept in hospital for 10 days owing to respiratory complications. This patient did not require any surgical intervention. Entry into the peritoneal cavity should be considered a complication.

<table>
<thead>
<tr>
<th>Table 3. Early postoperative and long-term outcomes of TAMIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complication</strong></td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td><strong>Short-term</strong></td>
</tr>
<tr>
<td>UTI</td>
</tr>
<tr>
<td>Leak</td>
</tr>
<tr>
<td>Readmission</td>
</tr>
<tr>
<td>Bleeding</td>
</tr>
<tr>
<td>Urinary retention</td>
</tr>
<tr>
<td>Pneumoperitoneum</td>
</tr>
<tr>
<td><strong>Long-term</strong></td>
</tr>
<tr>
<td>Anal stricture</td>
</tr>
<tr>
<td>LAR/APR requirement</td>
</tr>
<tr>
<td><strong>Recurrence</strong></td>
</tr>
<tr>
<td>Benign</td>
</tr>
<tr>
<td>Malignant</td>
</tr>
</tbody>
</table>

APR = abdominoperineal resection; LAR = low anterior resection; LOS = length of stay; TAMIS = transanal minimally invasive surgery; UTI = urinary tract infection.
However, this can be repaired intraoperatively without the need to convert to any other approach. In our experience, all of the peritoneal violations were amendable to repair through the TAMIS platform with suture closure. Based on our experience, we recommend that anterior lesions that are suspected to be above the peritoneal reflection should not be operated using the TAMIS method unless the surgeon is experienced with suturing through the TAMIS platform.

There is some debate in the literature as to whether the postresection defect should be reapproximated. In 86% of our patients, we reapproximated the defect as part of hemostasis or controlling perforations into the peritoneum. Such defects were left open when the lesion was close to the anal sphincter to avoid sphincter injury and subsequent fecal incontinence. Overall, we did not find any anorectal malfunctions due to this type of closure, nor did we find any significant difference in postoperative outcomes. A series by Hahnloser and colleagues\textsuperscript{16} showed the rectal defect can be left open without increasing complications or compromising rectal continence.\textsuperscript{16} Haugvik and colleagues\textsuperscript{17} left the rectal defect open in 25% of their cases and did not find any increase in surgical morbidity. These studies will likely help guide practice when the lesion is too close to sphincters and too technically difficult to close.

Based on our study, even with adequate preoperative workup, adenomas and T1 early tumours can be more advanced on final pathology. Consequently, patients with a preoperative workup of cancer or positive margin status can be found to have no malignancy on final pathology (Fig. 3). These findings are echoed in the literature, in which up to 44% of rectal lesions can be incorrectly staged even with adequate preoperative workup.\textsuperscript{11} In our series, 6 cases were overestimated on initial workup and 8 cases were underestimated, in which final pathology revealed T2 lesions compared with T1 or adenoma on initial workup; the overall rate of incorrect staging was 28%. As oncological outcome with local excision for pathological T2 adenocarcinomas is likely inadequate, 3 of these 6 patients underwent LAR, 1 had APR, 1 had re-excision with FSIG surveillance, and 1 was not treated owing to comorbidities. The TAMIS technique can be both a curative and staging procedure for lesions in the grey zone between benign and malignant on preoperative assessment. In malignant cases, TAMIS is undertaken only for early lesions without features of aggressiveness, such as poor differentiation, lymphovascular invasion (LVI), perineural invasion (PNI), T2 or positive lymph node. The only exceptions will be in patients with significant medical morbidities that prevent them from undergoing a radical intervention. In some cases, we cannot establish with certainty whether a patient has any malignancy, therefore TAMIS can be considered the ultimate biopsy. In some cases these biopsies can lead to a more radical procedure. In order to prevent increasing complexity at the time of radical surgery, full thickness of the mesorectum is avoided at all cost, as it will be a direct violation of the mesorectal plane.

To our knowledge, no study is available to evaluate the equivalency of oncological outcomes between radical surgery and TAMIS; however, QOL is likely better with the latter. Flexible sigmoidoscopic surveillance and clinical follow-up after TAMIS is important to identify any cancer or polyp recurrence, such that reoperation can be done in a timely fashion in order to avoid disseminated cancer. Currently, there is no guideline available.\textsuperscript{18} We recommend follow-up every 3–6 months with FSIG for about 2–3 years.

Our recurrence rate in the present study was 8% (4 of 50), which is better than the rate of 17% for local recurrence after TEM reported in the literature.\textsuperscript{19} Rectal stenosis is more likely to occur when the circumference of the lesion is large. Likewise, urinary retention occurs more often when the lesion is more circumferential.\textsuperscript{4}

Our technique is adequate, with a total TAMIS completion rate of 100% for lesions that averaged 7 cm from the

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients</th>
<th>Diameter, cm</th>
<th>Distance from anal verge, cm</th>
<th>Duration of surgery, min</th>
<th>Mean LOS, d</th>
<th>Morbidity, %</th>
<th>Mortality, %</th>
<th>Negative margin, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>50</td>
<td>2.5</td>
<td>7</td>
<td>73</td>
<td>1.1</td>
<td>16</td>
<td>0</td>
<td>84</td>
</tr>
<tr>
<td>Haugvik et al.\textsuperscript{17}</td>
<td>51</td>
<td>3.2</td>
<td>8</td>
<td>40</td>
<td>1*</td>
<td>12</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>Keller et al.\textsuperscript{22}</td>
<td>75</td>
<td>3.2</td>
<td>10</td>
<td>69</td>
<td>1*</td>
<td>5.30</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Sumrren et al.\textsuperscript{9}</td>
<td>281</td>
<td>5*</td>
<td>NA</td>
<td>&lt; 60</td>
<td>1.5</td>
<td>23</td>
<td>0</td>
<td>82</td>
</tr>
<tr>
<td>Versevold et al.\textsuperscript{21}</td>
<td>24</td>
<td>6 cm\textsuperscript{2}</td>
<td>8*</td>
<td>NA</td>
<td>NA</td>
<td>4</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Gill et al.\textsuperscript{8}</td>
<td>32</td>
<td>2.1</td>
<td>7.5</td>
<td>131</td>
<td>1.1</td>
<td>50</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Maglio et al.\textsuperscript{10}</td>
<td>15</td>
<td>3.5</td>
<td>7</td>
<td>86</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>McLeMere et al.\textsuperscript{12}</td>
<td>32</td>
<td>0.5–8.5</td>
<td>1–11\textsuperscript{†}</td>
<td>123</td>
<td>2.5</td>
<td>16</td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>Schiphorst et al.\textsuperscript{20}</td>
<td>37</td>
<td>18 cm\textsuperscript{2}</td>
<td>7\textsuperscript{†}</td>
<td>64\textsuperscript{*}</td>
<td>1*</td>
<td>8</td>
<td>0</td>
<td>78</td>
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<tr>
<td>Albert et al.\textsuperscript{7}</td>
<td>50</td>
<td>2.75</td>
<td>8.1</td>
<td>75</td>
<td>0.6</td>
<td>8</td>
<td>0</td>
<td>90</td>
</tr>
</tbody>
</table>

LOS = length of stay in hospital; NA = not available.
\*Median.
\*80% success rate.
\*Dentate.
anal verge, a positive margin rate of only 8% (4 of 50), morbidity rate of 16% and an average LOS of 1.1 day. Our outcomes were comparable or better than those of other published series in recent years^7^–^10^,^17^,^18^,^20^–^22^ (Table 4). The TAMIS technique is efficient, viable and safe for the treatment of rectal lesions.

**Limitations**

One of the limitations of our study was the lack of QOL measurements. The post-TAMIS clinical follow-up was limited to patients who would present with anorectal complications as opposed to administering QOL assessment in all patients who underwent TAMIS. Measures based on questions 19–23 from the International Consultation on Incontinence Modular Questionnaire (ICIQ) from a small series conducted in the United Kingdom showed anf function to be acceptable post-TAMIS.^21^ Another small series examined functional outcomes using the Fecal Incontinence Severity Index (FISI) and showed no TAMIS-related sphincter injury or fecal incontinence, and a generic QOL measure using the EuroQolEQ-5D questionnaire showed sphincter injury or fecal incontinence, and a generic QOL limitation includes the inherent bias with retrospective analysis; based on these small series will also vary by centre. Likewise, oncological outcomes as opposed to administering QOL assessment in all patients who underwent TAMIS. Measures based on questions 19–23 from the International Consultation on Incontinence Modular Questionnaire (ICIQ) from a small series conducted in the United Kingdom showed anf function to be acceptable post-TAMIS.^21^ Another small series examined functional outcomes using the Fecal Incontinence Severity Index (FISI) and showed no TAMIS-related sphincter injury or fecal incontinence, and a generic QOL measure using the EuroQolEQ-5D questionnaire showed improved QOL after TAMIS, presumably secondary to tumour excision.^21^ The aforementioned questionnaires are easy for patients to use, are excellent tools for assessing anorectal function over time^20^ and can potentially be incorporated into routine clinical follow-up at our centre. Another limitation includes the inherent bias with retrospective analysis owing to missing data from medical records; however, our surgical and clinical data set was complete as data were collected prospectively. Pathological records occasionally lacked tumour dimensions, but the margin analyses were well described. Finally, it is important to keep in mind that TAMIS is an evolving surgical technique, and the sample sizes in published series are small, hence surgical outcomes are subject to variation by centre. Likewise, oncological outcomes based on these small series will also vary by centre.

**Conclusion**

In congruency with current evidence, which supports TAMIS as a viable alternative to radical excision of the rectum with less morbidity, faster recovery and greater potential cost savings, we have shown TAMIS to be a safe, efficacious and reproducible technique in this endeavour. Furthermore, we foresee increasing use of this technique for more complex colorectal surgeries at our centre.

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**Competing interests:** None declared.

**Contributors:** All authors designed the study, acquired and analyzed the data, wrote and reviewed the article and approved the final version for publication.

**References**

The importance of cognitive map placement in bile duct injuries

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SUMMARY

Bile duct injuries often occur because of surgeon spatial disorientation. The psychological concept of cognitive map misplacement is a useful explanation of how this disorientation and injury occurs. Surgeons may find that using a “bile duct time out” is a helpful way to orient. Based on the mnemonic B-SAFE, they can use 5 subhepatic landmarks (B, bile duct; S, sulcus of Rouviere; A, hepatic artery; F, umbilical fissure; E, enteric/duodenum) to correctly place their cognitive map.

Despite ongoing attention, the incidence of bile duct injuries during cholecystectomy remains high. New understanding in the field of cognitive psychology offers a possible explanation and solution to this vexing problem.

Maintaining spatial orientation during surgery is an ongoing psychological task. To be safe, surgeons must identify and maintain landmarks throughout the operation. During the process of “knowing” their environment, a surgeon accumulates spatial knowledge. The construction of a cognitive map serves the organization of this knowledge. It involves a series of psychological transformations that acquire, encode, store, recall, decode and then utilize spatial information. A surgeons’ map is not just a simple route. It is a complex collage of information rich in meaning. It carries with it an inherent risk assessment for various areas, an understanding of tissues and how they separate, and various options for forward moves. The development of a useful cognitive map may require years of training and may then be used in a largely subconscious, intuitive way.

A surgeons’ use of cognitive maps to perform surgery has received little attention. Most cognitive map studies deal with large-scale environments; however, the principles are the same for the surgeons’ small-scale environment. The use of a cognitive map is a heuristic (mental shortcut). Surgeons may place their cognitive maps on the presenting surgical environment based on fixed landmarks. This mental imagery fills in perceptual blanks and sorts ambiguous anatomy so that the operation can proceed rapidly. Not every structure must be meticulously explored, as the map makes assumptions about their nature. However, cognitive maps are not a perfect representation of reality; they “appear to be fragmented, schematized, inconsistent and multimodal.” They are also subject to their own set of biases, such as remembering things being more organized than they really are. Placement of a cognitive map in the wrong location is an ongoing risk for every surgeon.

Spatial disorientation has been recognized as a major cause of bile duct injuries. The following of a misplaced cognitive map further explains how the error in a classical bile duct injury proceeds. Traction on the infundibulum (Hartmann pouch) may line up the common bile duct and cystic duct in the same axial plane and create an angle between the
common bile duct and common hepatic duct that may appear like the angle between the cystic duct and gall-bladder wall. This creates an illusion that convinces the operator to fix his or her cognitive map medially and inferiorly in the “porta hepatis” triangle rather than the hepatobiliary triangle (Fig. 1). Inflammation may obscure and close the hepatobiliary triangle; the tissues and anatomy in the porta hepatis triangle may also appear remarkably similar. The common bile duct is clipped and divided as if the cystic duct (Fig. 1, lower arrow), and the left side of the hepatic duct is followed to the liver as if it was the gallbladder wall. Cautery is then used to divide the common hepatic duct at or above the hilum as if separating the gallbladder from the liver (Fig. 1, higher arrow). It is the following of the map that results in the second division of the bile duct. The fact that this second division puts the operator back into the correct map location explains why most of these injuries are not recognized at the time of surgery.4

Five landmarks around the gallbladder can cue the surgeon to his or her spatial location (Fig. 2). First, the bile duct (B) itself can often be seen either just above the duodenum or at the hilum. The sulcus of Rouviere (S) in some form is usually present on the undersurface of the right side of the liver. The pulsations of the hepatic artery (A) can be seen on the left side of the porta hepatitis. Also on the left side, the umbilical fissure (F) can be visualized. Inferiorly, one can use the enteric (E) stomach/duodenum to orient vertical position. By using these 5 landmarks — the B-SAFE mnemonic — the operator can orient in space and accurately set a cognitive map of the operation before starting.5

Using timeouts is a cognitive strategy for debiasing our decisions. It is a forcing rule that, in a specific situation, makes us move from an intuitive (fast) thinking mode to a more reliable, analytic (slow) thinking mode. A bile duct time out can do this before the dissection commences and before division of any structure. The operator should stop, back the camera up, lift segment 4 of the liver and identify the 5 landmarks (B-SAFE) to be sure their map is correctly placed. It takes only seconds, and allows the surgeon to confirm spatial orientation.

Although completely eliminating bile duct injuries may be impossible, an improved understanding of the psychological basis from which surgeons operate offers new ways to improve outcome.

Affiliations: From the Department of Surgery, University of Calgary, Calgary, Alta.

Competing interests: None declared.

Contributors: Both authors contributed substantially to the conception, writing and revision of this article and approved the final version for publication.

References


Users’ guide to the surgical literature: how to assess a noninferiority trial

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A well-planned randomized controlled trial (RCT) is the most optimal study design to determine if a novel surgical intervention is any different than a prevailing one. Traditionally, when we want to show that a new surgical intervention is superior to a standard one, we analyze data from an RCT to see if the null hypothesis of “no difference” can be rejected (i.e., the two surgical interventions have the same effect). Let’s consider a hypothetical RCT that compares laparoscopic to open appendectomy and the outcome measured is a pain score based on a Likert scale from 0 to 10. Suppose it was found that the mean pain score following laparoscopic appendectomy was 7 points and that following open appendectomy was 8 points, and that this 1-point difference was statistically significant. Such a result would be uncommon because it would require a large sample size, but let’s accept this for now. Although statistically the result is significant, we do not consider this 1-point difference to have clinical relevance. This type of thinking addresses the concept of minimum clinically important difference (MCID), which describes a threshold that might persuade us to change our surgical practice. The meaningful MCID is usually based on the available best evidence derived from previous systematic reviews, pilot/feasibility studies or clinical judgment based on discussion with experts in the field.

In another hypothetical RCT, the length of stay (LOS) after laparoscopic appendectomy was observed to be 24 hours versus 30 hours after open appendectomy, with a \( p < 0.05 \). It would be meaningless to conclude that the observed difference of 6 hours is the truth without reporting a confidence interval (CI), as a \( p \) value alone does not provide information on the degree of uncertainty (variation) applied in measuring the difference in hospital stay. Briefly, a CI provides information regarding the degree of uncertainty associated with the observed difference of 6 hours in hospital stay. It is within the CI that the true difference will likely lie. Let’s say that in our hypothetical example the 95% CI for hospitalization time difference of 6 hours was 1–11 hours in favour of the laparoscopic approach. This means we are 95% confident that the true difference lies somewhere between 1 and 11 hours,
which is quite wide, raising uncertainty when a definitive conclusion is made.

In the last decade, we have observed an increase in the publication of noninferiority RCTs. This article explores this type of study design and discusses the tools that can be used to appraise such a study.

**CLINICAL SCENARIO**

At the last cardiac surgery weekly academic rounds there was a heated exchange between 2 surgeons, who were arguing the merit of ex-vivo heart perfusion compared with cold storage as a means of preserving donor hearts before transplantation. To resolve this dilemma, the division head has assigned you, the newest member of the division, with the task of finding the best evidence to answer this clinical question and report your findings to the group at next week’s rounds.

**FINDING THE EVIDENCE**

To identify the best evidence and inform your colleagues you begin by conducting a literature search according to the “Users’ guide to the surgical literature: how to perform a high-quality literature search.” You follow the PICOT format, which serves as the starting point for identification of important key words used in the search process:
- **Population:** heart transplant patients
- **Intervention:** heart transplantation with ex-vivo perfusion
- **Comparison:** heart transplantation with cold storage
- **Outcome:** patient survival and graft survival
- **Time horizon:** 30 days after transplant

You then conduct a literature search in PubMed Clinical Queries using the search terms “heart transplantation” AND “ex-vivo perfusion” AND “cold storage,” using the “Therapy” and “Broad” filters. You identify 10 articles: 7 ex-vivo human/animal studies, 1 nonrandomized clinical study, 1 review and 1 RCT. The RCT addresses your research question and has the benefit of being level-I evidence. However, when reading the article, you are perplexed that it is labelled as a “randomized noninferiority trial.”

**NONINFERIORITY RCT DESIGN**

A noninferiority RCT design seeks to determine whether a new intervention is not worse than a prevailing (standard) one within an acceptable margin of risk or benefit, referred to as the noninferiority margin. It is usually assumed that the standard intervention has been shown to have better (superior) clinical effect than a placebo or an earlier intervention. The new intervention is considered to be noninferior to the standard one when it is shown to have reduced costs, have fewer adverse effects (harm), be less invasive, and be of greater convenience. In trials that investigate noninferiority, the null hypothesis is not symmetric. The new intervention will be proven noninferior if it is similar to the standard intervention, but not beyond the margin of noninferiority for a specified outcome measure. If the new intervention is found to be superior, it is an additional benefit. Tests of noninferiority should be linked to the predefined noninferiority margin and predefined $\alpha$. An $\alpha$ of 0.025 for a 1-sided noninferiority hypothesis is equivalent to the 1-sided 97.5% CI, as an $\alpha$ of 0.05 for a 2-sided hypothesis is equivalent to a 2-sided 95% CI.

Suppose the hospital administrators would like to expedite surgical patients’ hospital discharge with the adoption of this new surgical approach if it is proven to be noninferior to the standard procedure within a 3-hour noninferiority margin.

Figure 1 presents some possible scenarios for noninferiority trials observing mean differences in hospital stay following laparoscopic and open approaches. Scenario A shows that laparoscopic surgery is superior to open surgery, as the CI lies to the left of the no difference line (zero). In scenario B, the CI includes the threshold of noninferiority. It means that noninferiority is not shown, as the true difference in hospital stay could be worse than the 3-hour predefined noninferiority margin for laparoscopic surgery. Scenarios C and D show that laparoscopic surgery is noninferior to open surgery because the upper confidence limit lies to the left of the 3-hour noninferiority margin in hospital stay. Scenario D shows that laparoscopic surgery is definitely noninferior to open surgery, as the CI lies to the left of the noninferiority margin and also excludes zero line of no difference. In scenario E, the laparoscopic surgery is definitely inferior to open surgery with respect to hospital stay, as the lower bound of the CI lies to the right of the noninferiority margin. Such a scenario is less likely, as it requires a very large sample size.

The choice of noninferiority margin requires sound clinical judgment. The noninferiority margin should be the smallest clinically meaningful difference between the 2 surgical interventions. In general, margins for mortality or serious adverse events should be more stringent than those for symptom control or quality of life. Many experts have stipulated that the noninferiority margin for efficacy outcomes should be no more than 50%, and preferably no more than 20% of the treatment effect for the standard treatment, as established in placebo-controlled superiority RCTs. Unfortunately no validated rules exist for calculating the noninferiority margin, and many trials use margins that statisticians consider to be too liberal. It is important that, whenever possible, this margin be validated by published expert consensus and not left to the sole discretion of the investigators or sponsors of the study.

**RETURNING TO THE CLINICAL SCENARIO**

The article you identified is a prospective, open-label, multicentre, randomized noninferiority trial, by Ardehali and colleagues that took place at 10 heart transplant centres in the United States and Europe. Eligible heart transplant patients were randomly assigned to receive either...
donor hearts preserved with the organ care system (OCS; ex-vivo heart perfusion) or standard cold storage (SCS). The key methodological characteristics of the study are summarized in Figure 2 and Table 1. \textsuperscript{15}

To effectively appraise a noninferiority surgical RCT, you use a similar framework to that of previous users’ guide articles (Box 1). \textsuperscript{1,3,23}

Are the results valid?

Did the novel and standard surgical interventions start with similar prognostic factors?

As with the more commonly seen superiority RCT, the non-inferiority RCT is expected to minimize the risk of bias by ensuring concealment of randomization, balance between known and unknown prognostic factors, blinding of patients, surgeons and outcome assessors to treatment allocation, and complete follow-up of all patients. In reviewing the noninferiority trial by Ardehali and colleagues, \textsuperscript{15} you see that an independent biostatistician prepared sealed and masked randomization envelopes, which were assigned to the research trial sites. The investigators, however, did not report if the envelopes were opened sequentially and one at a time. Patients, investigators and medical personnel were not blinded to group allocation. They chose an open-label design because the method of donor heart preservation made blinding of medical staff infeasible. In reviewing Table 1 of their article, you see no glaring differences in main demographic characteristics of patients assigned to the 2 competing approaches; these characteristics included age, sex, height, body mass index (BMI), diagnosis of cardiomyopathy of the recipient patients, and the cause of death of the donor patients.

There was, however, some imbalance in the preservation time before the heart transplantation. The preservation time was longer in the OCS group than in the SCS group (324 ± 79 min v. 195 ± 65 min, \(p < 0.001\)); however, the mean total ischemia time was significantly shorter in the OCS group than in the SCS group (113 ± 27 min v. 195 ± 65 min, \(p < 0.001\)).

Was the prognostic balance between the 2 surgical groups maintained as the RCT progressed?

As the heart transplantation is a definitive procedure, there is probably little room to provide differential care to affect the prognostic balance after the event. Figure 2 of the article by Ardehali and colleagues \textsuperscript{15} shows the flow of the patients in the 2 groups. It details the results of the randomization protocol, wherein 130 patients were randomly assigned to either group: 67 to OCS and 63 to SCS. There appears to have been deviation of the protocol in 2 patients in the OCS and 5 in the SCS groups. It is important to note that 2 patients in the OCS group and 1 patient in the SCS group crossed over (i.e., these patients were transplanted using the other respective system).

Ardehali and colleagues \textsuperscript{15} did not report details regarding postoperative care, so you do not know if there was differential care between the 2 groups. Therefore, you cannot conclude with any certainty whether the 2 groups were balanced in this regard.

Did the investigators guard against an unwarranted conclusion of noninferiority?

In the present noninferiority trial, the investigators declared the noninferiority margin (\(\Delta\)) to be 0.10 (10%). Unfortunately, they did not provide any evidence to

![Fig. 1. Possible scenarios for observed mean differences in hospital stay between laparoscopic and open surgery in noninferiority designs. The dotted line represents the noninferiority margin. Reproduced from the study by Piaggio and colleagues\textsuperscript{17} with permission from the American Medical Association (license no. 4003080684018).](image-url)
support this difference, which leads you to wonder if a smaller noninferiority margin (e.g., 5%) could have, or indeed should have, been accepted.

Did the investigators analyze patients according to the surgical treatment they received, as well as to the groups to which they were assigned? The purpose of randomization is to ensure that prognostic factors are balanced between the surgical interventions. Patients who do not adhere to the allocated treatment, as in the study protocol, may have a different prognosis than those who do. Omission of patients who do not adhere to the novel intervention is likely to bias results toward overestimation of treatment effects in a superiority trial. An intention-to-treat analysis, wherein patients are analyzed according to the group they were assigned, provides an unbiased estimate of the treatment effectiveness, irrespective of their adherence to the study protocol.

Ardehali and colleagues conducted both the intention-to-treat and the as-per-protocol analyses and found...

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**Fig. 2.** Methodological characteristics of the PROCEED II Trial. One patient experienced clinically significant ventricular assist device-related complications while waiting for a second donor offer, 1 patient needed a combined heart and kidney transplant while waiting for a second offer; 1 patient became ventilator-dependent on day of transplant, and 1 patient deteriorated and was delisted; 1 donor heart had left-ventricular hypertrophy (> 1.3 cm), and 1 donor was older than 60 years. One opened randomization envelopes before confirming availability of the Organ Care System team, 1 organ procurement organization refused to retrieve the Organ Care System because of absence of research consent, and 1 donor heart had a high concentration of serum lactate before retrieval. After turning down initial donor heart offers, 1 recipient had more than 2 sternotomies while waiting for a third offer and 1 recipient withdrew before a second offer. The randomization card was misread. Deviations in the organ care system group were due to user error in cannulation and 1 recipient receiving unassigned treatment; in the standard cold storage group 1 recipient was enrolled in another pharmaceutical trial and 4 received unassigned treatment. Reproduced from the study by Ardehali and colleagues with permission from Elsevier (license no. 4003081323980).
similar results in both analyses. Therefore, you remain assured that the authors’ analysis of the results may be appropriate. However, the authors could have assured readers of the findings by statistically addressing the missing data (e.g., multiple imputations or best and worst case scenario).

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Group; no. (%)</th>
<th>1-sided 95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outcome (30-d patient and transplant survival)</td>
<td>OCS</td>
<td>63/67 (94%)</td>
<td>2.8 (8.8)</td>
</tr>
<tr>
<td>As-treated</td>
<td>61/63 (97%)</td>
<td>3.5 (9.6)</td>
<td>0.36</td>
</tr>
<tr>
<td>As-per-protocol</td>
<td>56/60 (93%)</td>
<td>3.4 (9.9)</td>
<td>0.39</td>
</tr>
<tr>
<td>Secondary outcome (as-treated population)</td>
<td>OCS</td>
<td>6/12 (50%)</td>
<td>1.0 (2.0)</td>
</tr>
<tr>
<td>ICU length of stay, median (IQR), h</td>
<td>147 (107–212)</td>
<td>137 (97–197)</td>
<td>10 (10 to 42)</td>
</tr>
</tbody>
</table>

Box 1. Framework for critical appraisal of an article that deals with a surgical noninferiority randomized controlled trial (RCT)

**Are the results valid?**
- Did the novel and standard surgical intervention groups start with similar prognostic factors?
- Was the prognostic balance between the 2 surgical groups maintained as the RCT progressed?
- Did the investigators guard against an unwarranted conclusion of noninferiority?
- Did the investigators analyze patients according to the surgical treatment they received, as well as to the groups to which they were assigned?
- Did the investigators report a predefined noninferiority margin?
- Did the investigators power the study for test of noninferiority?

**What are the results?**
- Were all patient-important outcomes considered?
- Were the results precise?
- Were the investigators appropriately interpreting the concept of noninferiority?

**How can I apply the results to my patient or clinical practice?**
- Were the study patients similar to my patient?
- Were all patient-important outcomes considered?
- Are the likely advantages of the novel surgical treatment worth the potential harm and costs?

Did the investigators report a predefined noninferiority margin?

In a noninferiority RCT it is important that the investigators report the noninferiority margin and the rationale for choosing it. In the statistical analysis section of their methods, Ardehali and colleagues mentioned a 10% noninferiority margin, but provided no rationale for choosing it.

Did the investigators power the study for a test of noninferiority?

The investigators reported in the Methods section of their article that they calculated the 1-sided 95% upper confidence bound based on the normal approximation for the difference between the 2 population proportions. An upper confidence bound less than the 10% noninferiority margin would have rejected the null hypothesis. For the purpose of sample-size calculation, they assumed πOCS = 0.95 and πSOC = 0.94. On the basis of these assumptions, use of a normal approximation test and a 1-sided α level of 0.05, inclusion of 54 patients per treatment group would have provided 80% power.

There should be a justification for choosing a superiority versus a noninferiority study design. To some degree the authors justified the choice of the noninferiority design in that the OCS system provides certain benefits, such as the potential of “distant procurement for donor hearts, thus expanding the donor pool” in contrast to the standard cold storage. The justification of the study design is made on the research question asked and the hypothesis — specifically on the clinical advantages of the novel intervention. The measured outcomes play an important role in the sample size calculation through the choice of the MCID. Survival should demand a smaller MCID than, for example, a quality of life (QOL) outcome. The 10% choice as the noninferiority margin seems very liberal, which most surgeons or patients would not accept in a case of life or death. A noninferiority margin of 1%–2% would likely be a better choice. This raises the concern that the study may have been designed originally as a superiority study.

What are the results?

Were all patient-important outcomes considered?

The investigators found that the 30-day patient and heart transplant survival rate (primary outcome) was 94% in the OCS group and 97% in the SCS group (p = 0.45). The intention-to-treat analysis (94% vs. 97%, p = 0.36) and the as-per-protocol analysis (93% vs. 97%, p = 0.39) supported the overall estimate. Multiple clinically important outcomes were included, such as graft failure and left and right ventricular dysfunction, with a time horizon of 30 days. Some surgeons may consider this short-term time frame of limited value; a longer follow-up would have been more appropriate. Patient-important
outcomes, such as quality of life, were not considered. A validated patient-reported outcome scale would have provided more information on the merits of the comparative interventions. You note this as a limitation of this noninferiority RCT.

The secondary outcomes — serious adverse events, incidence of severe rejection and median length of stay in the intensive care unit (ICU) — were similar for the 2 approaches. Based on these results, the investigators concluded that the OCS approach was not inferior to the SCS approach. You believe that their conclusion is reasonable based on the results of the study.

Were the results precise?
The precision of the results is normally presented as a confidence interval (CI). In this noninferiority study the authors provided the CI for both the primary outcomes (30-d patient and graft survival) and the secondary outcomes (cardiac-related serious adverse events, incidence of severe rejection and ICU length of stay). They provided this for the intention-to-treat, as-treated and as-per-protocol analyses (Table 1).

Did the investigators appropriately interpret the concept of noninferiority?
The authors reported the 30-day patient and graft survival rates to be 94% in the OCS group and 97% in the SCS group. The patient and graft survival rates were the same, as no repeat heart transplant surgeries were performed. The authors reported that the upper bound of the 95% CI for the percentage differences in the primary effectiveness outcome between the 2 populations was 8.8%, which is less than 10%, so the null hypothesis was rejected in favour of the alternative hypothesis. Based on this finding you concur that noninferiority was shown.

How can I apply the results to my patient or clinical practice?

Were the study patients similar to my patient?
Based on the demographic evidence provided by Ardehali and colleagues in Table 1 of their study (not shown here), in which they reported the mean age, weight, height, BMI and types of cardiomyopathy their patients had as well as the donor characteristics, you conclude that the patients treated in your division would be similar and that, therefore, the study’s conclusions are applicable.

Were all patient-important outcomes considered?
The investigators included patient and graft 30-day survival as a primary outcome. A longer survival time horizon (e.g., 1- or 2-yr survival) would have been preferable. The investigators also included 30-day right and left ventricular function and length of stay in the ICU as secondary outcomes. The outcomes research movement in the last 20 years, however, expects clinical investigators to measure patients’ quality of life after medical interventions. The quality of life assessment requires a longer follow-up, and this trial was designed based on immediate and short-term outcome assessment. The authors might have suggested this for future investigation.

Are the likely advantages of the novel surgical treatment worth the potential harm and costs?
Although the authors concluded that the novel intervention was noninferior to the standard approach, you should not be rushed to adopt it. The investigators did not report the resource utilization associated with either approach. Many new innovations are costly. The ideal study, therefore, would be one in which resource utilization and costs are captured. Health-related quality of life can also be measured using a utility scale from which quality-adjusted life years (QALYs) can be calculated. The integration of costs and QALYs in a cost–utility analysis can help determine whether the new innovation is cost-effective or not.

Resolution of the scenario

There are consequences to future patients and society if incorrect inferences from a poorly designed and conducted noninferiority RCTs are accepted. It is important to determine if this noninferiority study is really a failed superiority RCT. You can do this by determining whether the authors’ noninferiority threshold was appropriate or not. To do so, you review the literature for similar studies to determine the upper boundary for the CI of the primary outcome (30-d mortality and heart transplant survival) and examine the extent to which it exceeds the chosen threshold. If the upper boundary is substantially greater/lower than the threshold chosen by the investigators (10%) you may choose not to adopt this new technology. This is, unfortunately, the case with the RCT by Ardehali and colleagues. Their noninferiority margin of 0.10 (10%) was chosen without supportive documentation.

Conclusion

Although, in general, you are happy with the designation of this study as an RCT, you are not persuaded that it met all the criteria for its designation as a noninferiority RCT. Specifically, you are concerned that their noninferiority margin of 0.10 (10%) was chosen without supportive evidence. As a result, you recommend to your colleagues that the study has definite weaknesses. You then offer to review and critique a superiority RCT comparing these approaches to present at next week’s rounds.

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Competing interests: None declared.

Contributors: All authors designed the study. D. Waltho acquired the data, which F. Farrokhyar, D. Waltho and C. Goldsmith analyzed. A. Thoma, F. Farrokhyar and D. Waltho wrote the article, which all authors reviewed and approved for publication.

References
**Response to: Attitudes and factors contributing to attrition in Canadian surgical specialty residency programs**

“Attitudes and factors contributing to attrition in Canadian surgical specialty residency programs” by Adams and colleagues’ is of special interest to all final-year medical students, like myself, currently applying for surgical residencies in Canada.

The authors point out that most residents leaving general surgery programs pursue nonsurgical fields. This is consistent with my own anecdotal survey of colleagues in a variety of surgical specialties who left their residencies for family practice. The study suggests an underestimation by medical students who go on to pursue surgical residencies of the disparity between work life and personal life that is inherent to becoming a highly competent surgeon. Interestingly, the article also highlights that surgical residency attrition cannot be purely because of long hours and poor lifestyle. The questions posed, if re-framed by medical students considering surgical specialties, queries, “Do we really know what we are getting ourselves into?”

Three main points come to mind. First, an important factor that is widely known and canvassed is the lack of meaningful exposure to most of the surgical residency choices during medical school, which may play a role in later regrets and attrition. The clerkship year introduces medical students to the ward, core areas of medicine, and some limited subspecialized areas. Students rotate through the various specialties as if through a restaurant’s tasting menu, with each exposure spanning a mere few weeks. The Canadian Resident Matching Service (CaRMS) deadline in November of final year, just 6 months after clerkship ends, forces students to restrict the number and types of electives that can be accommodated in the small window before applications are due. Experiences encountered after the deadline may have limited influence on choice of career. One only hopes students do not discover their calling during a winter or spring elective during final year, when the ship for applying has already sailed. It cannot be surprising that young physicians find themselves in an area of medicine they are unhappy with or not particularly suited for, and that they ultimately feel unfulfilled.

Second, it is widely understood that medical students are expected to demonstrate “commitment” to their surgical specialty of choice.2,3 Thus, students often further prune their limited pre-CaRMS electives to be a competitive applicant. This is a great shame because, although the days of the rotating internship are long gone, many a satisfied and happy senior doctor have divulged that they have found themselves in an unintended area after rotating through a fortuitous elective.

Third, fear of underemployment is real and palpable among students, and why wouldn’t it be? This is a relatively recent concern for the medical profession and a phenomenon the previous generation didn’t face.

At the end of the day, I have always been told that your best track is the work you love to do — if indeed you are lucky enough to discover that early enough in your training.

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**References**


**Author response**

We are grateful to Ms. Lichtenstein for taking the time both to read our paper and for offering her thoughts and observations on the issues raised.

The purpose of our study was partly to try to quantify the scale of the problem of career dissatisfaction in surgery at the resident level, but also to create some food for thought among those on either side of the Canadian Resident Matching Service (CaRMS) process. The observation that it is difficult to confidently recognize what one will want to be doing for the next 30 or 40 years based on a few weeks of limited exposure is well recognized in the world of medical education. This appears to be equally true whether one has entered medical school directly from high school, as is the European model, or after a period of undergraduate tertiary education, as is required in North America. Indeed changes in preferences, values and life goals can occur at any age, not least in the early stages of one’s career regardless of the field or vocation.

Ultimately the best advice we can offer to those entering the CaRMS match is to do everything you can to “know what you’re getting yourselves into.” This is, after all, why students are favoured if they have shown a commitment to a specialty — not that it constitutes a guarantee of subsequent fulfilment and happiness, but because it is simply an indication that they have as good an idea of what they’re getting themselves into as they can possibly get for their stage in...
life. Further academic research into medical students’ career decision-making processes and their level of appreciation into what a career in the various specialties entails would undoubtedly be of value to both medical students and postgraduate educators alike. Unfortunately, with medical education being as demanding and intensive as it is and with the volume of knowledge that must be instilled in this timeframe there can only ever be a short, finite window of opportunity in which medical students can consider and research their potential future careers. On that rather poignant note we wish Ms. Lichtenstein and all those entering CaRMS the very best of luck in matching to the specialty to which they are most suited.

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Evaluation of the Influence of Student-Led Surgery Interest Groups: A Pan-Canadian Survey

Interest in surgical residency programs has been decreasing in Canada and the United States over the past 2 decades. While this phenomenon is likely multifactorial, early surgical exposure and surgical role models are factors known to increase the number of applications to surgical residency programs. Surgery interest groups (SIGs) have arisen as a student-led initiative to foster interest in aspiring medical students and provide a platform to challenge dissuasive long-standing notions surrounding work-life balance and personal satisfaction.

A number of papers recently published in the Canadian Journal of Surgery (CJS) have addressed the topics of surgical education, recruitment, and residency attrition rates in Canada.1–3 These studies unanimously discuss the importance of early surgical exposure to improve continuity in both entrance and completion rates of surgical disciplines. Adams and colleagues1 resonate this notion: “efforts to educate prospective residents about the reality of the surgical lifestyle and to optimize employment prospects may improve [residency] completion rates.”

We conducted a pan-Canadian study investigating how SIGs operate and influence medical students’ interest in surgical careers. The study was completed by disseminating 2 unique surveys to SIG executive and members enrolled in Canadian medical schools during the 2016/17 academic year. The executive survey focused on types of events hosted, the structure/support of their society, as well as barriers and plans for improvement. The members survey focused on degree of student involvement, impact on interest and competencies, and avenues for improvement.

The key findings from our survey showed that surgical skills events followed by career nights were the most anticipated and beneficial to members (Fig. 1). The largest barriers to implementing SIG initiatives were insufficient funding and time conflicts with other student groups. Hence, increased budgets and administrative aid were deemed the greatest opportunities for improvement. Conversely, member survey respondents commonly felt SIG events were collegial and accessible opportunities to complement their academic curricula. Overall, members felt that SIGs provided meaningful preclinical exposure, helped develop connections and mentorship, and addressed inquiries surrounding occupation and lifestyle to fortify interest in surgical careers.

Previous studies investigating the influence of surgical societies to pique surgical interests have also illustrated greater rates of interest and enrollment in surgical disciplines. Namely, a Columbia University–based study4 found that entrance rates into general surgery programs tripled following establishment of their SIG. The existing literature surrounding the utility and practicality of SIGs highlights their role in encouraging future generations of medical students toward a career in surgery.

Early surgical exposure through SIGs and similar student-led initiatives shows clear promise in achieving the common goal of fostering exploration-driven interest in a historically daunting field. The ongoing support of undergraduate medical education departments is necessary for SIGs to thrive and help meet the persistent demand for surgeons across Canada.

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DOI: 10.1503/cjs.013017

References

Fig. 1. Box and whisker plots of survey responses from SIG members. Ratings are on an ordinal Likert scale, where 1 = Strongly disagree and 5 = Strongly agree. The box represents the interquartile range, and the whiskers the minimum and maximum values. Median values are displayed as separate lines in the box, but often overlap with interquartile values and are not displayed.
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Email paa@dradamson.com
Tel (416) 323-3900
Canadian physicians have lots of ideas

That's **not** the problem.

At Joule, we believe that when we work together, great things happen — things like helping physicians keep pace with today’s rapid rate of change. When it comes to our aging population, system inefficiencies, or improved patient outcomes, Joule connects physicians to innovators and innovations to help shape the future of health care.

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Health Care System</th>
<th>Business Enterprise Research and Development</th>
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<tbody>
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<td>10TH 11 D</td>
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<tr>
<td>Canada’s 2015 ranking behind Sweden, Denmark, Finland, U.S., Switzerland, Netherlands, Austria and Norway.*</td>
<td>Performance of Canada’s health care system remains far behind that of other OECD countries, ranking 10th out of 11. **</td>
<td>Canada might get an A for entrepreneurial ambition but we get a D in our commitment to innovation.*</td>
</tr>
</tbody>
</table>

**Joule raises the grade**

- **Innovation Challenges**
  Stimulate ideas through collaboration that result in competitive new products that improve patient outcomes.

- **Innovation Grants**
  Identify and fund ventures with the potential to have an impact on national and global health care needs.

- **Innovation Showcase**

- **Innovation Education**
  Joule and the World Health Innovation Network assist physician leaders and health teams in accelerating innovation adoption and scalability across health systems.

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** (Davis K, Stremikis K, Squires D, Schoen C. Mirror, Mirror on the Wall, 2014 Update: How the U.S. Health Care System Compares Internationally; 2016.)