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Winds of change in delivery of quality surgical care are not strong enough

There is no question Canada and other large parts of the world have difficulty providing adequate care. Rural and not so rural communities are lacking total health care coverage. The continual downgrading of resources to care for all patients in Canada has resulted in a lack of critical care coverage zones, increasing wait times for even prioritized procedures and rapidly rising numbers of underemployed surgeons and other physicians. The last issue of CJS included discussion of 2 options\textsuperscript{1,2} as well as a proposed plan\textsuperscript{3} to solve some of the issues at hand.

I worry, however, about quality medical care. Quality of care monitoring has become a piecemeal affair with the use of patient databases and comparisons to other sector demographics. I think the measures proposed to help monitor how care is given are too little, too late. Certainly a family in northern Quebec, for example, will not have access to state-of-the-art neonatology services or even run-of-the-mill physiotherapy care. Delivery of these and other services by other practitioners educated through a Competency by Design (CBD) model — if it is ever revealed — may be part of the answer. Whether a family practitioner wants to spend a lot of time training for a rarely performed procedure has yet to be determined.

The enhanced surgical skill set necessary to be proficient seems daunting. And CBD testing with oral and written exams seems a little dated, especially for the physicians in rural settings. A combination of simulation training and telemedicine mentoring needs to mature to make this really possible. Unfortunately, the health care system and the Canadian research institutes have been slow to respond. We need to treat rural medicine in more ways like delivery of care to a spacecraft.

Certainly large corporations like Google and Microsoft are now offering hardware that can be used to facilitate distance learning and delivery of health care. Although Google Glass was a consumer failure, the uptake by the medical community was much greater. The safe use of the glasses to oversee procedures being performed remotely by an expert is now well established. Microsoft launched a look-alike product aimed at making the wearer/treating surgeon able to see overlaid holograms, thereby allowing remote surgeons the possibility to map out 3-dimensional surgical plans on the patient in real time or to annotate the procedure as it happens. Remote sensing packages with cloud-driven oversight applications would make it simpler to keep healthy patients at home and recognize sick patients earlier in their disease states. Both would increase quality of care and decrease costs to the system.

Agreement among physicians on quality of care parameters is another important step we must take in order to make any health system change. I think that some of the debate about whether we can transfer high-level care to the rural setting would be clarified if we could just bring modern technology into the argument. Certainly, rural care cannot be as good or complete as urban care for major, uncommon diseases, but it could be a lot safer very quickly for the more common ailments.

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References

Pour la prestation de soins chirurgicaux de qualité, le vent du changement ne souffle pas assez fort

Il ne fait aucun doute qu’au Canada et dans d’autres grandes régions du monde, on a du mal à offrir des soins adéquats. Bien des communautés plus ou moins rurales n’ont pas accès à l’éventail complet des soins de santé. La compression incessante des ressources qui permettent de fournir des soins à tous les patients au Canada a produit des zones de couverture incomplète pour les soins critiques, ce qui a contribué à l’allongement des temps d’attente, même pour les interventions prioritaires, et à une croissance rapide du sous-emploi chez les chirurgiens et autres médecins. Dans le dernier numéro du JCC, on a signalé 2 possibilités1,2 et une proposition3 visant à résoudre certains de ces problèmes.

Je m’inquiète toutefois de la qualité des soins. L’utilisation de bases de données sur les patients et de comparaisons démographiques d’autres secteurs a fragmenté le suivi dans ce domaine. À mon avis, les mesures proposées pour faciliter le suivi de la prestation des soins arrivent trop tard et sont insuffisantes. De toute évidence, une famille du nord du Québec, par exemple, n’aura pas accès aux services de pointe en néonatologie ou même aux soins de physiothérapie les plus élémentaires. La prestation de ces services et de certains autres par des praticiens formés selon le modèle de la « compétence par conception » — si le modèle en question finit par être dévoilé — pourrait faire partie de la solution. Reste à savoir si un médecin de famille voudra consacrer beaucoup de temps à acquérir la formation nécessaire pour une intervention rarement effectuée.

La somme des compétences chirurgicales avancées qu’il faut absorber pour maîtriser une intervention a de quoi intimider. Et le mode d’évaluation prévu dans le modèle de la compétence par conception (examens oraux et écrits) semble quelque peu archaïque, surtout pour les médecins des milieux ruraux. Il faudra attendre l’émergence d’une combinaison de formation par simulation et de mentorat à distance avant qu’il devienne vraiment possible d’appliquer ce modèle. Pourtant, en réalité, nous disposons déjà de presque tous les outils nécessaires à cette transition. Malheureusement, le système de santé et les instituts de recherche canadiens ont été lents à réagir. À bien des égards, il faut aborder la médecine rurale comme s’il s’agissait d’organiser la prestation des soins au personnel d’une station spatiale.

De grandes sociétés, comme Google et Microsoft, ont déjà du matériel susceptible de faciliter l’apprentissage et la prestation des soins à distance. Même si Google Glass a connu un échec sur le marché grand public, il a été largement adopté par le milieu médical. Il est déjà bien établi que les lunettes Google Glass peuvent servir en toute sécurité à la supervision par un expert d’interventions effectuées à distance. Microsoft a lancé un produit similaire qui permet à la personne qui porte les lunettes et au chirurgien qui effectue l’intervention de voir des hologrammes surimposés; le chirurgien-conseil peut ainsi, à distance, tracer une cartographie tridimensionnelle du plan chirurgical sur le patient en temps réel ou annoter l’intervention au fur et à mesure. Au moyen d’appareils de télédétection gérés par des applications nuagiques, on pourrait laisser à la maison les patients en santé et dépister plus rapidement les troubles chez les patients malades. Les 2 technologies amélioreraient la qualité des soins et réduiraient les coûts pour le système de santé.

L’implantation d’un changement, quel qu’il soit, dans le système de santé, comporte une autre étape importante : les médecins doivent s’entendre sur les paramètres de la qualité des soins. À mon avis, le débat portant sur la possibilité de fournir des soins de haut niveau en milieu rural gagnerait en clarté s’il tenait simplement compte des technologies modernes. De toute évidence, dans le cas des maladies très graves et des troubles rares, les soins fournis en milieu rural ne peuvent être aussi bons ou aussi complets que les soins offerts dans les centres urbains. Toutefois, pour les maladies courantes, il serait possible d’améliorer très rapidement la sûreté des soins.

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Références
Point of care ultrasonography use and training among trauma providers across Canada

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Point of care ultrasonography (POCUS) is revolutionizing care of critically ill patients. However, training in POCUS is extremely variable, with no accepted curriculum or certification process. We aimed to delineate the training experience and use of POCUS among trauma providers across Canada via a secure e-questionnaire sent to members of the Trauma Association of Canada. This commentary discusses our survey results and argues for the standardization of POCUS training and certification in Canada.

Point of care ultrasonography (POCUS) has become an integral part of patient care worldwide. The Focused Assessment with Sonography for Trauma (FAST) examination remains the most common form of POCUS used in trauma care. Despite its popularity, however, we suspect that there remains a wide disparity in the level of training among practitioners. We conducted a brief survey to illustrate the training experience among trauma care providers across Canada.

We chose to survey members of the Trauma Association of Canada (TAC), as it is a multidisciplinary group that we feel is representative of trauma care providers in Canada. All physician members of TAC (n = 133), regardless of specialty, were surveyed via SurveyMonkey.

Seventy-two (54.1%) TAC members responded: 43.1% surgeons, 52.8% emergency physicians and 4.2% other specialties. In total 75% work in a level I trauma centre. The majority (83%) of respondents reported using FAST regularly. In addition, 83% of respondents use POCUS for applications beyond FAST, including thoracic and cardiac ultrasonography and for the guidance of invasive procedures.

Training experience

There is a paucity of literature describing the POCUS training experiences of current trauma care providers. Many POCUS courses are offered worldwide. Our survey results illustrate this inconsistency, with trauma providers in Canada reporting training by at least 4 distinct courses. There is also variability by specialty, with many surgeons participating in courses from the American College of Surgeons (ACS), while most emergency physicians have completed the Emergency Department Echo (EDE) course (Fig. 1). In addition, a larger percentage of surgeons than emergency physicians reported receiving training during residency or fellowship. This gives the impression that POCUS skills acquired may not be uniform among trauma care providers in Canada. In addition, 24.3% reported that they had not received any formal POCUS training, suggesting the possibility of self teaching with variable results. Given that ultrasonography is a user-dependent skill and that the learning curve for FAST may be steep, this creates the potential for misinterpretation of ultrasound findings. All in all, this emphasizes the need for a national, standardized course for all trauma providers.
Certification

Not all POCUS courses in North America offer a formal certification. Certification is a process in which the trainee is assessed by a governing body. In Canada, the Canadian Emergency Ultrasound Society offers such certification. Overall, only 35% of respondents had completed a formal certification process. There was a clear disparity between those from a surgical versus emergency medicine training background, with 16% and 50%, respectively, completing a certification process. This disparity may be for a number of reasons. First, surgeons may have been slower to accept the idea of formal certification of training for FAST. Being from a procedure-based specialty, surgeons may not feel that formal certification is necessary. Further, a larger percentage of surgeon respondents acquired those skills during residency or fellowship rather than through formal courses. The most likely reason, however, is the lack of formal certification offered through the surgical societies in Canada. This further emphasizes the need for a national, standard certification process that transcends specialties.

Most respondents (61.1%) reported that having a unified certification process of some sort is essential. The majority of courses currently define a certified user based on the completion of a training curriculum that includes practical and didactic components, followed by a variable number of mentored examinations. The main aim of setting a minimum number of exams for the certification process seems to be related to building confidence and raising accuracy. This number of mentored exams differs based on course and certification body and ranges from 10 to 150.1-4 None of these recommendations, however, are evidence-based. The challenge with setting a minimum number of examinations rests in the fact that the learning curve may vary by individual. Our survey showed a similar lack of consensus among respondents as to the ideal number of mentored examinations, with the majority of respondents suggesting it is somewhere between 11 and 50. In addition, most respondents recognized the limitations of defining certification based solely on a set number of examinations, with 72.2% advocating that a change in the current certification process was necessary. The majority supported the introduction of a standardized assessment of ultrasonography technique potentially combined with the current mentored examinations and/or a written examination of ultrasound interpretation. A new definition of certification would be consistent with the shift in the medical education community toward competency-based education.

Confidence and Accuracy

A direct correlation between confidence and accuracy of exams has been established by Jang and colleagues.5 Tracking one’s accuracy can give objective feedback on performance and can help guide the practitioner by increasing confidence in medical decision making and conversely can alert the end user as to the need for review or retraining if accuracy is sub-par. In total, 67% of

![Fig. 1. Number of respondents who have completed formal Focused Assessment with Sonography for Trauma (FAST) training courses, including totals and by base specialty. ACS = American College of Surgeons; EDE = Emergency Department Echo; WINFOCUS = World Interactive Network Focused On Critical Ultrasound.](image-url)
respondents supported the statement that trauma care providers should regularly track their accuracy in FAST, with 56.9% already doing so. Various options exist when developing a quality assurance program. The simplest method may involve tracking positive and negative scans and comparing these predicted results to the appropriate gold standard (laparotomy findings, computed tomography scan, or formal ultrasonography), depending on the clinical scenario. This, however, can be logistically challenging, especially in small centres where patients may need to be transported out for definitive management. Using video archiving and regular, blinded peer review of captured images represents a complementary option. Some respondents suggested, via open-ended response, that keeping track of POCUS accuracy must be incorporated in the hospitals’ quality assessment processes rather than being driven by the practitioner.

**Conclusion**

Despite obvious potential limitations in sample size and response bias, we feel our survey results represent a “needs analysis,” which has identified a number of areas in POCUS training requiring further study. There is a wide variation in POCUS training among trauma providers in Canada, with only a minority completing a formal certification process. There is no consensus on the optimal curriculum for POCUS training. Creation of a standardized POCUS curriculum and certification process for trauma providers, regardless of profession, affiliation or specialty, is desired and necessary.

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

**References:**

S.T.A.R.T.T. plus: addition of prehospital personnel to a national multidisciplinary crisis resource management trauma team training course

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The Simulated Trauma and Resuscitation Team Training (S.T.A.R.T.T.) course was designed to teach crisis resource management (CRM) skills, such as teamwork, problem solving, situational awareness, communication, leadership and resource management, to multidisciplinary trauma teams. The course has been associated with high satisfaction ratings among participants, improved attitudes toward CRM training and improved CRM performance.1,2 To date, multidisciplinary participants have included physicians (general surgeons and emergency medicine doctors, registered nurses (RNs) and respiratory therapists (RTs). Here we discuss the design and results from a new pilot course integrating prehospital personnel into the S.T.A.R.T.T. curriculum.

The basic S.T.A.R.T.T. course design has been described previously.1,2 Briefly, it is a 1-day course beginning with a short introductory lecture discussing basic CRM principles and trauma team structure. For the remainder of the 8-hour day, participants are divided into “trauma teams,” consisting of 4–6 physicians, 2–3 RNs and 1–2 RTs. These teams rotate through 4 high-fidelity trauma simulations. Simulations last approximately 15 min followed by 45 min of debriefing. The content of the simulation scenarios vary with each course, but the 4 simulations follow the same template:
• a delayed-entry scenario;
• a multicasualty scenario;
• a distance resuscitation scenario; and
• a “wild-card” scenario, as described later in this article. Each scenario is specifically designed to focus on 1 or more specific CRM skills.2

PILOT COURSE

In a new pilot course we embedded 2 prehospital personnel within each trauma team. Specifically, we included 1 flight nurse and 1 flight paramedic from our local Helicopter Emergency Medicine Service (HEMS). In order to
COMMENTAIRE

To accommodate the additional learning needs of the HEMS crews, we adapted the course design and scenarios. First, each scenario was increased in duration to 30 min, followed by the same 45-min debrief. Second, given the growing acknowledgement of the patient safety implications of handoff (i.e., the transfer of pertinent patient information from one team to another), the scenarios were modified to stress communication and teamwork between the prehospital and in-hospital teams. The teams rotated through 3 scenarios in the morning followed by a large mass casualty scenario in the afternoon.

**Delayed entry scenario**

In this scenario, the HEMS crew entered the room first, simulating the pickup of a trauma patient at a small rural centre. The HEMS crew had to assess and stabilize the simulated patient and then “transport” the patient across the hall to another simulation suite, where the remainder of the trauma team was awaiting to receive the patient. After handover from their HEMS crew, the trauma team carried on with the resuscitation of the patient.

**Multicasualty scenario**

In this scenario, the HEMS crew was integrated directly into the trauma team, having been told they were completing a “training day” in the local trauma centre emergency department. They participated as additional personnel, aiding with procedures where necessary during this multicasualty resuscitation.

**Distance resuscitation scenario**

In this scenario, the RNs and RTs participated in “hands-on resuscitation,” having been told that they were working in a northern remote nursing station with no physicians available within the community. The physicians and HEMS crew were located in an adjoining simulation room and were reachable only by phone, meaning that they could give only verbal guidance (i.e., “verbal resuscitation”) and advice to the RNs and RTs. The HEMS crew, after hearing the initial patient description, were then “mobilized” to the nursing station and seconded to a third room to simulate their travel to that station. At the end of the scenario, the HEMS crew arrived at the nursing station and received handover from the RNs and RTs. They then had 10 min to prepare the patient for flight before their flight window closes.

**Wild-card scenario**

The afternoon “wild-card” scenario consisted of a mass-casualty simulation for all participants. Twenty-eight volunteers were moulaged in order to simulate a gang fight at a rave. In mass-casualty triage terms using the Simple Triage And Rapid Treatment (START) system, there were a total of 2 “black” (i.e., “deceased”) patients and 5 “red” (i.e., “immediate care”) patients; the remaining patients were “yellow” (i.e., “delayed care”) or “green” (i.e., “ambulatory care”). The HEMS crews were dispatched and told to secure the scene, triage the patients and transport the most appropriate patients back to the simulation centre, where their respective trauma teams were waiting to receive and to continue the resuscitation. The HEMS crews could communicate via hand-held radios with their respective trauma teams, updating them on the situation at the scene and on the status of the patients.

**Evaluation**

The course was evaluated by all participants using the same 5-point Likert satisfaction survey used in previous publications. We added 3 additional questions to

![Fig. 1. Participant response to satisfaction survey, by background. HEMS = helicopter emergency medicine service; MD = medical doctor; RN = registered nurse; RT = respiratory therapist.](start-gillman.indd)
explore the success (or failure) of integrating the HEMS crews into the course and the overall success of the mass casualty simulation.

Course participants included 6 general surgery residents, 6 emergency medicine residents, 9 emergency nurses, 6 respiratory therapists and 6 HEMS crew members. Satisfaction was excellent across all participants, with no differences among professional disciplines (Fig. 1). All participants, regardless of base specialty, reported that incorporation of prehospital personnel added to, rather than detracted from, the learning experience.

We have demonstrated how to develop unique scenarios to address the learning objectives of a group that has been relatively ignored up until now: prehospital personnel. This was done without detracting from the learning needs of core participants. We have illustrated how incorporation of prehospital personnel into the S.T.A.R.T.T. curriculum is feasible and well received and how it may even offer putative benefits to all team members. Given that one of the strengths of simulation compared with traditional didactic or unidisciplinary training is that simulation mimics multidisciplinary trauma care, this is important and reassuring. Our work suggests that rather than fearing or loathing multidisciplinary training, there is hunger for training that resembles everyday practice.

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

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Does ultrasonography predict intraoperative findings at cholecystectomy? An institutional review

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Background: Ultrasonography (US) is the mainstay of biliary tract imaging, but few recent studies have tested its ability to diagnose acute cholecystitis (AC). Our objective was to determine how well a US diagnosis of AC correlates with the intraoperative diagnosis. We hypothesize that US underestimates this diagnosis, potentially leading to unexpected findings in the operating room (OR).

Methods: This retrospective review included all patients admitted to the acute care surgical service of a tertiary hospital in 2011 with suspected biliary pathology who underwent US and subsequent cholecystectomy. We determined the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of US using the intraoperative diagnosis as the gold standard. Further analysis identified which US findings were most predictive of an intraoperative diagnosis of AC. We used a recursive partitioning method with random forests to identify unique combinations of US findings that, together, are most predictive of AC.

Results: In total, 254 patients underwent US for biliary symptoms; 152 had AC diagnosed, and 143 (94%) of them underwent emergency surgery (median time to OR 23.03 hr). Ultrasonography predicted intraoperative findings with a sensitivity of 73.2%, specificity of 85.5% and PPV of 93.7%. The NPV (52.0%) was quite low. The US indicators most predictive of AC were a thick wall, a positive sonographic Murphy sign and cholelithiasis. Recursive partitioning demonstrated that a positive sonographic Murphy sign is highly predictive of intraoperative AC.

Conclusion: Ultrasonography is highly sensitive and specific for diagnosing AC. The poor NPV confirms our hypothesis that US can underestimate AC.

Contexte : L'échographie est la pierre angulaire de l'imagerie des voies biliaires, mais peu d'études récentes ont vérifié sa capacité de diagnostiquer la cholécystite aiguë (CA). Notre objectif était de déterminer dans quelle mesure le diagnostic échographique de la CA est en corrélation avec son diagnostic peropératoire. Selon notre hypothèse, l'échographie sous-estime ce diagnostic, ce qui pourrait entraîner des résultats inattendus au bloc opératoire.

Méthodes : Cette revue retrospective a inclus tous les patients admis en 2011 au service chirurgical d'urgence d'un hôpital de soins tertiaires pour une pathologie biliaire prouvée et qui ont subi une échographie, suivie d'une cholécystectomie. Nous avons déterminé la sensibilité, la spécificité, la valeur prédictive positive (VPP) et la valeur prédictive négative (VPN) de l'échographie, avec le diagnostic peropératoire comme base de référence. Une analyse plus approfondie a permis d'établir quels paramètres échographiques étaient les plus prédictifs d'un diagnostic peropératoire de CA. Nous avons utilisé la méthode de partitionnement récursif avec forêts aléatoires pour recenser les différents paramètres échographiques qui, ensemble, permettent le mieux de prédire la CA.

Résultats : En tout, 254 patients ont subi une échographie pour des symptômes biliaires; 152 ont reçu un diagnostic de CA et 143 ont subi une intervention chirurgicale d'urgence (temps médian avant l'arrivée au bloc opératoire 23.03 h). L'échographie a permis de prédire le diagnostic peropératoire avec une sensibilité de 73,2 %, une spécificité de 85,5 % et une VPP de 93,7 %. La VPN (52,0 %) était plutôt faible. Les paramètres échographiques les plus prédictifs de la CA sont une paroi épaisse, un signe de Murphy échographique positif et la cholelithiase. Le partitionnement récursif a démontré qu’un signe de Murphy échographique positif est une solide prédiction de la CA peropératoire.

Conclusion : L’échographie est hautement sensible et spécifique pour le diagnostic de la CA. La pierre VPN confirme notre hypothèse selon laquelle l’échographie pourrait sous-estimer la CA.
Cholelithiasis is a common finding, present in 10%–15% of the general population. Among patients with cholelithiasis, 1%–4% will become symptomatic per year.\(^1\) Acute cholecystitis (AC) will develop in up to 30% of these patients, with cholelithiasis being the inciting pathology in 90%–95% of cases.\(^2,12\) Acute cholecystitis is one of the most common reasons for emergency admission to general surgical services.\(^1,4\) A history of recurrent or unremitting right upper quadrant pain, fever, nausea and vomiting along with physical examination findings of right upper quadrant tenderness, positive Murphy sign and an elevated white blood cell (WBC) count are classic for AC.\(^5,6\) However, patients often have a nonspecific presentation, where the history and physical examination are insufficient to establish the diagnosis.\(^7,8\) Imaging is therefore an important part of the diagnostic process. Ultrasonography (US) is the mainstay of biliary tract imaging, as it is readily available, is inexpensive to perform and has a high sensitivity and specificity for AC (81% and 83%, respectively).\(^2,8–11\) However, there have been few recent studies assessing its ability to diagnose AC.

Most published studies analyzing the diagnostic ability of US use the pathological findings as the definitive diagnosis. Very few studies use intraoperative findings as the gold standard. However, it is important to consider the anticipated severity of disease and surgical difficulty, as they may substantially impact operative plans, including the operative time of day, availability of intraoperative fluoroscopy for cholangiograms, surgical assistant skill and even surgeon selection. Arguably, in the current era of immediate cholecystectomy for AC, the patient’s symptomatology and the intraoperative findings are far more relevant to the treating surgeon than the final pathological diagnosis.

Classically, AC was managed with conservative antibiotic therapy and interval cholecystectomy in the following weeks. It was previously thought that the rates of complications and conversions were higher in the acute setting.\(^12,11\) Recently, there has been a paradigm shift away from the classical approach toward immediate surgical management. This is reflected in the recent Cochrane review that concluded that early cholecystectomy is safe and has the advantage of a shorter overall hospital stay.\(^14\) The early approach is further supported by a new large retrospective cohort study demonstrating decreased risk of major bile duct injuries, death and shorter hospital stays with early cholecystectomy.\(^11\) Additionally, a multicentre randomized controlled trial in 2013 confirmed decreased morbidity, decreased length of hospital stay, and decreased costs in the immediate cholecystectomy group (within 24 hr of admission).\(^16\) In keeping with this, our institutional practice has shifted to performing urgent cholecystectomy (within 24–48 hr) upon admission of patients with AC unless a patient’s anesthetic risk is deemed prohibitive.

With the institution of acute care surgery in Winnipeg, Man., there was consolidation of emergency surgery care in 3 hospitals. The Acute Care Surgical Service (ACSS) is the largest acute care surgery service in Winnipeg and was established at St. Boniface General Hospital (SBGH) in April, 2008. As a result of regionalization of care, the ACSS saw a 221% increase in patient volume after its inception.\(^17\) Included in this expanded case volume was a 149% increase in biliary tract disease and a 162% increase in AC. A surgeon leads the ACSS team for a 7-day period from Monday to Sunday, 8 am to 4 pm. A separate surgeon manages the service overnight on home call. A dedicated resident team, generally with a single senior general surgery resident and a varying number of junior residents, staff the ACSS for 4-week periods at a time. In 2011, the ACSS had a dedicated daytime operating room (OR) during the week from 7:30 am to 4 pm. The OR time was then shared with other surgical services in the evenings and on weekends on a case priority basis.

The objective of our study was to determine how well a US diagnosis of AC correlates with the intraoperative diagnosis. We hypothesized that US underestimates the frequency and severity of AC in the emergency setting, which could lead to unexpected findings in the OR.

**METHODS**

Institutional and University of Manitoba ethics review board approvals were granted before the study began.

**Inclusion criteria**

All patients who were admitted to the ACSS of a tertiary hospital, SBGH, in 2011 were retrospectively reviewed as a sample of convenience from a larger data set evaluating Winnipeg’s ACSS patient outcomes. Patients were included in the analysis if they were admitted with suspected biliary pathology, underwent diagnostic US and had a subsequent cholecystectomy. Patients were suspected to have cholecystitis based on a history of recurrent or unremitting right upper quadrant pain; any combination of fever, nausea and vomiting; a physical exam of right upper quadrant tenderness; positive Murphy sign; and an elevated WBC count.\(^5,6\) Charts were identified according to diagnostic codes for biliary tract disease and then selected by procedure code for cholecystectomy. Patients with suspected or confirmed acalculous cholecystitis were excluded from the analysis. Patients with AC diagnosed using computed tomography (CT), magnetic resonance imaging (MRI) or alternative imaging modalities were also excluded.
Ultrasound findings

Diagnostic abdominal US was undertaken upon presentation with suspected biliary pathology. All US scans were performed in the radiology department by a certified ultrasonographer and reported by a tertiary care US radiologist. Features noted on abdominal US included cholelithiasis, an immobile calculus or one lodged in the gallbladder neck, pericholecystic fluid, thick gallbladder wall (including the measured thickness in millimetres), gallbladder distension, a positive sonographic Murphy sign, intramural air and perforation.2,6,8 The overall radiological impression or diagnosis was also recorded. Major US criteria used in our institution to diagnose AC are the combination of cholelithiasis (especially an immobile calculus), wall thickening (> 3 mm) and a positive sonographic Murphy sign.18,19 Minor indicators include pericholecystic fluid and gallbladder distension. These criteria are locally agreed upon among the US radiologist staff as there are no universally accepted US diagnostic criteria. Intramural air and perforation were considered indicators of severe or complicated AC.

Intraoperative findings

All patients had an attempted laparoscopic cholecystectomy. Intraoperative observations, methods and diagnoses were taken from the dictated operative report. For the purposes of this study, we defined a “difficult” cholecystectomy as one where a retrograde or fundus-down approach was used, a partial or subtotal cholecystectomy was performed, a drain was placed, a fifth laparoscopic port was inserted, or conversion to open cholecystectomy was required.

Statistical analysis

We determined the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of US diagnosis using the intraoperative diagnosis as the gold standard. Further analysis identified which individual US criteria were most predictive of an intraoperative diagnosis of AC, of gangrenous AC and a difficult operation. We compared the pathological diagnosis from the official pathology report with the US diagnosis for the correlation. Logistic regression was used to analyze the effect of age, sex, body mass index (BMI), diabetes, time to OR and degree of wall thickness on US reliability using interaction terms, which, if significant, would indicate that the reliability of US for predicting AC was dependent on these factors. We used a recursive partitioning method with random forests to identify unique combinations of US findings that, together, are most predictive of AC.

Recursive partitioning is a nonparametric modelling approach that allows us to identify complex nonlinear associations between sets of potential risk factors and the dependent variable.20 This enables flexible exploratory modelling without any a priori distributional assumptions, which may be important if risk factors combine their effects in unexpected ways. We used the party package of R version 3.0.2 to perform the recursive partitioning and SAS version 9.3 (SAS Institute) for all other analyses.

RESULTS

In total, 254 patients were admitted to the ACSS and underwent urgent abdominal US to investigate suspected biliary symptoms; 152 patients received definitive diagnoses of AC based on US, and 143 (94%) of these patients underwent emergency surgery (median time to OR 23.03 hr). The 9 patients with AC diagnosed US who did not undergo a cholecystectomy were excluded from the study cohort, leaving 245 patients who met the inclusion criteria (Fig. 1).

Table 1 lists the demographic and clinical characteristics of our study cohort. Of note, the majority of patients were women (65.5%), and the mean BMI was 30.8. Importantly, of the 245 patients who underwent cholecystectomy, the overall intraoperative complication rate

Fig. 1. Flow of patients through the study. AC = acute cholecystitis; US = ultrasonography. *Median time to the operating room was 23.03 hours.
was low (3.3%). There were no bile duct injuries, 8 (3.3%) patients had intraoperative bleeding, and 9 (3.7%) patients experienced bile leaks necessitating a postoperative endoscopic retrograde cholangiopancreatography (ERCP). These bile leaks were all attributed to cystic duct stump leaks on ERCP. Our conversion to open rate was 1.1%, and the rate of subtotal cholecystectomy was 7.8% (Table 1). Ultrasonography predicted intraoperative findings with a sensitivity of 73.2%, specificity of 85.5% and PPV 93.7%. The NPV (52.0%) was quite low. The 102 patients without signs of AC on US underwent cholecystectomies for various pathology, including biliary colic, choledocholithiasis, cholangitis and gallstone pancreatitis. Those in whom biliary colic was diagnosed on admission to the ACSS had an operative rate of 96.7%. Patients with biliary obstruction (choledocholithiasis, cholangitis, gallstone pancreatitis) had an operative rate of 60.3%. Of the 102 patients with other biliary pathology who underwent a cholecystectomy, 49 had intraoperative findings suggestive of AC (false negative rate of 48.0%; Fig. 1). There were no conversions to open cholecystectomy in this group. The ability of US to predict intraoperative findings is summarized in Table 2.

The intraoperative and pathological diagnoses of AC correlated 65.7% of the time. However, when acute and chronic cholecystitis were combined as a diagnosis of “cholecystitis” and compared with a combined pathological diagnosis of “cholecystitis,” the correlation was 95.7%. The intraoperative diagnosis underestimated the pathological diagnosis of “cholecystitis” 4.3% of the time.

The individual US indicators most predictive of AC were cholelithiasis (sensitivity 90.0%, specificity 4.6%, PPV 75.3%, NPV 12.5%), a thickened gallbladder wall (sensitivity 71.4, specificity 72.3, PPV 89.3%, NPV 43.9%) and a positive sonographic Murphy sign (sensitivity 71.4, specificity 72.3, PPV 89.3%, NPV 43.9%). These findings are summarized in Table 3. While the PPVs of our minor US criteria (immobile calculus in the gallbladder neck, gallbladder distension and pericholecystic fluid) were very high (PPV 90.5%, 90.0% and 94.3%, respectively), the sensitivities were very low (36.2%, 34.3% and 15.7%, respectively), suggesting these are of limited diagnostic utility for AC. Table 3 also lists the individual US signs that are most predictive of a difficult operation. The most predictive signs were cholelithiasis (sensitivity 93.6%, specificity 9.3%, PPV 22.9%, NPV 83.3%), thickened gallbladder wall (sensitivity 71.0%, specificity 41.4%, PPV 25.9%, NPV 83.2%) and a stone in the gallbladder neck (sensitivity 48.4%, specificity 74.9%, PPV 35.7%, NPV 83.4%).

The individual US findings found to be most predictive of an intraoperative diagnosis of gangrenous cholecystitis are listed in Table 3. These values, however, should be interpreted with caution as they are derived from a sample of only 3 patients with a US diagnosis of gangrenous cholecystitis.

The logistic regression model revealed that the selected patient demographic and clinical characteristics had no statistically significant effect on the accuracy of US diagnosis (BMI $p = 0.24$, age $p = 0.42$, sex $p = 0.67$, diabetes $p = 0.94$, time to OR $p = 0.29$, degree of wall thickness $p = 0.81$; Table 4).

Recursive partitioning (Fig. 2) demonstrated that a positive sonographic Murphy sign was independently predictive of a high risk of intraoperative AC and, when absent, the risk of AC depends on the presence of a thickened gallbladder wall.

**Discussion**

Since the 1970s, US has been shown to be a fast, accurate, accessible and cost-effective modality for imaging of the biliary tract. No other imaging modality is more sensitive or specific for the detection of gallstones (sensitivity 97%, specificity 95%). However, the utility of US in diagnosing AC remains questionable, as the literature contains variable results. Because of this, AC remains very much a clinical diagnosis, with US providing a diagnostic adjunct. Additionally, many studies use a pathological diagnosis as the gold standard, which

---

**Table 1. Patient demographic and clinical characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (range) or %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>47.9 (18–92)</td>
</tr>
<tr>
<td>Male sex</td>
<td>34.5</td>
</tr>
<tr>
<td>BMI</td>
<td>30.8 (16.0–59.2)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>10.6</td>
</tr>
<tr>
<td>Procedure duration, min</td>
<td>96.9 (26–229)</td>
</tr>
<tr>
<td>Overall complication</td>
<td>3.3</td>
</tr>
<tr>
<td>Conversion rate</td>
<td>1.1</td>
</tr>
<tr>
<td>Subtotal cholecystectomy</td>
<td>7.8</td>
</tr>
<tr>
<td>Bile duct injuries</td>
<td>0</td>
</tr>
<tr>
<td>Bile leaks (stump leaks)</td>
<td>3.7</td>
</tr>
<tr>
<td>Intraoperative cholangiogram</td>
<td>3.3</td>
</tr>
<tr>
<td>BMI = body mass index.</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Agreement between US and intraoperative diagnosis of AC**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Intraoperative AC</th>
<th>No intraoperative AC</th>
<th>Total</th>
<th>PPV/NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US AC</td>
<td>134</td>
<td>9</td>
<td>143</td>
<td>PPV 93.7</td>
</tr>
<tr>
<td>No US AC</td>
<td>49</td>
<td>53</td>
<td>102</td>
<td>NPV 52.0</td>
</tr>
<tr>
<td>Total</td>
<td>183</td>
<td>62</td>
<td>245</td>
<td></td>
</tr>
<tr>
<td>Sensitivity/ specificity, %</td>
<td>73.2</td>
<td>85.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AC = acute cholecystitis; NPV = negative predictive value; PPV = positive predictive value; US = ultrasonography.
may not correlate with clinical findings. The literature is additionally limited by many single-institution, retrospective, small data sets.10

Our study included one of the largest data sets (n = 245) in the current literature as well as a high operative rate (94%) for AC with a short time interval from US to OR (median 23.03 hr). This short interval should optimize the correlation between the US findings and intraoperative findings by reducing the time for progression or resolution of disease. Early cholecystectomy is our institutional practice, which is supported by the most up-to-date literature, suggesting more favourable outcomes, including reduced major bile duct injuries and death, as well as shorter length of overall hospital stay.14,15 This literature includes a Cochrane review,14 a large retrospective cohort study of more than 14 000 patients,15 and a large multicentre randomized controlled trial.16 Interestingly, many of the studies on US for the diagnosis of AC are from the 1980s and 1990s, a time when the standard practice was a delayed cholecystectomy.9 The disadvantage of the shift toward early cholecystectomy is the increased frequency of difficult cholecystectomies encountered in the emergency setting. This increases the need for an accurate diagnosis and prediction of the severity of AC in order to allow the surgeon to be adequately prepared with appropriate equipment and assistance, to consider the operative time of day and even consultation or referral to another surgeon. Despite difficult emergency cholecystectomies, our 1-year cohort had a very low conversion rate of 1.1% and a low rate of subtotal cholecystectomy of 7.8%. We felt these results are a reflection of the skill set of our ACSS surgeons, 4 of whom have fellowship training in minimally invasive surgery. Subtotal or partial cholecystectomy is used in our institution as a technique to reduce the morbid complications associated with difficult gallbladders, particularly common bile duct injuries, and reflects the recent trend and growing acceptance of this approach.21 This practice is further supported by the recent systematic review and meta-analysis of more than 1200 subtotal cholecystectomies confirming that this technique, for difficult gallbladders, achieves morbidity rates comparable to total cholecystectomy in uncomplicated cases and is, therefore, an important tool in the approach to the difficult gallbladder.21 Our study, however, like many in the literature, is still limited as a single-institution, retrospective analysis.

A recent systematic review and meta-analysis of imaging in AC suggested that the diagnostic accuracy of US in AC was lower than that reported in previous studies (sensitivity 81%, specificity 83%).9 This is contrasted to an older meta-analysis stating a sensitivity of 88% (95% CI 0.74–1.00) and a specificity of 80% (95% CI 0.62–0.98), adjusted for verification bias.10 Our study is in keeping with previously published data with a specificity of 85.5%, though our sensitivity was lower at 73.2%. The low NPV of 52.0% nonetheless confirms our hypothesis that US can underdiagnose AC, suggesting that consistent major and minor US criteria should be considered.

Table 3. Sonographic indicators predictive of intraoperative diagnosis of AC

<table>
<thead>
<tr>
<th>Sonographic indicator</th>
<th>No.</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of AC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholelithiasis</td>
<td>245</td>
<td>90.0</td>
<td>4.6</td>
<td>75.3</td>
<td>12.5</td>
</tr>
<tr>
<td>Thick wall</td>
<td>172</td>
<td>71.4</td>
<td>72.3</td>
<td>89.3</td>
<td>43.9</td>
</tr>
<tr>
<td>Murphy sign</td>
<td>137</td>
<td>59.5</td>
<td>86.2</td>
<td>93.3</td>
<td>39.7</td>
</tr>
<tr>
<td>Stone in neck</td>
<td>84</td>
<td>36.2</td>
<td>87.7</td>
<td>90.5</td>
<td>29.8</td>
</tr>
<tr>
<td>Distended</td>
<td>80</td>
<td>34.3</td>
<td>87.7</td>
<td>90.0</td>
<td>29.2</td>
</tr>
<tr>
<td>Pericholecystic fluid</td>
<td>35</td>
<td>15.7</td>
<td>96.9</td>
<td>94.3</td>
<td>26.3</td>
</tr>
<tr>
<td>Diagnosis of difficult operation*</td>
<td>245</td>
<td>93.6</td>
<td>9.3</td>
<td>22.9</td>
<td>83.3</td>
</tr>
<tr>
<td>Cholelithiasis</td>
<td>172</td>
<td>71.0</td>
<td>41.4</td>
<td>25.9</td>
<td>83.2</td>
</tr>
<tr>
<td>Thick wall</td>
<td>137</td>
<td>50.0</td>
<td>51.2</td>
<td>22.8</td>
<td>78.0</td>
</tr>
<tr>
<td>Murphy sign</td>
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<td>48.4</td>
<td>74.9</td>
<td>35.7</td>
<td>83.4</td>
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<tr>
<td>Stone in neck</td>
<td>80</td>
<td>33.9</td>
<td>72.6</td>
<td>26.3</td>
<td>79.2</td>
</tr>
<tr>
<td>Distended</td>
<td>35</td>
<td>14.5</td>
<td>87.9</td>
<td>25.7</td>
<td>78.1</td>
</tr>
<tr>
<td>Diagnosis of gangrenous AC</td>
<td>245</td>
<td>85.2</td>
<td>8.1</td>
<td>9.2</td>
<td>83.3</td>
</tr>
<tr>
<td>Cholelithiasis</td>
<td>172</td>
<td>77.8</td>
<td>40.7</td>
<td>12.5</td>
<td>94.4</td>
</tr>
<tr>
<td>Thick wall</td>
<td>137</td>
<td>70.4</td>
<td>53.6</td>
<td>14.2</td>
<td>94.3</td>
</tr>
<tr>
<td>Murphy sign</td>
<td>84</td>
<td>37.0</td>
<td>70.2</td>
<td>11.9</td>
<td>91.1</td>
</tr>
<tr>
<td>Stone in neck</td>
<td>80</td>
<td>44.4</td>
<td>72.6</td>
<td>15.0</td>
<td>92.3</td>
</tr>
<tr>
<td>Distended</td>
<td>35</td>
<td>18.5</td>
<td>87.9</td>
<td>14.3</td>
<td>90.8</td>
</tr>
</tbody>
</table>

AC = acute cholecystitis; NPV = negative predictive value; PPV = positive predictive value.
*Difficult operation: fundus-down dissection, drain, partial cholecystectomy, conversion, or fifth port insertion.
be set for a sonographic diagnosis to improve its accuracy. Instead of using the pathological diagnosis as the reference standard, we used the intraoperative diagnosis. Dynamic in vivo imaging was therefore compared with direct intraoperative observation of the in vivo gallbladder where the gallbladder is intact, perfused, unaltered by fixatives and electrocautery, and unaffected by pathological sampling error. Also, the intraoperative findings are perhaps more clinically and surgically relevant given that an accurate prediction of the intraoperative findings could help a surgeon to appropriately prepare for operative challenges, potential complications, additional equipment, availability of intraoperative fluoroscopy for cholangiograms and adequate assistance. A limitation to our data, however, is that they are subject to verification bias, as they were retrospectively collected and the decision to proceed with the gold standard (cholecystectomy) was reliant on the results of the diagnostic test (US). Verification bias would result in an overestimation of the sensitivity of the US and underestimation of the specificity. It is possible that a cohort of patients who presented with biliary symptoms underwent US that found no AC and were subsequently discharged without operative intervention. These patients may have then proceeded to elective cholecystectomy with intraoperative findings of cholecystitis. This group would not have been captured by our study cohort and therefore reflects an additional bias of our study. However, if included, this group would have further increased the false-negative rate of US, thus our results may appear better than reality. Ultrasonography is known to be a user-dependent imaging modality, which is a disadvantage of this technique. We did not control for the user-dependency of US in our analysis, which does limit our results. This was primarily owing to the retrospective nature of the study and would be easier to account for in a prospective trial.

A 2004 study attempted to reduce verification bias by performing a prospective study of US compared with both the intraoperative and pathological diagnosis of AC. Furthermore, this was one of the few studies comparing US diagnosis to intraoperative findings. They proceeded with cholecystectomy if the clinical picture suggested AC and

### Table 4. Logistic regression — moderator effect on US diagnosis of AC

<table>
<thead>
<tr>
<th>Moderator</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>0.24</td>
</tr>
<tr>
<td>Age</td>
<td>0.42</td>
</tr>
<tr>
<td>Sex</td>
<td>0.67</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.94</td>
</tr>
<tr>
<td>Time from US to OR</td>
<td>0.29</td>
</tr>
<tr>
<td>Degree of wall thickness</td>
<td>0.81</td>
</tr>
</tbody>
</table>

AC = acute cholecystitis; BMI = body mass index; OR = operating room; US = ultrasonography.

**Fig. 2:** Recursive partitioning demonstrated that a positive sonographic Murphy sign was independently predictive of a high risk of intraoperative acute cholecystitis (AC) and, when absent, the risk of AC depends on the presence of a thickened gallbladder wall. US = ultrasonography.
the US confirmed gallstones, regardless of signs of inflammation on US. Their results demonstrated a much lower sensitivity and specificity of 60% and 77%, respectively, than previously published data, but their results are closer to ours. However, they had a very high rate of non-inflamed gallbladders at cholecystectomy (15 of 55, 27.3%). This same group also suggested the importance of a positive sonographic Murphy sign to the diagnostic accuracy of US by showing the sensitivity improved from 54% to 60% and the specificity improved from 67% to 77% when the radiologist was aware of the presence or absence of this sign. This is in alignment with our findings, where a thickened gallbladder wall and positive sonographic Murphy sign were most predictive of AC (sensitivity 71.4%, specificity 72.3%, and sensitivity 59.5%, specificity 86.1%, respectively). Our recursive partitioning model concurrently demonstrates that a positive sonographic Murphy sign independently was highly predictive of AC. Recursive partitioning is a powerful technique for evaluating unique combinations of potential risk factors that may interact in unexpected ways. However, a limitation to recursive partitioning models is that they can be sensitive to mild perturbations in the data. This may result in arriving at a slightly different conclusion with another sample from the same population. Interestingly, our analysis was the first to demonstrate that potential moderators of diagnostic accuracy (BMI, age, sex, diabetes, time to OR, and degree of gallbladder wall thickness) had no statistically significant effect on the ability of US to diagnose AC.

CONCLUSION

Ultrasonography is highly sensitive and specific for diagnosing AC; however, the low NPV confirms our hypothesis that US can underestimate the diagnosis of AC. The most predictive individual US signs for AC are a positive sonographic Murphy sign, thickened gallbladder wall and cholelithiasis, which is consistent with the literature. Independently, a positive sonographic Murphy sign is highly predictive of AC. These signs should be considered as major criteria for sonographic diagnosis of AC.

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Affiliations: All authors are from the Department of Surgery, Section of General Surgery, University of Manitoba, Winnipeg, Man.

Competing interests: None declared.

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Contributors: All authors designed the study. S. Stogryn and J. Metcalfe acquired and analyzed the data, which A. Vergis and K. Hardy also analyzed. All authors wrote and reviewed the article and approved the final version for publication.

References

Recurrence of inguinal hernias repaired in a large hernia surgical specialty hospital and general hospitals in Ontario, Canada

Atiqa Malik, MSc
Chaim M. Bell, MD, PhD
Thérèse A. Stukel PhD
David R. Urbach, MD, MSc

Background: The effect of hospital specialization on the risk of hernia recurrence after inguinal hernia repair is not well described.

Methods: We studied Ontario residents who had primary elective inguinal hernia repair at an Ontario hospital between 1993 and 2007 using population-based, administrative health data. We compared patients from a large hernia specialty hospital (Shouldice Hospital) with those from general hospitals to determine the risk of recurrence.

Results: We studied 235,192 patients, 27.7% of whom had surgery at Shouldice Hospital. The age-standardized proportion of patients who had a recurrence ranged from 5.21% (95% confidence interval [CI] 4.94%–5.49%) among patients who had surgery at the lowest volume general hospitals to 4.79% (95% CI 4.54%–5.04%) who had surgery at the highest volume general hospitals. In contrast, patients who had surgery at the Shouldice Hospital had an age-standardized recurrence risk of 1.15% (95% CI 1.05%–1.25%). Compared with patients who had surgery at the lowest volume hospitals, hernia recurrence among those treated at the Shouldice Hospital was significantly lower after adjustment for the effects of age, sex, comorbidity and income level (adjusted hazard ratio 0.21, 95% CI 0.19–0.23, \( p < 0.001 \)).

Conclusion: Inguinal hernia repair at Shouldice Hospital was associated with a significantly lower risk of subsequent surgery for recurrence than repair at a general hospital. While specialty hospitals may have better outcomes for treatment of common surgical conditions than general hospitals, these benefits must be weighed against potential negative impacts on clinical care and the financial sustainability of general hospitals.
Inguinal hernia is a common problem, affecting more than one-quarter of men during their lifetime. Surgical repair of inguinal hernia is one of the most frequent surgical procedures performed, with an estimated 800,000 hernia repairs performed in the United States each year. Since inguinal hernia repair is usually an ambulatory procedure and complications are uncommon, hernia recurrence is a key quality measure. Hernia recurrence risk can reach up to 15%, depending on a variety of factors, including surgeon expertise, and is commonly used as an outcome measure in evaluative studies of hernia repair.

Ambulatory surgical centres and specialty hospitals provide care to patients with specific problems, such as elective cardiac or orthopedic conditions. Proponents of specialty hospitals advocate their potential benefits in terms of quality, efficiency and cost of care. The high volume of procedures performed at specialty hospitals may largely explain why the reported outcomes of care are frequently better than those at general hospitals. Critics of specialty hospitals point out their potential to “cream skim” profitable and low-risk episodes of care. The Shouldice Hospital in Toronto, Ont., is a surgical specialty hospital focused exclusively on the surgical treatment of abdominal wall hernias, performing thousands of hernia procedures each year and accounting for a large proportion of all such operations performed in Ontario. Surgeons at the Shouldice Hospital typically perform 20 times more hernia repairs than surgeons in general hospitals, making it an extreme outlier in procedure volume. The Shouldice Hospital has been prominently cited as a prototypical surgical specialty facility and as a business model for the type of “focused factory” that could translate the efficiencies seen in the manufacturing industry to health care. Although there are reports of low rates of hernia recurrence among patients who had surgery at the Shouldice Hospital, there are no published population-based studies.

The purpose of the present study was to compare hernia recurrence rates among patients having primary elective inguinal hernia repair at the Shouldice Hospital with those having surgery at general hospitals in Ontario. We sought to determine whether surgery at the Shouldice Hospital was associated with a lower risk of hernia recurrence and how the risk of recurrence was influenced by procedure volume among those treated at general hospitals.

Methods

Study overview

We conducted a retrospective cohort study using population-based administrative health data for the province of Ontario. All Ontario residents who underwent primary elective inguinal hernia repair in Ontario between Jan. 1, 1993, and Dec. 31, 2007, were followed until Mar. 31, 2010, to assess for hernia recurrence. We were interested in determining whether the Shouldice Hospital — a specialty hospital for hernia surgery — had a lower rate of inguinal hernia recurrence than general hospitals after accounting for surgical volume.

Data sources

We used encrypted, individual level administrative data from the Ontario Health Insurance Plan (OHIP) physician billing database, the Canadian Institute for Health Information Hospital Discharge Abstract Database (CIHI-DAD) and the Registered Persons Database (RPDB). These data sets were held securely in a linked, deidentified form and analyzed at the Institute for Clinical Evaluative Sciences. These databases are considered to be population-based and valid for the ascertainment of surgical procedures, including inguinal hernia repair. The research ethics board of Sunnybrook Health Sciences Centre approved our study protocol.

Study participants

We identified Ontario residents aged 18–90 years who underwent primary elective nonrecurrent inguinal hernia repair between Jan. 1, 1993, and Dec. 31, 2007. Inguinal hernia repairs were not eligible for inclusion in the study if they were coded as massive inguinal hernias or strangulated or incarcerated hernias. We included the first eligible inguinal hernia repair for patients who had more than 1 repair during the study period; the data sources did not distinguish whether a hernia repair was a right- or left-sided procedure.

Exposures

For each participant, we measured the volume of elective inguinal hernia surgeries performed at their hospital in the year before surgery and categorized them into 4 equal groups (quartiles). We also identified the hospital where the hernia surgery was done. While the number of hospitals varied during the study period owing to openings, closings and amalgamations, more than 100 general hospitals performed hernia surgery in each year of the study period. Because the volume of hernia repairs done at the Shouldice Hospital was substantially larger than all other hospitals, this hospital was categorized separately.

Several variables that might influence inguinal hernia recurrence were measured. These included age, sex, rurality, health region and median household income in the neighbourhood of residence. We assessed comorbidity using the Johns Hopkins Case-Mix Adjusted Clinical Groups (ADG) comorbidity score. Overall comorbidity was estimated by summing the presence of each of the 12 Collapsed ADG Clusters (CADG) and further stratified.
into low and high comorbidity levels, with a score of 7 or greater indicating high comorbidity.

Outcome

The primary outcome of interest was surgical repair of a recurrent inguinal hernia at any hospital in Ontario. We identified recurrence events using OHIP fee codes for recurrent hernia, regardless of whether the repair was uncomplicated or associated with an emergent presentation, such as strangulation. Hernia repair events occurring within 2 days of an earlier primary repair were not considered to indicate hernia recurrence, since bilateral repairs were often performed sequentially.

Statistical analyses

We estimated the rate of recurrent hernia repair per 1000 person-years of follow up as well as the overall crude and age-standardized proportion of participants who had a surgical recurrence. For each participant, we also calculated the time between the date of the initial surgery and the earliest occurrence of recurrent hernia surgery, death, loss of registration for health services, or study end date (Mar. 31, 2010). The time to hernia recurrence was plotted using Kaplan–Meier survival curves and compared between hospital categories using the log rank test. We used Cox proportional hazards models to estimate the effects of the various exposures, including patient and hospital characteristics, on the time to hernia recurrence using variance-corrected estimates to account for hospital-level clustering.

We performed a number of stratified analyses to determine whether the Shouldice Hospital had substantially different outcomes than general hospitals for different subgroups. We used interaction terms to test whether hernia recurrence risk differed according to age, sex, time period of hernia repair (1993–2000 v. 2001–2007), income and comorbidity.

We performed multiple sensitivity analyses to test whether aspects of the study design influenced the study findings. First, we analyzed only the healthiest participants in the cohort according to the CADG score. Second, we performed separate analyses for the periods 1993–2000 and 2001–2007 to account for secular changes in inguinal hernia repair techniques, such as the use of surgical mesh and tension-free repair. Finally, we tested the extent to which selection of patients with favourable hernias (“cherry picking”) influenced the results of the Shouldice Hospital. We identified patients who had a consultation with a Shouldice Hospital surgeon between 2004 and 2006 to determine what proportion subsequently had surgery at the Shouldice Hospital or a different hospital as well as the rate of hernia recurrence in each group. All statistical analyses were done using SAS version 9.2 (SAS Institute Inc.). We considered results to be significant at p < 0.05.

Results

Participants

A total of 235 192 patients had an eligible inguinal hernia repair in Ontario between Jan. 1, 1993, and Dec. 31, 2007: 170 065 at general hospitals and 65 127 at the Shouldice Hospital. The Shouldice Hospital accounted for 27.7% of all hernia repairs in the study, with annual volumes that were at least 6-fold greater than the highest annual volume of a general hospital (Table 1). The median age of participants was 55 years, and 90% were men. Participant characteristics were similar across volume categories for general hospitals. In comparison, those having surgery at the Shouldice Hospital were more likely to reside in higher-income neighbourhoods and have a lower burden of comorbidity.

Risk of hernia recurrence

A total of 9020 patients had surgical repair of an inguinal hernia recurrence during the study period (Table 2). The

| Table 1. Characteristics of patients having primary inguinal hernia repair in Ontario, according to hospital volume and specialty status (Shouldice Hospital v. general hospitals) |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Characteristic                  | General hospitals by volume*    |                                 |                                 | Shouldice Hospital              | Overall                        |
|                                 | Quartile 1                      | Quartile 2                      | Quartile 3                      | Quartile 4                      |                                 |
| No. of patients                 | 42 427                         | 42 644                         | 42 346                         | 42 648                         | 65 127                         | 235 192                        |
| Hospital volume, median (range) | 61 (1–106)                     | 142 (107–185)                  | 219 (186–267)                  | 341 (268–803)                  | 5672 (5103–5888)               | —                              |
| Mean age, yr                    | 57                             | 56                             | 56                             | 55                             | 54                             | 55                             |
| Male sex, %                     | 88.5                           | 88.3                           | 88.4                           | 89.4                           | 94.5                           | 90.3                           |
| Low income, %†                  | 60.8                           | 60.9                           | 60.2                           | 56.8                           | 48.2                           | 56.5                           |
| High comorbidity, %§            | 27.6                           | 29.9                           | 30.8                           | 30.1                           | 23.3                           | 27.8                           |
| Rural, %                        | 42.2                           | 15.6                           | 8.7                            | 6.2                            | 9.7                            | 15.8                           |

*Participants were divided into 4 equal groups of hospital volume (quartiles), with quartile 1 including hospitals with the lowest volume and quartile 4 including hospitals with the highest volume of primary elective inguinal hernia repair.
†Volume indicates the number of primary inguinal hernia repairs in the preceding 1-year period.
§Patients residing in the highest 75% of neighbourhoods according to median household income.
$Sum of Collapsed Adjusted Diagnosis Groups categories greater than 6 (out of 12).
age-standardized proportion of patients who had a recurrence ranged from 5.21% (95% confidence interval [CI] 4.94%–5.49%) among those who had surgery in the lowest volume general hospitals to 4.79% (95% CI 4.54%–5.04%) of those who had surgery at highest volume general hospitals. In contrast, those who had surgery at the Shouldice Hospital had an age-standardized recurrence risk of 1.15% (95% CI 1.05%–1.25%). The cumulative probability of recurrence was significantly lower (p < 0.001) among patients who had surgery at the Shouldice Hospital than at general hospitals, regardless of volume (Fig. 1).

The reduction in recurrence risk observed at the Shouldice Hospital persisted after accounting for potentially confounding variables. Compared with patients who had surgery at the lowest volume hospitals, hernia recurrence among those treated at the Shouldice Hospital was significantly lower after adjustment for the effects of age, sex, CADG and income level (adjusted hazard ratio [HR] 0.21, 95% CI 0.19–0.23, p < 0.001; Table 3). Compared with patients having surgery at general hospitals in the lowest volume quartile, the adjusted relative risk of recurrence for those who had surgery at general hospitals in the highest volume quartile was 0.94 (95% CI 0.89–1.00, p = 0.06). Analyses limited to only patients with low burden of comorbidities showed similar results to the main analysis.

Stratified analyses

Compared with the risk of recurrence in patients who had surgery at general hospitals, the risk of recurrence was lower in those who had a hernia repair at the Shouldice Hospital for each subgroup examined (Fig. 2). However, the effect on reduction of hernia recurrence was larger among patients younger than 55 years, men and patients with fewer comorbidities. Patients who had surgery between 1993 and 2000 had a larger benefit than those who had surgery between 2001 and 2007 at the Shouldice Hospital.

A total of 6566 patients had a consultation with a surgeon at the Shouldice Hospital between 2004 and 2006 and subsequently had an inguinal hernia repair. Of these, 633 (9.6%) had their surgery at a general hospital instead of the Shouldice Hospital; a recurrence later developed in 20 of them (3.2%).

Discussion

In a population-based study of patients having primary elective repair of an inguinal hernia in Ontario, we found that those who had surgery at the Shouldice Hospital — a specialty hospital for hernia repair and an extreme high outlier for surgical procedure volume — had more than a 4-fold lower risk of recurrence requiring subsequent surgical repair than those whose initial surgery was done at a general hospital. This effect could not be explained by differences among patients who had surgery at different types of hospitals or by selection of patients at particularly low risk of hernia recurrence at the Shouldice Hospital. Our findings regarding hernia recurrence, the key outcome measure for hernia repair, suggest that increasing the number of people having inguinal hernia surgery at “focused factories” would result in improved surgical outcomes.

Results in relation to other studies

In randomized trials of hernia repair, the Shouldice technique of hernia repair was associated with fewer recurrences than tissue repairs, but there was no advantage over tension-free repairs using prosthetic mesh.15–24 The reasons why the Shouldice Hospital performed so much better in our study than in the clinical trials is not clear. In addition to performing a specific type of hernia repair in a very reproducible fashion at the Shouldice Hospital,25,26 a variety of processes of care are followed: patients are kept in hospital for several days after hernia repair, strict selection criteria are applied, and the surgeons perform extraordinarily large numbers of hernia surgeries. While we did not identify a statistically significant effect of hospital volume on recurrence among patients treated at general hospitals, our findings did suggest an underlying association, similar to other studies that demonstrated an influence of surgical volume on recurrence and other outcomes of inguinal hernia repair.27–29

Table 2. Risk of hernia recurrence according to hospital volume and specialty status (Shouldice Hospital v. general hospitals)

<table>
<thead>
<tr>
<th>Recurrence risk factor</th>
<th>General hospitals by volume*</th>
<th>Shouldice Hospital</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quartile 1</td>
<td>Quartile 2</td>
<td>Quartile 3</td>
</tr>
<tr>
<td>No. of patients</td>
<td>42,427</td>
<td>42,644</td>
<td>42,346</td>
</tr>
<tr>
<td>No. of recurrences</td>
<td>2,163</td>
<td>2,320</td>
<td>1,916</td>
</tr>
<tr>
<td>Incidence (per 1000 person-years)</td>
<td>5.68</td>
<td>6.30</td>
<td>5.32</td>
</tr>
<tr>
<td>Crude risk</td>
<td>5.10</td>
<td>5.44</td>
<td>4.52</td>
</tr>
<tr>
<td>Age-standardized risk (95% CI)**</td>
<td>5.21 (4.94–5.49)</td>
<td>5.63 (5.35–5.91)</td>
<td>4.90 (4.64–5.17)</td>
</tr>
</tbody>
</table>

CI = confidence interval.
*Patients were divided into 4 equal groups of hospital volume (quartiles), with quartile 1 including hospitals with the lowest volume and quartile 4 including hospitals with the highest volume of primary elective inguinal hernia repair.
†Proportion of all patients who experienced a recurrence.
‡Age-standardized according to the 1991 Canadian population census data.
Strengths and limitations

The strengths of our study include its large size and population-based sampling, the longitudinal assessment of surgical recurrence regardless of where it was repaired and our ability to identify patients who had surgery at the Shouldice Hospital.

Our study had several limitations. We lacked detailed clinical information on smoking; obesity; and hernia characteristics, such as size, all of which can influence recurrence risk. Although most of the hernia repairs among people who had surgery at the Shouldice Hospital were likely to be Shouldice repairs, we could not determine the specific surgical technique used in other hospitals, including whether repairs were open, laparoscopic, tension-free or “tissue” repairs. Because this study was limited to Ontario residents, we lacked information on procedures and outcome events for people from outside the province who had surgery in Ontario, many of whom would have had surgery at the Shouldice Hospital. We measured only hospital volume and not surgeon volume and therefore cannot exclude the effects of surgeon volume and expertise. Because recurrence was defined as surgical repair of a recurrent hernia, we could not detect subclinical recurrences, nor could we identify recurrences among patients who did not choose to have their recurrent hernia repaired.30 We were not able to measure differences in wound complications, which may occur due to surgical technique and suture materials. Finally, our data did not distinguish between left- and right-sided inguinal hernias. For patients with a surgical recurrence who had 2 prior inguinal hernia repairs, we attributed the recurrence to the hospital where the first primary inguinal hernia was repaired. To the extent that people had 2 inguinal hernias repaired at 2 different hospitals, this error would have falsely attributed the recurrence to the wrong hospital approximately half the time. Since all of these types of misclassification error are nondifferential and would bias our findings toward the null hypothesis of finding no effect of the Shouldice Hospital, it is unlikely that any of these sources of error biased our findings in favour of the results we observed.

Study implications

There are 2 main explanations for our principal findings regarding surgical recurrence. Either surgical care is substantially better at a surgical specialty hospital, or patients at substantially lower risk of recurrence were preferentially selected for surgery. Patients having surgery at the Shouldice Hospital were generally healthier and had a higher household income. There was no evidence that use of local anesthesia at the Shouldice Hospital led to more medically high-risk patients having surgery there. It is possible that the specialty hospital operated on patients with highly favourable hernias, or on minimally detectable hernias on which other surgeons would not operate.31 Our results do not provide support to the hypothesis that patient selection alone.
can explain the observed results. An estimate of the extent of out-selection is the 10% of patients who had a consultation with a surgeon at the Shouldice Hospital but subsequently had surgery at a general hospital. Only an extraordinarily high recurrence rate among these patients would explain the large effect we observed; the actual recurrence risk of approximately 3% among these patients suggests a very limited effect of patient selection. While our findings suggest that specialty hospitals treat patients with selected and favourable demographic characteristics, we did not find that they preferentially selected patients based on expected treatment outcome. The Shouldice Hospital is unique in that it is not only just a very high-volume specialty surgical hospital, but also the champion of a surgical technique that is rarely used in other hospitals. The favourable results we observed regarding hernia recurrence at the Shouldice Hospital may be associated with surgical volume, surgical technique and processes of care, or with all of these factors.

Our findings raise important questions for future studies. What processes of care explain the striking differences in outcome we observed at the Shouldice Hospital? While it is an extreme outlier in terms of surgical volume, the rate of recurrence after surgery at the specialty hospital was substantially better than that at even the highest volume general hospitals. The importance of factors such as operative technique, patient preparation, postoperative care, or other processes of care are not clear, and better understanding of these issues will determine the extent to which the improved outcomes can be achieved in general hospitals. Finally, if surgical specialty hospitals can achieve substantially better outcomes than general hospitals, does it make sense to encourage more routine surgical care to be provided in these settings? Any potential benefits in

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital category</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>General hospitals†</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Quartile 1</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>Quartile 2</td>
<td>1.14 (1.07–1.21)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Quartile 3</td>
<td>1.02 (0.97–1.08)</td>
<td>0.33</td>
</tr>
<tr>
<td>Quartile 4</td>
<td>0.94 (0.89–1.00)</td>
<td>0.06</td>
</tr>
<tr>
<td>Shouldice Hospital</td>
<td>0.21 (0.19–0.23)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Age (per year)</td>
<td>1.01 (1.01–1.01)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Female sex</td>
<td>1.29 (1.20–1.39)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Income quintile</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1 (Lowest)†</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>1.01 (0.94–1.08)</td>
<td>0.86</td>
</tr>
<tr>
<td>3</td>
<td>0.96 (0.89–1.02)</td>
<td>0.18</td>
</tr>
<tr>
<td>4</td>
<td>1.02 (0.95–1.09)</td>
<td>0.58</td>
</tr>
<tr>
<td>5 (Highest)†</td>
<td>1.01 (0.94–1.08)</td>
<td>0.81</td>
</tr>
<tr>
<td>Year</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1993–1997‡</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>1998–2002</td>
<td>0.66 (0.63–0.70)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>2003–2007</td>
<td>0.51 (0.48–0.54)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

CI = confidence interval; HR = hazard ratio.
*Adjusted for all variables listed and Collapsed Adjusted Diagnosis Groups using a Cox proportional hazards model with adjustment for hospital-level clustering.
†Patients were divided into 4 equal groups of hospital volume (quartiles), with the lowest volume and quartile 4 including hospitals with the highest volume of primary elective inguinal hernia repair.
‡Referent category.

**Fig. 2.** Hazard ratios for repair of recurrent inguinal hernia, by age, sex, time period, income and comorbidity. CI = confidence interval.
clinical outcomes must ultimately be considered in the context of the negative consequences of specialty hospitals, such as maintaining expertise in surgical care at general hospitals and drawing profitable episodes of care away from general hospitals that rely on revenue from elective surgery to subsidize more costly types of hospital care.12

CONCLUSION

Inguinal hernia repair at a large hernia specialty hospital was associated with a substantially lower risk of subsequent surgery for hernia recurrence than repair at a general hospital. These results could not be explained entirely on the basis of surgical volume, patient selection or confounding factors. While specialty hospitals may have better outcomes for treatment of common surgical conditions than general hospitals, these benefits must be weighed against potential negative impacts on clinical care and the financial sustainability of general hospitals.

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Competing interests: None declared.

Contributors: C. Bell, T. Stukel and D. Urbach designed the study. A. Malik and D. Urbach acquired the data, which all authors analyzed. A. Malik and C. Bell wrote the article, which all authors reviewed and approved for publication.

References

Working toward reducing postoperative fracture radiographs: a survey of Canadian surgeons

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Background: When fracture management includes operative fixation with a load-sharing construct in good-quality bone, screening for healing problems or hardware failure with radiographs in the first 6 postoperative weeks may be unnecessary. I sought to determine Canadian orthopedic surgeons’ current protocol for early postoperative radiographs of stable, internally fixed fractures as well as their willingness to adopt a simplified protocol.

Methods: Members of the Canadian Orthopaedic Association were surveyed electronically. Five examples of surgically treated fractures were chosen to represent the spectrum of load-sharing constructs. The survey collected demographic data and inquired about current postoperative radiograph protocols and consideration of a simplified protocol.

Results: Of the 822 emailed invitations to complete the survey, 400 were opened and 243 surveys were completed. Most participants (91%) practiced in Canada and managed some trauma (91%), but were not trauma specialists (82%). Surgeon experience was equally distributed. Sixty-six percent of respondents acquire immediate postoperative radiographs after femur and tibia intramedullary nails, and 62% repeat radiographs at 2-week follow-up. Fifty-one percent of respondents acquire immediate postoperative radiographs after forearm, humerus and ankle internal fixation, and 69% repeat radiographs at 2-week follow-up. Of the respondents who currently acquire radiographs, 33% would consider foregoing immediate postoperative radiographs after intramedullary nailing of femur and tibia fractures, while 25% would forego them at 2-week follow-up. Similarly, 58% would consider foregoing radiographs immediately after internal fixation of forearm, humerus and ankle fractures, while 24% would forego them at 2-week follow-up.

Conclusion: Many Canadian orthopedic surgeons do not acquire screening postoperative radiographs after stable fracture fixation, and many more are willing to adopt this practice. These findings support investigating the safety and cost-effectiveness of a simplified postoperative radiographic protocol.

Contexte : Lorsqu’une facture est prise en charge par fixation peropératoire au moyen d’une structure répartissant les charges dans un os de bonne qualité, il peut être inutile d’effectuer des radiographies pour dépister les problèmes de consolidation ou les défaillances matérielles dans les 6 semaines suivant l’intervention. J’ai voulu déterminer le protocole actuellement utilisé par les chirurgiens orthopédistes canadiens quant aux radiographies effectuées peu après une opération de fracture stabilisée par fixation interne, ainsi que la volonté des chirurgiens d’adopter un protocole simplifié.

Méthodes : Un sondage électronique a été envoyé aux membres de l’Association canadienne d’orthopédie; 5 exemples sélectionnés de fractures traitées par chirurgie y ont été utilisés pour représenter l’éventail de structures répartissant les charges. Des données démographiques ont été recueillies dans le sondage, qui comportait des questions sur les protocoles actuels de radiographie postopératoire et la prise en considération d’un protocole simplifié.

Résultats : Sur les 822 courriels d’invitation, 400 ont été ouverts; 243 personnes ont répondu au sondage. La plupart des répondants exerçaient au Canada (91 %) et prenaient en charge certains cas de traumatologie (91 %), mais n’étaient pas traumatologues (82 %). L’échantillon était composé de chirurgiens possédant divers degrés d’expérience selon une répartition homogène. Parmi les répondants, 66 % font une radiographie postopératoire immédiatement après l’enclouage centromédullaire de
Orthopedic surgeons frequently rely on radiographs for fracture diagnosis and thereafter for monitoring the progression of fracture healing. When fracture management includes operative fixation with a load-sharing construct in good-quality bone, screening for healing problems or hardware failure with radiographs in the first 6 postoperative weeks may be unnecessary.

For fractures treated with anatomic open reduction, compression and rigid internal fixation with a plate and screw construct, primary bone healing is expected. Investigators who have studied fractures treated in this fashion have expressed an inability to see any meaningful changes on radiographs obtained in the first 6 weeks after operative compression of the fracture. Evidence from animal models further demonstrates that compression is maintained across the fracture by the plate and screw construct over the course of 6 weeks. The implants themselves rarely seem to fail during this period and when they do, such failure, whether gradual or catastrophic, does not go undiagnosed owing to associated symptomatology to guide radiograph acquisition.

Similarly, for fractures treated with locked intramedullary nails where secondary bone healing is expected, in the majority of patients, callus is not visible on radiographs until after 6 weeks. Biomechanically, intramedullary nails have high fatigue strength compatible with supporting full weight bearing for well over 6 weeks, even in patients with comminuted fractures. In clinical cohorts nails do not fail, even with unrestricted activity over the initial 6 weeks without a significant traumatic event.

The literature therefore suggests that when fractures in good-quality bone are treated with compression plating and intramedullary nails, routine radiographs obtained in the first 6 weeks postoperatively do not inform the surgeon regarding healing progression and are unlikely to demonstrate or prevent problems with the implants. Omitting these radiographs may provide certain efficiencies for orthopedic surgeons and their patients. It is unclear how frequently these radiographs are currently part of surgical practice. The objective of this study was to describe Canadian orthopedic surgeons’ practice patterns with respect to screening radiographs in the first 6 postoperative weeks.

**Methods**

Five fractures and fixation types were selected to represent a spectrum of load-sharing constructs in both the upper and lower extremities. I selected noncomminuted fractures (with at most 1 butterfly fragment) involving the humerus shaft and/or the forearm to represent upper-extremity fractures treated with the lag screw technique and neutralization plating, or compression plating alone. I selected mid-shaft fractures of the tibia and femur to represent lower-extremity fractures treated with locked intramedullary nails. In addition, I chose noncomminuted ankle fractures to represent a common lower-extremity fracture, usually accompanied by weight bearing restrictions. Inclusion of ankle fractures into the survey would therefore explore surgeons’ approaches to a broader spectrum of injuries.

An electronic survey was created to describe these 5 types of fractures and fixation types. The first part of the survey collected surgeons’ demographic data. The second part asked participants their current protocol for the acquisition of postoperative screening radiographs immediately after surgery while the patient is still in hospital as well as at the 2-week follow-up visit in clinic. Participants were asked to assume that adequate intraoperative fluoroscopy images had been acquired. Finally, participants who routinely acquire screening radiographs in hospital and at the 2-week follow-up visit were asked whether they would consider changing their practices to a simplified protocol. This protocol involved acquisition of radiographs at those time points only in the presence of a clinical indication.
The University of Manitoba Ethics Review Board approved the study protocol, and the Canadian Orthopaedic Association (COA) distributed the survey by email to its members.

I used descriptive statistics to analyze the data.

**RESULTS**

The COA distributed 822 invitations by email to its members. Of these, 400 were opened. A total of 243 surgeons followed the link and completed the survey. The majority of surgeons were practising in Canada (91%) and managed some trauma (91%), but were not dedicated trauma specialists (82%). Surgeons of all experience levels were equally represented, with 23% having 0–5 years of experience, 23% having 5–10 years, 26% having 10–20 years and 29% having more than 20 years of experience.

Sixty-six percent of respondents currently acquire immediate postoperative radiographs for femur and tibia fractures treated with intramedullary nails, and 62% repeat radiographs at 2-week follow-up. Fifty-one percent of respondents currently acquire immediate postoperative radiographs for forearm, humerus and ankle fractures treated with open reduction and internal fixation, and 69% repeat radiographs at 2-week follow-up.

Of the respondents who currently acquire radiographs, 33% reported they would consider foregoing immediate postoperative radiographs after intramedullary nailing of femur and tibia fractures, whereas 25% would consider foregoing these radiographs at the 2-week follow-up. In the group currently acquiring radiographs, 58% would consider foregoing radiographs immediately after open reduction and internal fixation of forearm, humerus and ankle fractures, whereas 24% would consider foregoing radiographs at the 2-week follow-up.

**DISCUSSION**

This survey shows that a relatively large proportion of orthopedic surgeons currently do not feel that screening radiographs are needed in the first weeks after fixation of fractures for which a load-sharing construct is used. Approximately one-third of surgeons already do not acquire screening radiographs in their practices, while approximately one-quarter to one-half of those who do would consider a change in practice to a simplified radiographic protocol.

**CONCLUSION**

This work supports further investigation into the safety and associated cost savings of implementing a simplified postoperative radiographic protocol for fractures treated with a load-sharing construct. A randomized controlled trial comparing the use of postoperative screening radiographs to the use of such radiographs only when clinically indicated for the treatment of the fractures and fixation types outlined in this study would provide important data that could change orthopedic practice across Canada, maintaining safety and quality of care, while reducing costs for institutions and radiation exposure for patients.

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**Competing interests:** None declared.

**References**

Discrepancy between gastroenterologists’ and general surgeons’ perspectives on repeat endoscopy in colorectal cancer

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Background: A myriad of localization options are available to endoscopists for colorectal cancer (CRC); however, little is known about the use of such techniques and their relation to repeat endoscopy before CRC surgery. We examined the localization practices of gastroenterologists and compared their perceptions toward repeat endoscopy to those of general surgeons.

Methods: We distributed a survey to practising gastroenterologists through a provincial repository. Univariate analysis was performed using the \( \chi^2 \) test.

Results: Gastroenterologists (n = 69) reported using anatomical landmarks (91.3%), tattooing (82.6%) and image capture (73.9%) for tumour localization. The majority said they would tattoo lesions that could not be removed by colonoscopy (91.3%), high-risk polyps (95.7%) and large lesions (84.1%). They were equally likely to tattoo lesions planned for laparoscopic (91.3%) or open (88.4%) resection. Rectal lesions were less likely to be tattooed (20.3%) than left-sided (89.9%) or right-sided (85.5%) lesions. Only 1.4% agreed that repeat endoscopy is the standard of care, whereas 38.9% (n = 68) of general surgeons agreed (p < 0.001). General surgeons were more likely to agree that an incomplete initial colonoscopy was an indication for repeat endoscopy (p = 0.040). Further, 56% of general surgeons indicated that the findings of repeat endoscopy often lead to changes in the operative plan.

Conclusion: Discrepancies exist between gastroenterologists and general surgeons with regards to perceptions toward repeat endoscopy and its indications. This is especially significant given that repeat endoscopy often leads to changes in surgical management. Further research is needed to formulate practice recommendations that guide the use of repeat endoscopy, tattoo localization and quality reporting.

Contexte : De nombreuses options de repérage s’offrent aux endoscopistes dans les cas de cancer colorectal; on en sait cependant peu sur l’utilisation de ces techniques et leur lien avec les endoscopies répétées avant les interventions chirurgicales de traitement de ce cancer. Nous avons étudié les pratiques de repérage employées par des gastroentérologues et comparé leurs perceptions des endoscopies répétées à celles des chirurgiens généralistes.

Méthodes : Nous avons réalisé un sondage auprès de gastroentérologues en exercice figurant dans un répertoire provincial. Une analyse unidimensionnelle a été effectuée à l’aide du test \( \chi^2 \).

Résultats : Les gastroentérologues (n = 69) ont dit recourir à des repères anatomiques (91,3 %), au tatouage (82,6 %) et à des images (73,9 %) pour repérer les tumeurs. La majorité a dit tatouer les lésions ne pouvant être éliminées par colonoscopie (91,3 %), les polypes à haut risque (95,7 %) et les lésions de grande taille (84,1 %). Ils étaient tout aussi susceptibles de tatouer les lésions devant être éliminées par résection laparoscopique (91,3 %) ou ouverte (88,4 %). Ils étaient cependant moins susceptibles de tatouer les lésions rectales (20,3 %) que les lésions du côté gauche (89,9 %) ou du côté droit (85,5 %). Seul 1,4 % des gastroentérologues était d’avis que l’endoscopie répétée constitue une norme en matière de soins, contrairement à 38,9 % des chirurgiens généralistes (n = 68; p < 0.001). Les chirurgiens généralistes étaient plus nombreux à penser qu’une colonoscopie initiale incomplète était susceptible d’être associée à des endoscopies répétées (p = 0,040). En outre, 56 % d’entre eux ont indiqué que les résultats d’endoscopies répétées menaient souvent à des changements sur le plan chirurgical.

Conclusion : Il existe des divergences entre les perceptions des gastroentérologues et des chirurgiens généralistes quant aux endoscopies répétées et à leur indication. Ces divergences sont particulièrement pertinentes, étant donné que les endoscopies répétées entraînent souvent des changements aux interventions chirurgicales qui sont pratiquées ultérieurement. Des recherches approfondies seront nécessaires pour formuler des recommandations liées aux pratiques et orienter le recours aux endoscopies répétées et au repérage des lésions par tatouage ainsi que la production de rapports sur la qualité.
Colorectal cancer (CRC) is the third most commonly diagnosed cancer in Canada. In 2014, an estimated 24,300 individuals will have CRC diagnosed and an estimated 9,300 will die of the disease.\(^1\) Colonoscopy is considered the gold standard for detection of CRC, with a specificity of 90.0% and a sensitivity of 95.0%.\(^2\) Over the past decade, the rise of minimally invasive surgical (MIS) techniques has made endoscopic lesion localization critical to surgical planning. However, little is known about the localization practices of gastroenterologists and general surgeons.

Although colonoscopy demonstrates excellent detection rates for both malignancies and adenomas, its ability to provide precise localization information is less clear. In the literature, estimates of the error rate in tumour localization vary from as low as 4% to as high as 21%.\(^3–10\) These errors can have a dramatic impact on surgical management, especially in laparoscopic cases where the surgeon lacks the tactile ability to palpate the colon for the lesion. This may result in conversion from a laparoscopic to open approach, intraoperative colonoscopies and removal of incorrect segments of colon. To help surgical planning and prevent such complications, surgeons often perform repeat colonoscopy before CRC surgery to verify lesion location.

In a recent study by Al Abbasi and colleagues,\(^11\) the repeat endoscopy rate at a large tertiary academic centre before CRC surgery was estimated to be up to 40.5%. Factors associated with preoperative repeat endoscopy by the operating surgeon were left-sided colonic neoplasms, planned laparoscopic resection and failure to tattoo the lesion on the initial colonoscopy.\(^11\) However, to our knowledge, no studies have assessed the perceptions of gastroenterologists toward repeat endoscopy and its indications.

When a lesion is detected by colonoscopy, endoscopists have a myriad of localization techniques at their disposal. They include use of anatomic landmarks, distance from the anal verge, image capture if the lesion is near an identifiable landmark, hemoclips and tattooing. No formal protocols exist to guide endoscopists in choosing the appropriate localization technique, and little is known about current use of these practices as they relate to repeat endoscopy before CRC surgery. Localization based on anatomic landmarks is often reported in the vast majority of polypectomies;\(^12\) however, this technique has been associated with error rates as high as 21%.\(^1–10\) Less clear is the practice of coloscopic image capture, with studies demonstrating varied utilization rates.\(^12,11\) Moreover, there is a paucity of literature assessing the use of hemoclips in colonoscopy. Tattoo localization is considered the most accurate localization technique, and lack of tattoo localization is the most cited reason for repeat endoscopy by the operating surgeon.\(^11,14\) Nevertheless, the rate of tattooing remains quite low — between 0% and 23%.\(^15,16\) Furthermore, while tattoo localization is often recommended for colonic lesions suspicious for malignancy,\(^17\) the use of tattooing in different clinical scenarios remains unclear.

Given the limited evidence available on the localization practices of endoscopists, including the use of tattoo localization, the primary objective of our study was to identify the colonoscopic localization practices of gastroenterologists and to clarify the role of tattoo localization in this setting. The secondary objective was to assess the attitudes and perceptions of gastroenterologists toward repeat endoscopy and to compare their perceptions to those of general surgeons identified by a recent survey.

**METHODS**

**Instrument design**

We developed a preliminary questionnaire based on a Medline literature review to ascertain the current localization practices and attitudes of gastroenterologists toward repeat endoscopy before CRC surgery. The preliminary survey was reviewed by a focus group consisting of 2 academic gastroenterologists, a community gastroenterologist, a gastroenterology resident and a practising general surgeon.

The final questionnaire comprised 16 questions that addressed demographic items, general localization practices, tattoo localization practices and indications for repeat endoscopy as well as attitudes and perceptions toward repeat endoscopy. The survey evaluated the frequency of 5 localization techniques used over the previous 12 months using a 5-point Likert scale (with possible responses being never, rarely, sometimes, frequently and always). Tattoo localization practices under 10 clinical scenarios were assessed using the same 5-point Likert scale. The 5 most common indications for repeat endoscopy were ranked from most to least frequent.\(^11\)

**Data collection and analysis**

We disseminated the questionnaire in an online, electronic format using QuestionPro. Participants were identified and recruited via the membership directory of the Ontario Association of Gastroenterology (OAG) and among attendees of the 17th Annual OAG Conference. We performed statistical analyses using SPSS Statistics software version 21.0 (IBM Corp.). We compared attitudes and perceptions of gastroenterologists toward preoperative repeat endoscopy and its perceived indications with those of practising general surgeons.\(^19\) Univariate group comparisons for categorical data were achieved using the \(\chi^2\) test. We considered results to be significant for all comparisons at \(p < 0.05\). The University Health Network Research Ethics Board approved our study protocol.
RESULTS

Of the 184 active members of the OAG, 69 practising gastroenterologists completed the survey, along with 3 trainees. Trainees were excluded from the statistical analysis, resulting in a response rate of 38%. The characteristics of participants excluding trainees are presented in Table 1. The majority of respondents were men (89.9%), had more than 20 years of practice experience (43.5%) and worked in an urban setting (92.8%). Most respondents were employed in a teaching hospital (60.9%); only 8.7% worked in private clinics. All respondents performed colonoscopies. Colonoscopy volume was widely distributed; whereas the majority of respondents performed between 50 and 100 colonoscopies per month (60.9%), 27.5% performed less than 50 colonoscopies per month.

Localization practices

On average, 56.5% ± 11.5% of respondents routinely shared colonoscopic images and/or videos with the consulting surgeon when referring patients for CRC surgery. The frequency of various localization techniques when a lesion was detected by colonoscopy is highlighted in Table 2. Most respondents used anatomical landmarks (91.3% ± 10.9%), followed by tattooing (82.6% ± 11.3%), image capture (73.9% ± 11.5%) and distance measured from the anal verge (71.0% ± 11.5%). No participants reported the use of hemoclips for localization.

Tattoo localization practices are highlighted in Table 3. The majority of respondents indicated they would tattoo lesions that could not be removed by colonoscopy (92.8% ± 10.9%), polyps with high-risk features (95.7% ± 10.7%) and large lesions suspicious for malignancy (84.1% ± 11.3%). In addition, 76.8% ± 11.5% indicated they would tattoo polypos smaller than 1 cm. The vast majority of respondents would routinely tattoo a lesion regardless of surgical approach (91.3% ± 10.9% for laparoscopic surgery; 88.4% ± 11.1% for open surgical resection). With respect to tumour location, respondents said they would be likely to tattoo left-sided (89.9% ± 11.0%) and right-sided malignancies (85.5% ± 11.2%). Only 20.3% ± 8.2% said they would be likely to tattoo a rectal lesion.

Repeat colonoscopy prior to CRC surgery

Table 4 summarizes the perceived indications for preoperative repeat endoscopy specified by gastroenterologists as well as general surgeons. Gastroenterologists (80.6%) were more likely than general surgeons (56.6%) to identify preoperative planning or tattoo localization by the operating surgeon as the primary indication for repeat endoscopy (p < 0.001). General surgeons were more likely than gastroenterologists to agree that an incomplete initial colonoscopy was an indication for repeat endoscopy (14.9% v. 6.9%; p = 0.040).

Most (63 [91.3%]) gastroenterologists agreed that tattoo localization of a malignancy on the initial colonoscopy is the standard of care. Only 1 (1.4%) gastroenterologist agreed that repeat colonoscopy by the general surgeon before CRC surgery is the standard of care, whereas 68 (38.9%) general surgeons agreed (p < 0.001). The majority of gastroenterologists (48 [69.6%]) and general surgeons (105 [60.0%]) disagreed with the statement, “Repeat colonoscopy prior to surgery has minimal impact on total cost of care” (p = 0.15). A total of 104 (59.4%) general surgeons agreed that “Repeat colonoscopy prior to surgery has minimal impact on time to definitive surgery,” whereas

<p>| Table 1. Characteristics of study participants |</p>
<table>
<thead>
<tr>
<th>.Variable</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, n = 69</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>62 (89.9)</td>
</tr>
<tr>
<td>Female</td>
<td>7 (10.1)</td>
</tr>
<tr>
<td>Years in practice</td>
<td></td>
</tr>
<tr>
<td>&lt; 5</td>
<td>13 (18.8)</td>
</tr>
<tr>
<td>6–20</td>
<td>26 (37.7)</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>30 (43.5)</td>
</tr>
<tr>
<td>Practice location</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>64 (92.8)</td>
</tr>
<tr>
<td>Rural</td>
<td>5 (7.2)</td>
</tr>
<tr>
<td>Practice setting</td>
<td></td>
</tr>
<tr>
<td>Community hospital</td>
<td>21 (30.4)</td>
</tr>
<tr>
<td>Teaching hospital</td>
<td>42 (60.9)</td>
</tr>
<tr>
<td>Private clinic</td>
<td>6 (8.7)</td>
</tr>
<tr>
<td>No. of colonoscopies performed, average per mo</td>
<td></td>
</tr>
<tr>
<td>&lt; 50</td>
<td>19 (27.5)</td>
</tr>
<tr>
<td>50–69</td>
<td>11 (15.9)</td>
</tr>
<tr>
<td>70–89</td>
<td>20 (29.0)</td>
</tr>
<tr>
<td>90–100</td>
<td>11 (15.9)</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>8 (11.6)</td>
</tr>
<tr>
<td>No. of CRCs diagnosed on colonoscopy in past 12 mo</td>
<td></td>
</tr>
<tr>
<td>&lt; 5</td>
<td>10 (14.5)</td>
</tr>
<tr>
<td>5–10</td>
<td>37 (53.6)</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>22 (31.9)</td>
</tr>
</tbody>
</table>

CRC = colorectal cancer.

<table>
<thead>
<tr>
<th>Table 2. Localization practices for lesions detected by colonoscopy for gastroenterologists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localization technique</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Colonoscopy tip measured from anal verge</td>
</tr>
<tr>
<td>Anatomical landmark</td>
</tr>
<tr>
<td>Image capture</td>
</tr>
<tr>
<td>Tattoo localization</td>
</tr>
<tr>
<td>Hemoclips</td>
</tr>
</tbody>
</table>

only 28 (40.6%) gastroenterologists agreed (p = 0.003). Further, 84 (56%) of the general surgeons surveyed indicated that the findings of repeat endoscopy often lead to changes in the operative plan. With regard to conducting repeat endoscopy before CRC surgery in the previous 12 months, 46 (26.9%) never performed repeat endoscopy, 73 (42.7%) in less than 50% of CRC cases, 24 (14.0%) in 51%–75% of cases and 28 (16.4%) performed repeat endoscopy in more than 75% of cases.

**DISCUSSION**

Our study demonstrates that for lesions detected by colonoscopy, gastroenterologists most frequently use anatomical landmarks (91.3%) for tumour localization. This is followed by tattooing (82.6%), image capture (73.9%) and colonoscopy tip measured from the anal verge (71.0%). Use of hemoclips was not reported by any of the respondents in this study. The frequent use of anatomical landmarks corroborates recent findings by Beaulieu and colleagues, who demonstrated a 99.1% anatomical location-based reporting rate. Despite these results, use of anatomical landmarks compared with intraoperative location has been associated with localization error rates as high as 21%, thus leading many to recommend tattoo localization instead.

Given that lack of tattoo localization was cited as one of the most common indications for repeat endoscopy by general surgeons, the results of our study are an important contribution to further understanding this practice by gastroenterologists. For lesions detected at colonoscopy in the previous 12 months, 74% of respondents said they frequently localized the lesion by tattooing. This result is similar to those of Conaghan and colleagues, who demonstrated a tattoo localization rate of 65.1% in 85 patients who underwent laparoscopic resection for colorectal tumours. However, in their study, 31% of patients were tattooed at a repeat endoscopy, a procedure that is both costly and has associated risks. Respondents in our study were very likely to tattoo lesions that could not be removed by colonoscopy (92.8%), polyps with high-risk features (95.7%) and polyps with features that may require follow-up colonoscopy (76.8%). These findings are in contrast to those of a recent study by Zafar and colleagues, who examined tattoo localization in 165 patients with polyps and reported a tattoo rate of only 23%. Our study demonstrates a tattoo rate of only 2.9% for polyps smaller than 1 cm and much higher rates for polyps with high-risk features. To our knowledge, this is the first study to explicitly assess tattooing practices based on polyp features.

There is a paucity of literature evaluating tattoo rates with respect to tumour location. Most of the respondents in our study said they would tattoo right-sided (85.5%) and left-sided malignancies (89.9%), whereas only 20.3% said they would tattoo rectal lesions. Keller and colleagues demonstrated an even lower rectal tattoo rate of 4.1% in 49 patients with rectal polyps that were later diagnosed as neoplastic. This discrepancy in tattooing of rectal lesions may best be explained by the clinical scenarios addressed: whereas Keller and colleagues assessed only tattooing of polyps, our study assessed the likelihood of tattooing rectal lesions suspicious for malignancy. Interestingly, our study demonstrates that gastroenterologists are likely to tattoo malignancies in the right colon despite evidence that right-sided lesions close to known anatomical landmarks, such as the ileocecal junction or appendiceal

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**Table 3. Primary indication for repeat endoscopy before colorectal cancer surgery identified by gastroenterologists and general surgeons**

<table>
<thead>
<tr>
<th>Primary indication</th>
<th>Gastroenterologists</th>
<th>General surgeons</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative planning or tattoo localization by surgeon</td>
<td>56 (81.2)</td>
<td>99 (65.1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lack of information provided by initial colonoscopy report</td>
<td>7 (10.1)</td>
<td>24 (15.8)</td>
<td>0.26</td>
</tr>
<tr>
<td>Incomplete initial colonoscopy</td>
<td>5 (7.2)</td>
<td>26 (17.1)</td>
<td>0.040</td>
</tr>
<tr>
<td>Repeated therapeutic attempt</td>
<td>1 (1.4)</td>
<td>3 (2.0)</td>
<td>0.79</td>
</tr>
</tbody>
</table>

*Based on a recent survey of practising general surgeons in Ontario.**
The findings of the present study should be interpreted within the context of the following limitations. First, the results may have been influenced by recall bias. To minimize this possibility, we used Likert scales and ranges rather than soliciting discrete values from respondents. Second, although respondents included gastroenterologists from across the province of Ontario, the results may not be generalizable to other gastroenterology groups. Finally, the results are based on self-reporting by clinicians, and thus we were unable to calculate precise rates of tumour localization practices.

**Conclusion**

The present study confirms that anatomic landmarks are the most commonly used localization technique by gastroenterologists for lesions detected by colonoscopy. Moreover, gastroenterologists frequently use tattoo localization for high-risk polyps, large lesions suspicious for malignancy, and left- and right-sided malignancies. However, discrepancies exist between gastroenterologists and general surgeons with regards to perceptions toward repeat endoscopy and its indications. Such discrepancies highlight the importance of developing standardized guidelines for tattooing, repeat endoscopy and reporting of localization information among endoscopists. This is especially important given that general surgeons report frequent changes in the operative plan as a result of new information learned at repeat endoscopy. Further research is needed to formulate practice recommendations that guide the use of repeat endoscopy and tattoo localization with the aim of improving quality of patient care while minimizing cost.

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**Competing interests:** None declared.

**Contributors:** T.D. Jackson, A. Okrainec, P.G. Rossos and F.A. Quereshy designed the study. A. Azin, M.C. Jimenez acquired the data, which A. Azin, M.C. Jimenez and M.C. Cleghorn analyzed. The Department of Surgery, University of Toronto, Toronto, Ont. (Azin, Okrainec, Quereshy) reviewed. All authors approved the final version of the manuscript for publication.

**References**


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Trauma care and referral patterns in Rwanda: implications for trauma system development

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Background: Trauma remains a leading cause of death worldwide. The development of trauma systems in low-resource settings may be of benefit. The objective of this study was to describe operative procedures performed for trauma at a tertiary care facility in Kigali, Rwanda, and to evaluate geographical variations and referral patterns of trauma care.

Methods: We retrospectively reviewed all prospectively collected operative cases performed at the largest referral hospital in Rwanda, the Centre Hospitalier Universitaire de Kigali (CHUK), between June 1 and Dec. 1, 2011, for injury-related diagnoses. We used the Pearson $\chi^2$ and Fisher exact tests to compare cases arising from within Kigali to those transferred from other provinces. Geospatial analyses were also performed to further elucidate transfer patterns.

Results: Over the 6-month study period, 2758 surgical interventions were performed at the CHUK. Of these, 653 (23.7%) were for trauma. Most patients resided outside of Kigali city, with 337 (58.0%) patients transferred from other provinces and 244 (42.0%) from within Kigali. Most trauma procedures were orthopedic (489 [84.2%]), although general surgery procedures represented a higher proportion of trauma surgeries in patients from other provinces than in patients from within Kigali (28 of 337 [8.3%] v. 10 of 244 [4.1%]).

Conclusion: To our knowledge, this is the first study to highlight geographical variations in access to trauma care in a low-income country and the first description of trauma procedures at a referral centre in Rwanda. Future efforts should focus on maturing prehospital and interfacility transport systems, strengthening district hospitals and further supporting referral institutions.

Contexte : Les traumatismes demeurent l’une des principales causes de décès dans le monde. La mise au point de systèmes de traumatologie dans des milieux défavori-sés pourrait toutefois contribuer à améliorer la situation. Notre étude avait pour objectif de décrire les interventions chirurgicales pratiquées sur les victimes de traumatismes dans un établissement de soins tertiaires de Kigali, au Rwanda, et d’évaluer les variations géographiques et les habitudes d’orientation des patients dans le domaine de la traumatologie.

Méthodes : Nous avons évalué rétrospectivement les données recueillies de façon prospective sur l’ensemble des interventions réalisées au plus grand centre hospitalier régional du Rwanda, le Centre hospitalier universitaire de Kigali (CHUK), du 1er juin au 1er décembre 2011 pour les diagnostics liés à des blessures. Nous avons eu recours au test $\chi^2$ de Pearson et au test exact de Fisher pour comparer les cas issus de la province de Kigali à ceux provenant d’autres provinces. Nous avons en outre effectué des analyses géospatiales afin de mieux comprendre les habitudes d’orientation des patients.

Résultats : Au cours des 6 mois de l’étude, 2758 interventions chirurgicales ont été pratiquées au CHUK, dont 653 (23,7 %) pour des traumatismes. La majorité des patients résidaient à l’extérieur de la capitale : 337 (58,0 %) d’entre eux avaient été transférés d’autres provinces, et 244 (42,0 %), d’ailleurs dans la province. Si la plupart des interventions chirurgicales étaient orthopédiques (489, soit 84,2 %), les patients d’autres provinces ont plus souvent subi des interventions générales que leurs compatriotes de la province de Kigali (28 sur 337, soit 8,3 %, par rapport à 10 sur 244, soit 4,1 %).
A n estimated 5.8 million people die annually from injury-related events, representing more than 10% of deaths worldwide each year. The 3 most common causes of injury-related deaths — road traffic crashes, homicide and suicide — are expected to rise substantially in the coming years, joining the top 20 causes of death by 2030. Not all groups are equally vulnerable to injuries. Trauma is 1 of the top 3 leading causes of death in people between the ages of 5 and 44 years, the most productive portion of the population. Moreover, approximately 90% of injury-related deaths occur in low- and middle-income countries (LMICs).

The development of trauma systems, including regionalized trauma care and the utilization of referral trauma centres, has been shown to significantly decrease injury-related mortality in high-income nations. There is evidence that the development of trauma systems in LMICs, specifically prehospital care, could yield similar results.

Nonetheless, the vast majority of studies evaluating trauma care in LMICs rely on evaluations of hospital-based resources. Although these studies provide valuable information regarding the potential capacity to treat injuries, there is a paucity of evidence regarding the actual utilization of resources in trauma and barriers to access definitive care. With the recent launch of the Lancet Commission on Global Surgery, increasing attention is being paid to this issue; however, primary data collection, particularly hospital-based data, appears to be invaluable for advocacy efforts.

In this context, the objective of our study was to describe operative procedures performed for trauma at a tertiary care facility in Kigali, Rwanda, and to evaluate geographical variations and referral patterns of trauma care in Rwanda.

**Methods**

**Context**

The Centre Hospitalier Universitaire de Kigali (CHUK) is the largest of 4 referral hospitals in Rwanda and is 1 of the 2 referral hospitals located in Rwanda’s most populated and capital city, Kigali. The CHUK serves an estimated population of more than 6.2 million. With approximately 513 beds, the CHUK provides the following services: surgery, obstetrics/gynecology, internal medicine, pediatrics, radiology, ophthalmology, dermatology and laboratory services. Critical care support is available, but bed capacity is limited. The anesthesia program is well developed and has been described previously. The hospital contains a total of 14 operating rooms separated into multiple distinct physical locations. The main operating theatre has 6 operating rooms; 2 are used for urgent operations and the remaining 4 are used for elective procedures by the departments of general surgery, orthopedics, urology, otorhinolaryngology and neurosurgery. There are separate theatres for minor surgery, oromaxillofacial surgery and ophthalmology.

During off-hours, there is 1 operating room available in the main operating theatre for nonelective cases. At the time of the study, the CHUK employed 5 general surgeons, 3 orthopedic surgeons, 1 neurosurgeon, 1 urologist, 3 otolaryngologists, 1 oromaxillofacial surgeon, 1 ophthalmologist and 5 obstetricians and gynecologists. There is a fully supported surgery residency program associated with the National University of Rwanda with 24-hour resident coverage under attending surgeon supervision. All operations are performed with surgical residents and attending surgeons present.

**Data collection**

We retrospectively reviewed all operative cases performed at the CHUK between June 1 and Dec. 1, 2011, for injury-related diagnoses. All patients who underwent a surgical procedure for nontraumatic acute care or who underwent elective surgery were excluded. We obtained ethics approval from the CHUK and McGill University.

The CHUK operating room case logs are prospectively completed in a handwritten record by the circulating operating room nurse participating in the operative intervention. The data collected for the purpose of this study included basic patient demographics (age, sex, district of residence in Rwanda), diagnosis, procedure performed, type of anesthesia and booking category (urgent v. nonurgent). Urgent operations were defined as any operation performed with the patient transferred directly to the operating room from the Accident and Emergency Area. In addition, the type of anesthesia administered was recorded and divided into 3 categories: local, regional and general. The procedures were categorized based on the surgical specialties (general surgery, orthopedics, neurosurgery and urology) originally transcribed into the logbooks. Similar methods have been described previously. For the purposes of this study, general surgery was defined as any surgery...
involving the thoracic or abdominal cavity (excluding the genitourinary system), the head/neck (thyroid) and the abdominal wall (including the inguinal region). Authors with specialty training in general surgery (E.G.W, M.C.R., M.D., M.W. and D.L.D.) retrospectively classified the operations into traumatic, nontraumatic acute care and elective surgery based on the diagnoses and the procedures performed. Traumatic operations were defined as any procedure performed specifically for an injury.

Statistical analysis

Handwritten case logs were collected and transcribed into an electronic database (Microsoft Excel). We initially used descriptive statistics to tabulate patient, diagnosis and procedure characteristics. Comparisons between cases originating from within Kigali city and from other provinces were performed using the Pearson $\chi^2$ test and the Fisher exact test for cells containing values of 5 or less. Statistical analyses were performed using Stata IC software version 13.1 (StataCorp).

In order to further evaluate geographical patterns, we also performed geospatial analyses. We determined longitude and latitude coordinates of the patients’ residences using Batchgeocoding at www.findlatitudeandlongitude.com (David B. Zwiefelhofer). We used ArcGIS mapping software (Esri) to graphically represent the patients undergoing surgery for injuries at the CHUK from the different districts and provinces of Rwanda.

Results

Over the 6-month study period, 2758 surgical interventions were performed at CHUK, spanning all surgical subspecialties and including both urgent and elective procedures. Of these, 653 (23.7%) were performed for trauma. The geographical origins were available for 581 (90.0%) of these patients, whose cases were retained for further analysis. Figure 1 illustrates the point of origin of these patients. The majority of patients resided outside of Kigali city, with 337 (58.0%) patients transferred from other provinces and 244 (42.0%) from within Kigali.

Fig. 1. Geographic mapping of origin of patients undergoing injury-related operations at the Centre Hospitalier Universitaire de Kigali (CHUK) in Rwanda between June 1 and Dec. 1, 2011.
Table 1 presents the patient, anesthesia and procedure characteristics according to the geographical origin. Overall, 174 of the 581 (30.0%) patients were children, and proportions were similar between patients from within and outside Kigali. Significantly more patients from other provinces than from Kigali were older than 50 years (84 of 337 [24.9%] v. 38 of 244 [15.6%]). Most patients were between the ages of 18 and 49 years (285 of 581 [49.1%]). Most patients who required operative treatment for trauma were male (411 of 581 [70.7%]), and this proportion was similar regardless of geographical origin.

Most of the 581 procedures were performed with the patients under general anesthesia (348 [59.9%]), but some patients received regional (214 [36.8%]) or local (12 [2.1%]) anesthesia. Most operations were performed in an urgent fashion (307 [52.8%]). The proportions of anesthesia modalities and urgent procedures did not differ significantly between patients originating from within Kigali and those from other provinces.

Overall, the vast majority of trauma procedures were orthopedic (489 [84.2%]), followed by neurosurgery (53 [9.1%]), general surgery (38 [6.5%]) and urology (1 [0.2%]). When looking at differences in proportions based on the geographical origins of patients, orthopedic procedures were more prominent in patients from Kigali than in those from outside Kigali (227 of 244 [93.0%] v. 262 of 337 [77.7%]). Interestingly, general surgery procedures represented a higher proportion of trauma surgeries in patients from outside of Kigali than in those from within Kigali (28 of 337 [8.3%] v. 10 of 244 [4.1%]). In other words, 73.7% of general surgery operations for injuries were performed on patients from other provinces.

All injuries requiring an operative intervention are detailed in Table 2. The 2 leading indications were fractures (444 [76.4%]) and dislocations (37 [6.4%]). Both of these diagnoses were more common in patients from Kigali (80.7% and 10.3%, respectively) than in patients from outside Kigali (73.3% and 3.6%, respectively). Although neurosurgical indications accounted for a minority of the total number of cases, epidural hematomas (17 [2.9%]) and intracerebral hemorrhages (12 [2.1%]) were the 2 most common neurosurgical indications, and both were more common in patients from other provinces (4.2% and 3.3%, respectively) than in patients from within Kigali (1.2% and 0.4%, respectively). Abdominal trauma represented only 15 (2.6%) traumatic surgical indications overall, but were more frequent in patients from other provinces (13 of 337 [3.9%]) than in patients from within Kigali (2 of 244 [0.8%]); therefore, the vast majority (13 of 15 [86.7%]) of abdominal trauma patients were transferred from outside of Kigali.

Specific operative procedures performed for trauma are displayed in Table 3. Fracture reduction and fixation predominated (416 [71.6%]), followed by wound debridement, drainage or suturing (47 [8.1%]) and

Table 1. Demographic and clinical characteristics of trauma patients treated at the Centre Hospitalier Universitaire de Kigali in Rwanda between June 1 and Dec. 1, 2011, by geographical origin

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total</th>
<th>Kigali</th>
<th>Non-Kigali</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 18</td>
<td>174 (29.9)</td>
<td>74 (30.3)</td>
<td>100 (29.7)</td>
<td>0.016</td>
</tr>
<tr>
<td>18–49</td>
<td>285 (49.1)</td>
<td>132 (54.1)</td>
<td>153 (45.4)</td>
<td></td>
</tr>
<tr>
<td>≥ 50</td>
<td>122 (21.0)</td>
<td>38 (15.6)</td>
<td>84 (24.9)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>411 (70.7)</td>
<td>167 (68.4)</td>
<td>244 (72.4)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>140 (24.1)</td>
<td>61 (25.0)</td>
<td>79 (23.4)</td>
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<tr>
<td>Missing</td>
<td>30 (5.2)</td>
<td>16 (6.6)</td>
<td>14 (4.2)</td>
<td></td>
</tr>
<tr>
<td>Anesthesia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>348 (59.9)</td>
<td>148 (60.7)</td>
<td>200 (59.4)</td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td>214 (36.8)</td>
<td>87 (35.7)</td>
<td>127 (37.7)</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>12 (2.1)</td>
<td>6 (2.5)</td>
<td>6 (1.8)</td>
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</tr>
<tr>
<td>Missing</td>
<td>7 (1.2)</td>
<td>3 (1.2)</td>
<td>4 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Degree of urgency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urgent</td>
<td>307 (52.8)</td>
<td>127 (52.0)</td>
<td>180 (53.4)</td>
<td>0.75</td>
</tr>
<tr>
<td>Nonurgent</td>
<td>274 (47.2)</td>
<td>117 (48.0)</td>
<td>157 (46.6)</td>
<td></td>
</tr>
<tr>
<td>Specialty</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>General surgery</td>
<td>38 (6.5)</td>
<td>10 (4.1)</td>
<td>28 (8.3)</td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>53 (9.1)</td>
<td>7 (2.9)</td>
<td>46 (13.7)</td>
<td></td>
</tr>
<tr>
<td>Orthopedics</td>
<td>489 (84.2)</td>
<td>227 (93.0)</td>
<td>262 (77.7)</td>
<td></td>
</tr>
<tr>
<td>Urology</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>581 (100.0)</td>
<td>244 (100.0)</td>
<td>337 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>

*Pearson's chi test or Fisher exact test, as appropriate, comparing characteristics according to geographical origin.

Table 2. Operative indications for trauma at the Centre Hospitalier Universitaire de Kigali in Rwanda between June 1 and Dec. 1, 2011, by geographical origin

<table>
<thead>
<tr>
<th>Indication</th>
<th>Total</th>
<th>Kigali</th>
<th>Non-Kigali</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremity fracture</td>
<td>444 (76.4)</td>
<td>197 (80.7)</td>
<td>247 (73.3)</td>
<td>0.037</td>
</tr>
<tr>
<td>Joint dislocation</td>
<td>37 (6.4)</td>
<td>25 (10.3)</td>
<td>12 (3.6)</td>
<td>0.001</td>
</tr>
<tr>
<td>Epidual hematoma</td>
<td>17 (2.9)</td>
<td>3 (1.2)</td>
<td>14 (4.2)</td>
<td>0.046</td>
</tr>
<tr>
<td>Abdominal trauma</td>
<td>15 (2.6)</td>
<td>2 (0.8)</td>
<td>13 (3.9)</td>
<td>0.031</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>12 (2.1)</td>
<td>1 (0.4)</td>
<td>11 (3.3)</td>
<td>0.017</td>
</tr>
<tr>
<td>Burn</td>
<td>11 (1.9)</td>
<td>4 (1.6)</td>
<td>7 (2.1)</td>
<td>0.77</td>
</tr>
<tr>
<td>Skull fracture</td>
<td>10 (1.7)</td>
<td>0 (0.0)</td>
<td>10 (3.0)</td>
<td>0.006</td>
</tr>
<tr>
<td>Laceration</td>
<td>8 (1.4)</td>
<td>2 (0.8)</td>
<td>6 (1.8)</td>
<td>0.48</td>
</tr>
<tr>
<td>Subdural hematoma</td>
<td>8 (1.4)</td>
<td>2 (0.8)</td>
<td>6 (1.8)</td>
<td>0.48</td>
</tr>
<tr>
<td>Tendon rupture</td>
<td>6 (1.0)</td>
<td>4 (1.6)</td>
<td>2 (0.6)</td>
<td>0.24</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>4 (0.7)</td>
<td>1 (0.4)</td>
<td>3 (0.9)</td>
<td>0.64</td>
</tr>
<tr>
<td>Hernoma/ contusion</td>
<td>3 (0.5)</td>
<td>2 (0.8)</td>
<td>1 (0.3)</td>
<td>0.58</td>
</tr>
<tr>
<td>Perineal/rectal trauma</td>
<td>2 (0.3)</td>
<td>0 (0.0)</td>
<td>2 (0.6)</td>
<td>0.51</td>
</tr>
<tr>
<td>Hemorrhax</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Compartment syndrome</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Missing</td>
<td>2 (0.3)</td>
<td>2 (0.8)</td>
<td>0 (0.0)</td>
<td>0.18</td>
</tr>
<tr>
<td>Total</td>
<td>581 (100.0)</td>
<td>244 (100.0)</td>
<td>337 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>
craniotomy or craniectomy (40 [6.9%]). Exploratory laparotomy accounted for a minority (11 [1.9%]) of all traumatic procedures. When comparing procedures based on geographical origin, fracture reduction/fixation represented a higher proportion of procedures in patients from Kigali (202 of 244 [82.8%]) than in patients from other provinces (214 of 337 [63.5%]). Neurosurgical procedures, such as craniotomies or craniectomies, were more prominent in patients transferred from outside Kigali (34 of 337 [10.1%]) than in patients from within Kigali (6 of 244 [2.5%]). We observed the same pattern for exploratory laparotomies, with 9 of 11 (85.0%) procedures performed on patients transferred from other provinces.

**DISCUSSION**

To our knowledge, this study was the first to evaluate trauma caseloads at the largest referral centre in Rwanda and the first to describe geographical variations in access to operative trauma care. Surgical procedures for trauma represented a large proportion of all operations performed at the CHUK, and a vast majority of these were orthopedic in nature. In fact, fractures and dislocations were the most common indications for surgery, and fracture reductions and fixations were the most commonly performed procedures. Approximately 58% of trauma patients were transferred from outside Kigali. Interestingly, almost three-quarters of general surgery procedures for trauma were performed on patients transferred from other provinces.

This study therefore has important implications. The sheer volume of surgical procedures — more than 2700 performed within a 6-month period — is impressive by any standard and attests to the surgical teams in this resource-limited setting. Nonetheless, a countrywide survey of unmet surgical needs conducted in 2011 revealed that 6.4% of the population had a current operative condition. This implies that future efforts should continue to augment hospital-based surgical capacity, even in the largest tertiary care centre in the country. The predominance of orthopedic procedures provides a specific alley for operative resource planning, ranging from mobilization and training of human resources to improvement of the material resource capacity. Ultimately, improved surgical and trauma capacity will go hand in hand.

It is estimated that 17% of the Rwandan population has experienced an extremity injury in their lifetime; this, in addition to the fact that more than 80% of trauma procedures at the CHUK were orthopedic, points to an important selection bias. It is likely that individuals with injuries affecting more life-threatening anatomic regions do not survive transport to a definitive care centre. Consequently, the finding that three-quarters of patients who underwent a general surgery procedure were transferred from outside Kigali is likely

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Region; no. (%)</th>
<th>Kigali</th>
<th>Non-Kigali</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture reduction/fixation</td>
<td>416 (71.6)</td>
<td>202 (82.8)</td>
<td>214 (63.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Wound debridement/drainage/suture</td>
<td>47 (8.1)</td>
<td>16 (6.6)</td>
<td>31 (9.2)</td>
<td>0.25</td>
</tr>
<tr>
<td>Craniotomy/craniectomy</td>
<td>40 (6.9)</td>
<td>6 (2.5)</td>
<td>34 (10.1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>External fixation</td>
<td>15 (2.6)</td>
<td>4 (1.6)</td>
<td>11 (3.3)</td>
<td>0.29</td>
</tr>
<tr>
<td>Prosthesis insertion</td>
<td>15 (2.6)</td>
<td>3 (1.2)</td>
<td>12 (3.6)</td>
<td>0.11</td>
</tr>
<tr>
<td>Exploratory laparotomy</td>
<td>11 (1.9)</td>
<td>2 (0.8)</td>
<td>9 (2.7)</td>
<td>0.13</td>
</tr>
<tr>
<td>Amputation</td>
<td>6 (1.0)</td>
<td>2 (0.8)</td>
<td>4 (1.2)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Skull elevation</td>
<td>6 (1.0)</td>
<td>0 (0.0)</td>
<td>6 (1.8)</td>
<td>0.043</td>
</tr>
<tr>
<td>Tendon repair</td>
<td>6 (1.0)</td>
<td>5 (2.1)</td>
<td>1 (0.3)</td>
<td>0.09</td>
</tr>
<tr>
<td>Chest tube insertion</td>
<td>5 (0.9)</td>
<td>1 (0.4)</td>
<td>4 (1.2)</td>
<td>0.41</td>
</tr>
<tr>
<td>Bowel resection/anastomosis</td>
<td>2 (0.3)</td>
<td>0 (0.0)</td>
<td>2 (0.6)</td>
<td>0.51</td>
</tr>
<tr>
<td>Fasciotomy</td>
<td>2 (0.3)</td>
<td>0 (0.0)</td>
<td>2 (0.6)</td>
<td>0.51</td>
</tr>
<tr>
<td>External ventricular drainage</td>
<td>2 (0.3)</td>
<td>0 (0.0)</td>
<td>2 (0.6)</td>
<td>0.51</td>
</tr>
<tr>
<td>Neurolysis</td>
<td>2 (0.3)</td>
<td>2 (0.8)</td>
<td>0 (0.0)</td>
<td>0.18</td>
</tr>
<tr>
<td>Arthroscopy</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Burr hole</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Gastrostomy</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Osteotomy</td>
<td>1 (0.2)</td>
<td>1 (0.4)</td>
<td>0 (0.0)</td>
<td>0.42</td>
</tr>
<tr>
<td>Plate removal</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Skin graft</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td>1 (0.3)</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Total</td>
<td>581 (100.0)</td>
<td>244 (100.0)</td>
<td>337 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>
an underestimation of the surgical need required to address injuries to the trunk outside of Kigali. This has important implications in the development of trauma systems, both at the prehospital level and in terms of strengthening district hospitals. In fact, a systematic review of barriers to surgical care in LMICs identified geographical distance, absence of suitable transport and lack of funds as the major obstacles.\(^\text{19}\) Recent evidence from Rwanda shows that 77.0% of households lack the funds for travel to the nearest referral hospital and 70.4% are located more than 2 hours away from the nearest operative services.\(^\text{17}\) In the present study, the selection bias leading to a predominance of orthopedic procedures highlights the importance of strengthening the prehospital and transfer system not only to better manage orthopedic injuries, but also to expedite the care of patients with trunk injuries who are likely not surviving the prolonged transfer times to definitive care. A large proportion of prehospital transport and first aid in LMICs is currently provided by commercial drivers and layperson bystanders.\(^\text{20}\) Training programs for layperson first responders build on available resources and have been successful in some settings.\(^\text{21,22}\) Future efforts may therefore focus on maturing the prehospital system by expanding first responder training programs and transport mechanisms between hospital centres and underserved areas.

The role of district hospitals in the development and regionalization of trauma systems cannot be overemphasized. A comprehensive review of emergency surgical capacity in Rwanda revealed that, although 80% of operating theatres were located in district hospitals, 80% of the surgical workforce was located in the capital city.\(^\text{14}\) A recent review of district hospitals across 17 countries, including Rwanda, reported that less than one-third were capable of providing basic resuscitation and 39% were not capable of performing laparotomies.\(^\text{23}\) Deficiencies at the district level inevitably translate into delayed presentations at the referral hospitals. Strengthening district hospitals, in terms of the care for orthopedic and thoracoabdominal injuries for example, may improve outcomes while freeing resources at the referral level. This is corroborated by the finding that orthopedic procedures were more common in patients from within Kigali city, which is likely explained by geographical proximity rather than provincial variations in mechanisms of injury. Moreover, it is unclear why most general surgery procedures performed for trauma at the CHUK were for patients transferred from other provinces; this may be explained by deficiencies in human and material resources at the district level for basic general surgery procedures, such as laparotomies. As prehospital systems mature, valuable resources at referral centres will be indispensable in addressing the influx of salvageable patients. Ultimately, hospital and trauma centre designations, such as those put forward by the American College of Surgeons’ Committee on Trauma,\(^\text{24}\) may contribute to better organizing referral systems.

The provision of trauma care is therefore a complex interplay of agencies, including prehospital, hospital (both district and tertiary), and interfacility services. The organization of this system will inevitably require input at the ministry level. Several educational initiatives have already been implemented, including the Trauma Team Training (TTT) and Advanced Trauma Life Support (ATLS) courses.\(^\text{25}\) The Human Resources for Health initiative is an example of health care development on a grander scale stemming from the Ministry of Health.\(^\text{26}\) Although the evaluation of the impact of these interventions is difficult given the multiagency and multifactorial nature of trauma care, this study provides evidence that deficiencies still exist and that specific future directions include strengthening district facilities, maturing prehospital and interfacility systems and further supporting referral centres.

**Limitations**

This study does present limitations. It is a retrospective review over a short period of time in a single institution. As trauma volumes may vary over time and among institutions, the findings may not be generalizable. Moreover, our study did not include other referral institutions, such as the Centre Hospitalier Universitaire de Butare, the Kanombe Military Hospital and the King Faisal Hospital, and it remains unclear why patients originating from regions closer to these hospitals were treated at the CHUK. A better understanding of the referral patterns among these institutions would be essential in regionalizing the trauma system. However, as the CHUK represents the largest referral centre in the country, its surgical volume is central to the development of this system. In select cases, geographical data may have limited validity if the trauma occurred at a site distant from the patient’s place of residence. This study does not include any outcomes data, which would be an important next step in evaluating and monitoring the trauma system. Nevertheless, our study provides an essential first step in describing the utilization of trauma resources at the CHUK.

**Conclusion**

To our knowledge, this is the first study to highlight geographical variations in access to trauma care in a low-income country and the first to describe trauma procedures at a referral centre in Rwanda. Future efforts should focus on maturing prehospital systems, strengthening hospitals at the district level and further supporting referral institutions as they strive to address the plight of injury in resource-limited settings.
Acknowledgments: We are grateful to all members of the surgery department at the CHUK for their dedication to patient care and data collection. The Centre for Global Surgery of the McGill University Health Centre provided financial support for travel expenses related to the work presented in this manuscript.

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Competing interests: G. Ntakiyiruta and P. Kyamanywa have received travel support from McGill University Health Centre. A.S. Liberman has received speaker fees from Covidien. T. Razek is a board member (unpaid) for the Canadian Network for International Surgery. No other competing interests declared.


References
Prevalence of musculoskeletal disorders among orthopedic trauma surgeons: an OTA survey

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Background: Occupational injuries and hazards have gained increased attention in the surgical community in general and in the orthopedic literature specifically. The aim of this study was to assess prevalence and characteristics of musculoskeletal disorders among orthopedic trauma surgeons and the impact of these injuries on the surgeons’ practices.

Methods: We sent a modified version of the physical discomfort survey to surgeon members of the Orthopaedic Trauma Association (OTA) via email. Data were collected and descriptive statistics were analyzed.

Results: A total of 86 surgeons completed the survey during the period of data collection; 84.9% were men, more than half were 45 years or older and 40.6% were in practice for 10 years or more. More than 66% of respondents reported a musculoskeletal disorder that was related to work; the most common was low back pain (29.3%). The number of body regions involved and disorders diagnosed was associated with increasing age and number of years in practice (p = 0.033). Time off work owing to these disorders was associated with working in a private setting (p = 0.045) and working in more than 1 institute (p = 0.009).

Conclusion: To our knowledge, our study is the first to report a high percentage of orthopedic trauma surgeons sustaining occupational injuries some time in their careers. The high cost of management and rehabilitation of these injuries in addition to the related number of missed work days indicate the need for increased awareness and implementation of preventive measures.

Contexte : Les blessures et les risques professionnels font l’objet d’une attention croissante dans le milieu chirurgical, plus précisément dans les articles scientifiques en orthopédie. Cette étude visait à évaluer la prévalence et les particularités des troubles musculosquelettiques chez les praticiens en chirurgie orthopédique et traumatologique ainsi que les répercussions de ces blessures sur la pratique des chirurgiens touchés.

Méthodes : Nous avons envoyé par courriel une version modifiée du sondage sur l’inconfort physique à des chirurgiens membres de l’Orthopaedic Trauma Association, ce qui nous a permis de recueillir des données et d’analyser des statistiques descriptives.

Résultats : En tout, 86 chirurgiens ont répondu au questionnaire pendant la période de collecte de données. Parmi les répondants, 84,9 % étaient des hommes, plus de la moitié étaient âgés de 45 ans ou plus, et 40,6 % exerçaient depuis 10 ans ou plus. Plus de 66 % ont indiqué souffrir d’un trouble musculosquelettique lié à leur travail, le plus courant étant la lombalgie (29,3 %). Le nombre de parties du corps touchées et de troubles diagnostiqués était corrélé à l’âge et au nombre d’années d’exercice (p = 0,033). Les congés attribuables à ces troubles étaient associés au travail dans le privé (p = 0,045) et au travail dans plusieurs établissements (p = 0,009).

Conclusion : À notre connaissance, notre étude est la première à faire état du pourcentage élevé de praticiens en chirurgie orthopédique et traumatologique atteints de lésions professionnelles à un moment ou à un autre de leur carrière. Compte tenu du coût élevé de la prise en charge et de la réadaptation ainsi que du nombre de jours de congé de maladie associés à ces blessures, il semble nécessaire d’accroître la sensibilité à ce sujet et d’entreprendre des mesures préventives.
O ccupational injuries and hazards have gained increased attention in the surgical community in general and in the orthopedic literature specifically. Different aspects of occupational hazards have been investigated, including radiation, chemical, psychological and musculoskeletal injuries. The orthopedic surgical environment has been the main culprit behind most of these hazards. A 25-fold increase in thyroid cancer incidence in spine surgeons has been reported and is most likely attributed to the increased exposure to radiation. In addition, polymethylmethacrylate cement, which has been in use in orthopedics since the 1950s, has been shown to have toxic effects on the skin and on the respiratory and nervous systems. Also, smoke inhalation from electrocautery causes greater exposure than second-hand smoking. Psychologically, loss of sleep and work demands were found to have a detrimental effect on the emotional health of physicians.

Orthopedic surgeons work in an environment that puts a high demand on their bodies, especially the musculoskeletal system. Repetitive movements while using tools, prolonged standing and operating in sustained and nonergonomic positions all contribute to this increased load on the bones and muscles. Studies have shown increased incidence of musculoskeletal complaints in orthopedic surgeons compared with other specialists. Most of the complaints included the neck, back and upper extremities. Although guidelines for a more ergonomic environment in the operating room are available, lack of awareness and difficulty applying these guidelines contribute to their ineffectiveness.

One of the orthopedic specialties with increased workload on the musculoskeletal system is orthopedic trauma. In a study by Davis and colleagues, who examined the prevalence and impact of musculoskeletal injuries on orthopedic surgeons in general, it was highlighted that orthopedic trauma surgeons had a higher rate of injuries than other specialists, but owing to the small number of trauma surgeons among their respondents this subgroup could not be analyzed.

In the present study, we assessed the musculoskeletal injury data from a survey of orthopedic trauma surgeons in North America and examined the impact of these injuries on the surgeons’ practices.

**METHODS**

**Survey**

After review board approval, a modified version of the physical discomfort web-based anonymous survey was posted on the Orthopaedic Trauma Association (OTA) website, and we sent a link to the survey to the OTA’s 595 active surgeon members via email. The first email was sent in July 2014, and a reminder email was sent in October 2014. The survey was closed in December 2014 and data collection commenced.

The web-based survey was divided into the following sections: demographics (age, sex and hand-dominance), type of institution, average number of cases per year and number of years in practice. Musculoskeletal disorders were classified according to body region (neck, shoulder, elbow/forearm, wrist/hand, hip, knee, foot/ankle and low back). In each section participants were asked about diagnosis, treatment required (if any) and time off work required. This survey was piloted among 20 volunteers to assess length, ease of navigation and comprehensibility.

**Statistical analysis**

Data were collected and descriptive statistics were analyzed. For data analysis, we performed a-way analysis of variance (ANOVA) and Fisher exact tests, as appropriate, to compare the variables. We considered results to be significant at $p < 0.05$.

**RESULTS**

**Participant demographics and descriptive data**

A total of 86 surgeons completed the survey during the period of data collection, resulting in a response rate of 14.5%. Of the respondents, 84.9% were men and more than half were 45 years or older (Table 1 and Fig. 1). The majority of respondents had been in practice for 10 years or longer and worked in academic institutions (Fig. 2 and Fig. 3). Of note, 5.9% of respondents worked in more than one of the orthopedic specialties with increased workload on the musculoskeletal system.

**Table 1. Sex and hand dominance of surveyed trauma surgeons ($n = 86$)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>73 (84.9)</td>
</tr>
<tr>
<td>Female</td>
<td>13 (15.1)</td>
</tr>
<tr>
<td>Hand dominance</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>79 (91.9)</td>
</tr>
<tr>
<td>Left</td>
<td>7 (8.1)</td>
</tr>
</tbody>
</table>

**Fig. 1. Age distribution among survey participants.**
1 institution. Overall, 66.7% of responding surgeons reported a work-related musculoskeletal disorder, of which 26.7% required time off work because of their injuries (Fig. 4, Table 2 and Table 3).

**Area injured**

The majority of musculoskeletal complaints and disorders were low back pain (26.7%), wrist or forearm tendinitis (17.4%), elbow lateral epicondylitis (15.1%), plantar fasciitis (14.0%), carpal tunnel syndrome (12.8%), shoulder pain or tendinitis (12.8%) and knee osteoarthritis (9.3%) (Fig. 1). Varicose veins (5.9%), inguinal hernia (4%), hearing problems (4%) and cataracts (2.6%) were the most commonly reported non-musculoskeletal disorders.

**Sex, age and hand dominance**

The sex of the surgeon was not associated with the number of disorders or regions involved; however, increasing age of the surgeon was associated with an increased number of body regions involved ($p = 0.033$). Neither the sex nor the age of the surgeons surveyed showed a significant association with the presence of a disorder or with requiring time off work because of the disorder. Interestingly, right-handed surgeons were...
more likely to report the presence of at least 1 musculoskeletal disorder ($p = 0.034$; Table 2).

**Type of practice**

When a musculoskeletal disorder was diagnosed, surgeons working in a private setting ($p = 0.009$) and surgeons working in more than 1 institute ($p = 0.009$) were significantly more likely to require time off work. Conversely, the surgeons’ type of practices had no influence on the presence of a disorder, the number of disorders, or the regions involved (Table 2).

**Annual caseload**

The surgeons' caseload per year was not associated with the presence of a disorder, the number of disorders, the regions involved, or the need for time off work (Table 3).

**Years in practice**

When data were grouped according to number of years in practice, the results showed a significant difference between the groups. Being in practice more than 10 years was

| Table 2. Number of surveyed trauma surgeons with disorders and their requirement of time off work according to sex, age, hand dominance, type of practice and number of institutions |
|---|---|---|
| Characteristic | Total no. of respondents | Respondents with injuries | Respondents with injuries who needed time off work |
| Age | | | |
| ≤ 45 | 44 | 24 (54.5) | 4 (16.7) |
| 46–55 | 26 | 20 (76.9) | 5 (25.0) |
| 56–65 | 12 | 9 (75.0) | 4 (44.4) |
| > 65 | 4 | 3 (75.0) | 2 (66.7) |
| Sex | | | |
| Male | 73 | 45 (61.6) | 12 (26.7) |
| Female | 13 | 11 (84.6) | 3 (23.1) |
| Hand dominance | | | |
| Right | 79 | 54 (68.4) | 15 (27.8) |
| Left | 7 | 2 (28.6) | 0 |
| Type of practice | | | |
| Academic | 55 | 33 (60.0) | 8 (24.2) |
| Community | 21 | 16 (76.1) | 2 (12.5) |
| Private | 4 | 3 (75.0) | 1 (33.3) |
| Other | 6 | 4 (66.7) | 4 (100.0) |
| No. of institutions | | | |
| 1 | 81 | 52 (64.2) | 11 (21.2) |
| > 1 | 5 | 4 (80.0) | 4 (100.0) |

| Table 3. Number of surveyed trauma surgeons with disorders and their requirement of time off work according to annual case load and number of years in practice |
|---|---|---|
| Characteristic | Total no. of respondents | Respondents with injuries | Respondents with injuries who needed time off work |
| Annual caseload | | | |
| ≤ 100 | 7 | 5 (71.4) | 2 (40.0) |
| 101–200 | 10 | 7 (70.0) | 2 (28.6) |
| 201–300 | 14 | 7 (50.0) | 4 (57.1) |
| 301–400 | 25 | 18 (72.0) | 2 (11.1) |
| 401–500 | 15 | 9 (60.0) | 1 (11.1) |
| > 500 | 15 | 10 (66.7) | 4 (40.0) |
| Years in practice | | | |
| ≤ 10 | 35 | 18 (51.4) | 3 (16.7) |
| 11–20 | 28 | 23 (82.1) | 5 (21.7) |
| 21–30 | 18 | 12 (66.7) | 5 (41.7) |
| > 30 | 5 | 3 (60.0) | 2 (66.7) |
associated with an increased number of regions involved ($p = 0.045$). Years in practice did not influence the surgeons’ need for time off work, nor did it have an effect on the presence of a disorder (Table 3).

**Number of disorders and regions involved**

Our results showed that both an increased number of regions involved ($p < 0.001$) and an increased number of musculoskeletal disorders ($p < 0.001$) were independently associated with a greater likelihood of surgeons needing time off work.

**DISCUSSION**

A number of studies in the surgical literature have identified an increased prevalence of occupational injuries in surgeons in general and specifically in orthopedic surgeons. Davis and colleagues found a 44% prevalence of injuries in surveyed orthopedic surgeons, with orthopedic trauma surgeons reporting more injuries than the other subspecialists. The same was true in our study, with a 65% prevalence of injuries among the respondents. The most commonly injured areas in all subspecialists reported by Davis and colleagues were the hand, low back, neck and shoulder, whereas in a study by Auerbach and colleagues involving spine surgeons low back and neck pain were the most commonly reported injuries. This group also reported a high prevalence of shoulder, elbow and wrist injuries. In our study of orthopedic trauma surgeons, the most commonly reported injured region was the low back, followed by the wrist, elbow and foot. This resemblance among studies in reported injuries can be attributed to the surgeons’ tendency toward prolonged periods of standing and sustaining constant positions (bending the head and back), especially during lengthy surgeries, thus exposing the neck and low back to increased mechanical stress. In addition, the use of repetitive movements when operating instruments and tools may have a role in increased prevalence of upper limb tendinitis, especially of the elbow and the wrist. Forst and colleagues reported an increased prevalence (up to 3 times) of carpal tunnel syndrome in surgeons who frequently use a Kerrison rongeur.

In the study by Davis and colleagues there was a higher prevalence of musculoskeletal disorders in surgeons who had been in practice for 20–30 years, whereas Auerbach and colleagues found no such association. Our results revealed no association between number of years in practice and reporting of an injury; however, we found that the number of regions involved increased when a surgeon was in practice for more than 10 years. Surprisingly, the surgeons’ age and caseloads had no association with the prevalence of a musculoskeletal injury in our study or in previously conducted surveys. Interestingly, in our study we found that right-handed surgeons were more likely to report an injury and that surgeons in a private setting were more likely to require time off work because of their disorders.

Our results indicate that attention should be directed toward making the operating room more surgeon-friendly in terms of more ergonomically safe postures and movements. Improvements can include using body support, taking stretch breaks, using the microscope rather than surgical loops (more neutral neck position) and using power to insert long screws, to name a few. More research is required to identify methods of improving the surgical setting and their effectiveness.

**Limitations**

Limitations of our study include the use of a self-reported measure, the validity and reliability of which have not been established. Recall bias is another limitation, as the disorders were surgeon-reported injuries.

**CONCLUSION**

To our knowledge, our study is the first of its kind reporting that a high percentage of orthopedic trauma surgeons sustain occupational injuries at some point in their careers. The cost of management and rehabilitation of these injuries in addition to the number of missed work days because of these injuries indicate that they have a significant economic burden on the health care system. Increased awareness may help with the early detection of these injuries and with the implementation of preventive measures.

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**Competing interests:** E.J. Harvey is the Chief Medical Officer of Greybox Healthcare (Montreal) and Chairman of the Board of NVT-Sens Inc. (Montreal). No other competing interests declared.

**Contributors:** All authors designed the study. S. AlQahtani and M. Alzahrani acquired the data, which M. Alzahrani analyzed. S. AlQahtani and M. Alzahrani wrote the article, which all authors reviewed and approved for publication.

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4. Jofe MH. Surgically generated smoke exposure to surgeons during...
Mid-term survivorship and clinical outcomes of cobalt-chrome and oxidized zirconium on highly crosslinked polyethylene

Background: The choice of bearing articulation for total hip arthroplasty in younger patients is amenable to debate. We compared mid-term patient-reported outcomes and survivorship across 2 different bearing articulations in a young patient cohort.

Methods: We reviewed patients with cobalt-chrome or oxidized zirconium on highly crosslinked polyethylene who were followed prospectively between 2004 and 2012. Kaplan–Meier analysis was used to determine predicted cumulative survivorship at 5 years with all-cause and aseptic revisions as the outcome. We compared patient-reported outcomes, including the Harris hip score (HHS), Western Ontario and McMaster University Osteoarthritis Index (WOMAC) and Short-form 12 (SF-12) scores.

Results: A total of 622 patients were followed during the study period. Mean follow-up was 8.2 (range 2.0–10.6) years for cobalt-chrome and 7.8 (range 2.1–10.7) years for oxidized zirconium. Mean age was 54.9 ± 10.6 years for cobalt-chrome and 54.8 ± 10.7 years for oxidized zirconium. Implant survivorship was 96.0% (95% confidence interval [CI] 94.9%–97.1%) for cobalt-chrome and 98.7% (95% CI 98.0%–99.4%) for oxidized zirconium on highly crosslinked polyethylene for all-cause revisions, and 97.2% (95% CI 96.2%–98.2%) for cobalt-chrome and 99.0% (95% CI 98.4%–99.6%) for oxidized zirconium for aseptic revisions. An age-, sex- and diagnosis-matched comparison of the HHS, WOMAC and SF-12 scores demonstrated no significant changes in clinical outcomes across the groups.

Conclusion: Both bearing surface couples demonstrated excellent mid-term survivorship and outcomes in young patient cohorts. Future analyses on wear and costs are warranted to elicit differences between the groups at long-term follow-up.

Contexte : Le choix de la surface d’appui à utiliser dans une arthroplastie totale de la hanche chez de jeunes patients ne fait pas l’unanimité. Nous avons comparé les résultats déclarés par les patients et la survie à moyen terme associés à 2 surfaces d’appui différentes dans une cohorte de jeunes patients.

Méthodes : Nous avons étudié les cas de patients ayant reçu une prothèse de chrome-cobalt ou de zirconium oxydé couplée au polyéthylène hautement réticulé suivis de façon prospective entre 2004 et 2012. La méthode de Kaplan–Meier a été employée pour déterminer la survie cumulative estimée après 5 ans dans les cas où le résultat est soit la reprise toutes causes confondues, soit la reprise aseptique. Nous avons comparé les résultats déclarés par les patients, notamment au moyen du score de Harris (HHS), de l’indice WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) et des scores issus de la version courte du questionnaire d’évaluation de l’état de santé général SF-12.

Résultats : Au total, 622 patients ont été suivis durant la période de l’étude. En moyenne, le suivi a duré 8,2 ans (plage de 2,0 à 10,6 ans) pour le chrome-cobalt et 7,8 ans (plage de 2,1 à 10,7 ans) pour le zirconium oxydé. L’âge moyen des patients était de 54,9 ± 10,6 ans pour le chrome-cobalt et de 54,8 ± 10,7 ans pour le zirconium oxydé. Le taux de survie de la prothèse était de 96,0% (IC à 95% 94,9–97,1%) pour le chrome-cobalt et de 98,7% (IC à 95% 98,0–99,4%) pour le zirconium oxydé couplé au polyéthylène hautement réticulé dans les cas de reprises toutes causes confondues, et de 97,2% (IC à 95% 96,2–98,2%) pour le chrome-cobalt et de 99,0% (IC à 95% 98,4–99,6%) pour le zirconium oxydé couplé au polyéthylène dans le cas de reprises aseptiques. Une comparaison appariée fondée sur l’âge, le sexe et le diagnostic réalisé entre le HHS, l’indice WOMAC et les scores au questionnaire SF-12 n’a démontré aucun changement significatif entre les groupes quant aux résultats cliniques.

Conclusion : Les 2 types de surface d’appui ont produit un taux de survie à moyen terme très élevé et d’excellents résultats dans des cohortes de jeunes patients. Il y a lieu de réaliser des analyses sur l’usure et les coûts afin de mettre en évidence les différences entre les groupes suivis à long terme.
The use of total hip arthroplasty in younger patient populations is becoming more common in clinical practice. Basic science and clinical research has provided an understanding of implant survivorship, patient satisfaction and complication rates in traditional bearing surfaces. Patient factors, implant-specific wear properties and survivorship influence implant selection. Concerns remain regarding polyethylene wear in younger, higher-demand patients, resulting in osteolysis secondary to localized phagocytosis. The introduction of highly crosslinked polyethylene has resulted in lower wear rates with at least intermediate follow-up than conventional polyethylene. The improved wear rates are also maintained across various manufacturers of highly crosslinked polyethylene. However, there is a variety of femoral heads to select and pair with this improved polyethylene surface.

Cobalt–chrome on polyethylene is a long-standing bearing couple that has the advantage of modularity and avoids the risk of fracture seen with ceramic articulations. However, both simulator and clinical studies demonstrate the potential for oxidative wear and damage, resulting in a roughened surface and accelerated polyethylene wear. Oxidized zirconium is a metallic alloy centre with an oxidized zirconium surface 5–10 μm thick that offers reduced wear rates on a polyethylene bearing surface. It was introduced to improve scratch resistance over traditional cobalt–chromium heads and to lower the risk of femoral head fracture reported with ceramic implants. Tri-biological testing has shown that oxidized zirconium has better wettability and less surface adhesion on polyethylene than cobalt–chrome.

Although the advantages and disadvantages of these bearing surface couples are well described, few studies have directly compared the bearing surface couples with respect to implant survivorship and clinical outcomes. Therefore, the purpose of this study was to directly compare age-, sex- and body mass index (BMI)–matched cohorts of patients who received cobalt–chrome or oxidized zirconium on highly crosslinked polyethylene. Our hypothesis was that implant survivorship and clinical outcomes would not differ significantly between the groups at mid-term follow-up.

**Methods**

We completed a retrospective review of our prospective institutional arthroplasty database for the period 2004–2012 to identify all patients undergoing primary total hip arthroplasty procedures using highly crosslinked polyethylene. Seven different surgeons within our institution performed the procedures. To be included in the analysis, patients had to be English-speaking and older than 19 years, and they had to have undergone primary total hip procedures performed using a cobalt–chrome or oxidized zirconium femoral head and a highly crosslinked polyethylene liner. Procedures were then stratified based on the femoral head bearing surface. We collected data, including patient age, sex, BMI and primary diagnosis at the time of the index procedure. The time to latest follow-up was also recorded.

We identified the patients in whom a cobalt–chrome femoral head was used, and these patients were matched with those who received an oxidized zirconium (Oxinium TM, Smith and Nephew) femoral head and compared based on sex, age and BMI. We included patients with a minimum 2-year follow-up and with complete clinical and radiographic data.

Implant survivorship data were collected, including the time to revision in years. We also documented the cause of revision. Clinical outcome measures, including the Harris Hip Score (HHS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Short-Form 12 (SF-12) questionnaire were reviewed. The pre- and postoperative scores for each questionnaire were recorded and used to calculate change scores at latest follow-up. We also compared the absolute value of each questionnaire at latest follow-up. Patients had routine follow-up at 6 weeks, 3 months and 1 year, and then annually or biannually depending on clinical progress.

Plain radiographs were obtained at routine follow-up visits. Views included an anterior–posterior (AP) pelvis as well as an AP and lateral view of the involved hip. Images were reviewed via the web-based image viewer Centricity Enterprise Web (GE Medical Systems) under 2× magnification. One of the operating surgeons (S.M.P.) interpreted the radiographs along with a fellowship-trained arthroplasty surgeon who did not operate on any of the included patients. The images were analyzed for areas of osteolysis within the femoral Gruen zones and acetabular DeLee–Charnley zones. Any cases revised during the study period were excluded from radiographic analysis. Institutional review board approval was obtained for completion of this study.

**Statistical analysis**

We assessed demographic variables using descriptive statistics. Kaplan–Meier analysis was used to generate survivorship curves with 95% confidence intervals (CIs) and to determine predicted cumulative survivorship at 5 years with revision for any cause as the end point. We also calculated the 5-year survivorship for aseptic revisions. All of the outcome measures (WOMAC, SF-12, HHS) and continuous variables were evaluated preoperatively and from the most recent postoperative visit using a 2-sided t test. Nominal data were compared using a Pearson χ² analysis. A 2-sided p < 0.05 indicated statistical significance. We used SPSS software version 20 (SPSS Inc) for all analyses.

**Results**

A total of 622 patients were included in our analysis; 311 received a cobalt–chrome femoral head and 311 received an
oxidized zirconium femoral head. Patient demographic and clinical characteristics for each group are outlined in Table 1. The mean time to latest follow-up was 8.1 (range 2.0–10.6) years for the cobalt-chrome group and 7.8 (range 2.1–10.7) years for the oxidized zirconium group. The most common primary diagnosis at the time of the index procedure in both groups was osteoarthritis (Table 1). The types and sizes of femoral heads as well as highly cross-linked polyethylene liners are listed in Table 2.

Implant survivorship was 96.0% (95% CI 94.9%–97.1%) for cobalt-chrome and 98.7% (95% CI 98.0%–99.4%) for oxidized zirconium on highly crosslinked polyethylene for all-cause revisions (Fig. 1). Implant survivorship was 97.2% (95% CI 96.2%–98.2%) for cobalt-chrome and 99.0% (95% CI 98.4%–99.6%) for oxidized zirconium for aseptic revisions (Fig. 2).

There were no statistically significant differences between the groups in the outcome measure change scores for age-, sex- and diagnosis-matched comparisons. There were also no statistically significant differences in the absolute SF-12, WOMAC or HHS scores at latest follow-up (Table 3).

There were a total of 19 complications requiring revision during the study period (Table 4). All cases revised for periprosthetic infection were managed with a 2-stage revision, as they were classified as chronic periprosthetic infections.23 The patient in the cobalt-chrome group whose case was revised for aseptic loosening had a loose femoral stem, the patient in the oxidized zirconium cohort whose case was revised for that reason had a loose acetabular component. One of the patients in the cobalt-chrome cohort who underwent revision for a dislocation had an acetabular revision with head and liner exchange. The remaining patients with dislocations were managed with closed reduction. One of the patients in the cobalt-chrome group with a periprosthetic fracture was revised to a long, extensively coated stem. The remaining patients with periprosthetic fractures had Vancouver AG fractures managed nonoperatively with protected weight bearing.24 No patients underwent revision for polyethylene wear.

**Discussion**

This study reports survivorship and clinical outcomes across 2 different femoral head options on a highly crosslinked polyethylene liner from a large, prospectively collected cohort. Survivorship was 96.0% for cobalt-chrome and 98.7% for oxidized zirconium for all-cause revisions at 5 years. Both bearing articulations demonstrated improvement in clinical outcome measures and had no statistically significant differences in change scores for age-, sex- and diagnosis-matched comparisons. The mean change scores all surpassed the minimally important difference reported in the literature for all outcome measures except the mental component summary score on the SF-12.25,26 The difference in number of instability revision cases may be attributable to reduced use of 32 mm and 36 mm femoral heads in the cobalt-chrome group.

Total hip arthroplasty is a procedure being performed in progressively younger patients, with increasing physical demands being placed on the implants. Highly crosslinked polyethylene was introduced in an effort to decrease wear rates and reduce the risk of osteolysis and aseptic loosening.

### Table 1. Patient demographic and clinical characteristics at the time of surgery

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Cobalt-chrome</th>
<th>Oxidized zirconium</th>
<th>p value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>54.9 ± 10.6</td>
<td>54.8 ± 10.7</td>
<td>0.20</td>
</tr>
<tr>
<td>Female sex, %</td>
<td>49.8</td>
<td>49.8</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>BMI</td>
<td>31.0 ± 7.8</td>
<td>30.9 ± 7.6</td>
<td>0.86</td>
</tr>
<tr>
<td>Primary diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>244 (78.5)</td>
<td>234 (75.2)</td>
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<tr>
<td>Osteonecrosis</td>
<td>20 (6.4)</td>
<td>28 (9.0)</td>
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<tr>
<td>Inflammatory arthritis</td>
<td>10 (3.2)</td>
<td>13 (4.2)</td>
<td></td>
</tr>
<tr>
<td>Posttraumatic arthritis</td>
<td>10 (3.2)</td>
<td>11 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Acetabular/femoral dysplasia</td>
<td>24 (7.7)</td>
<td>21 (6.8)</td>
<td></td>
</tr>
<tr>
<td>Slipped capital femoral epiphysis</td>
<td>3 (1.0)</td>
<td>3 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Postinfectious</td>
<td>—</td>
<td>1 (0.3)</td>
<td></td>
</tr>
</tbody>
</table>

BMI = body mass index; SD = standard deviation.
*Unless indicated otherwise.
†Reported p values result from a t-test and Pearson χ² test.

### Table 2. Distribution of femoral head implants and highly crosslinked polyethylene liners

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group, no. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Cobalt-chrome</td>
</tr>
<tr>
<td>S-ROM TM cobalt chrome (DePuy)</td>
<td>21</td>
</tr>
<tr>
<td>Articuleze TM cobalt chrome</td>
<td>111</td>
</tr>
<tr>
<td>LFIT anatomic TM CoCr</td>
<td>3</td>
</tr>
<tr>
<td>Cobalt chrome femoral head</td>
<td>176</td>
</tr>
<tr>
<td>Oxidized zirconium (Oxinium TM)</td>
<td>—</td>
</tr>
<tr>
<td>Crosslinked polyethylene liner</td>
<td></td>
</tr>
<tr>
<td>Reflection XLPE TM (Smith and Nephew)</td>
<td>148</td>
</tr>
<tr>
<td>R3 XLPE TM (Smith and Nephew)</td>
<td>26</td>
</tr>
<tr>
<td>X3 XLPE TM (Stryker)</td>
<td>9</td>
</tr>
<tr>
<td>Marathon XLPE TM (DePuy)</td>
<td>81</td>
</tr>
<tr>
<td>AltrX XLPE TM (DePuy)</td>
<td>41</td>
</tr>
<tr>
<td>Longevity XLPE TM (Zimmer)</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 3. Clinical outcome change score and score at latest follow-up

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Group; mean change score ± SD</th>
<th>p value*</th>
<th>Group; mean latest follow-up score ± SD</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cobalt-chrome</td>
<td>Oxidized zirconium</td>
<td></td>
<td>Cobalt-chrome</td>
</tr>
<tr>
<td>SF-12 MCS</td>
<td>1.7 ± 12.7</td>
<td>3.9 ± 11.3</td>
<td>0.06</td>
<td>52.8 ± 10.3</td>
</tr>
<tr>
<td>SF-12 PCS</td>
<td>13.3 ± 11.6</td>
<td>14.1 ± 12.9</td>
<td>0.49</td>
<td>41.8 ± 11.2</td>
</tr>
<tr>
<td>WOMAC pain</td>
<td>42.4 ± 25.8</td>
<td>40.3 ± 25.6</td>
<td>0.43</td>
<td>80.9 ± 23.0</td>
</tr>
<tr>
<td>WOMAC stiffness</td>
<td>39.1 ± 28.7</td>
<td>40.0 ± 24.3</td>
<td>0.74</td>
<td>73.8 ± 23.9</td>
</tr>
<tr>
<td>WOMAC function</td>
<td>40.4 ± 25.4</td>
<td>39.9 ± 24.7</td>
<td>0.84</td>
<td>78.0 ± 23.4</td>
</tr>
<tr>
<td>WOMAC total</td>
<td>40.5 ± 24.4</td>
<td>39.2 ± 25.0</td>
<td>0.62</td>
<td>78.2 ± 22.1</td>
</tr>
<tr>
<td>HHS pain</td>
<td>24.1 ± 8.4</td>
<td>24.0 ± 9.0</td>
<td>0.92</td>
<td>41.1 ± 5.7</td>
</tr>
<tr>
<td>HHS function</td>
<td>20.4 ± 10.3</td>
<td>20.2 ± 9.9</td>
<td>0.91</td>
<td>42.4 ± 8.6</td>
</tr>
<tr>
<td>HHS total</td>
<td>51.9 ± 20.2</td>
<td>52.6 ± 21.8</td>
<td>0.76</td>
<td>90.7 ± 11.8</td>
</tr>
</tbody>
</table>

HHS = Harris Hip Score; MCS = mental component score; PCS = physical component score; SD = standard deviation; SF-12 = Short-Form 12; WOMAC = Western Ontario and McMaster Universities Arthritis Index.

*Reported following a 2-sided t-test.
secondary to polyethylene wear.\textsuperscript{1,6,9,27,28} Previously, cobalt-chrome has been reported to have increased adhesive wear compared with oxidized zirconium on ultra-high molecular weight polyethylene.\textsuperscript{17} More recently, cobalt-chrome has demonstrated reduced wear rates using this bearing surface, and highly crosslinked polyethylene has been recommended for younger patients undergoing total hip arthroplasty.\textsuperscript{29-32} Our study demonstrates that excellent clinical outcomes are achievable with cobalt-chrome and oxidized zirconium femoral head articularations on a highly crosslinked polyethylene liner.

A study by Lewis and colleagues\textsuperscript{7} examined clinical outcomes with oxidized zirconium as a bearing articulation in 100 young patients undergoing total hip arthroplasty randomized to either cobalt-chrome or oxidized zirconium femoral heads. Both groups demonstrated excellent results and comparable improvements across the HHS, WOMAC and SF-12 outcome measures. Limitations to that study were that both groups received either conventional or highly crosslinked polyethylene, and the results were reported after only 2 years.\textsuperscript{2} That group’s findings are now supported by our findings at mid-term follow-up, as we found no significant differences between the groups across any of the outcome measures.

Periprosthetic dislocation was the most common complication and warrants further discussion. Implant retrieval studies have identified that although oxidized zirconium may be more scratch-resistant than cobalt-chrome,\textsuperscript{1} it is still vulnerable to in situ damage that may compromise long-term survivorship. One case report\textsuperscript{11} of an early anterior hip dislocation demonstrated surface damage to an oxidized zirconium head, exposing the zirconium-based undersurface. Electron microscopy demonstrated delamination of the oxidized layer. Another case report\textsuperscript{14} discussed an immediate revision for leg-length discrepancy using an oxidized zirconium head. Stereomicroscopy revealed evidence of metal transfer, likely from the acetabular component, deep scratches and cracks in the oxidized surface. Wear analysis of oxidized zirconium heads showed that the wear rates of those damaged clinically through attempted closed reductions or damaged through simulation were up to 50 times faster than wear rates in undamaged heads.\textsuperscript{15} These studies emphasize that great care needs to be taken when any closed reduction is attempted with an oxidized zirconium femoral head — a principle that should be applied to all bearing articulations.

**Limitations**

Our study is not without limitations. Owing to the improved wear properties of oxidized zirconium on highly crosslinked polyethylene reported in the literature, there is a selection bias to a younger or more active patient population. This cannot be accounted for using a retrospective study design. A randomized controlled trial would account for this limitation. As a result of this selection bias, the use of clinical questionnaires in this population may succumb to a ceiling effect, thus a detectable difference in clinical performance may not be possible.\textsuperscript{16} Furthermore, with the exception of the oxidized zirconium heads (which were from only 1 manufacturer), there was some heterogeneity with respect to the design and manufacturer of the femoral heads, highly crosslinked polyethylene liners and femoral stem and acetabular cup design. This heterogeneity is largely owing to surgeon preference. Our radiographic analysis was limited to a determination of osteolysis in either cohort; however, it would be unlikely that there would be any detectable differences in polyethylene wear between the groups given the mid-term follow-up period examined in this study.

**Conclusion**

Our results demonstrate excellent mid-term clinical outcomes and survivorship for both bearing surfaces. The cobalt-chrome and oxidized zirconium on highly crosslinked polyethylene articulations are both excellent considerations in young patients undergoing total hip arthroplasty. Further long-term clinical and radiographic follow-up of these cohorts is required to determine whether there is a detectable difference in polyethylene wear that may result in discernible differences in survivorship. Advanced techniques in wear analysis should also be used to delineate these differences in a matched bearing surface cohort. Finally, a cost-effectiveness analysis would be warranted given similar short- and mid-term clinical outcomes between the bearing articulations and differing costs among femoral head designs.

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**Competing interests:** R. McCalden is paid consultant for Smith and Nephew, J. Howard is paid consultant for Smith and Nephew, Stryker, and DePuy. D. Naudie is a paid consultant for Smith and Nephew, Stryker, and Zimmer. E. Vasarhelyi is paid consultant for DePuy. No other competing interests declared.

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

---

**Table 4. Etiology of revision cases**

<table>
<thead>
<tr>
<th>Reason for revision</th>
<th>Cobalt-chrome</th>
<th>Oxidized zirconium</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periprosthetic infection</td>
<td>5</td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>1</td>
<td>1</td>
<td>&gt; 0.99</td>
</tr>
<tr>
<td>Instability/dislocation</td>
<td>6</td>
<td>1</td>
<td>0.06</td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>2</td>
<td>1</td>
<td>0.96</td>
</tr>
<tr>
<td>Polyethylene wear</td>
<td>0</td>
<td>0</td>
<td>&gt; 0.99</td>
</tr>
</tbody>
</table>

*Reported following a Pearson χ² test.*
References


Prevention of perineal hernia after laparoscopic and robotic abdominoperineal resection: review with illustrative case series of internal hernia through pelvic mesh

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This review is intended to raise awareness of placing a pelvic mesh to prevent perineal hernias in cases of minimally invasive (MIS) abdominoperineal resections (APR) and, in doing so, causing internal hernias through the mesh. In this article, we review the published literature and present an illustrative series of 4 consecutive cases of early internal hernia through a pelvic mesh defect. These meshes were placed to prevent perineal hernias after laparoscopic or robotic APRs. The discussion centres on 3 key questions: Should one be placing a pelvic mesh following an APR? What are some of the technical details pertaining to the initial mesh placement? What are the management options related to internal hernias through such a mesh?

L’objectif du présent examen est de sensibiliser les praticiens au risque associé à la pose d’un treillis pelvien visant à prévenir les hernies périnéales après une résection abdominopérinéale à effraction minimale, pratique qui peut entraîner une hernie interne. Nous nous penchons ici sur les articles publiés à ce sujet et présentons une série éloquente de 4 cas consécutifs de hernies internes précoces attribuables à un défaut du treillis. Les dispositifs avaient été mis en place pour prévenir une hernie périnéale après des résections laparoscopiques ou robotiques. La discussion porte sur 3 questions centrales : Devrait-on poser un treillis pelvien à la suite d’une résection abdominopérinéale? Quels sont les éléments techniques à surveiller lors de la pose initiale? Quelles sont les options de prise en charge des hernies internes causées par les treillis?

Postoperative perineal hernia is a rare complication after abdominopерineal resection (APR), proctectomy, or pelvic exenteration. A perineal hernia can be defined as a protrusion of intra-abdominal contents through a defect in the pelvic floor. It may contain small bowel, large bowel, bladder, uterus and omentum. The first case of postoperative perineal hernia after proctectomy for rectal cancer was reported in 1939 by Yeoman. Since then many other case reports and case series have been published. The duration between surgery and hernia formation usually reported is 4–14 months. The most common presenting symptoms are perineal pain, dragging sensation and discomfort on standing or sitting. However, to our knowledge, there are no reported early postoperative internal hernias through a mesh defect after laparoscopic or robotic APR related to attempts at perineal hernia prevention. We present a series of 4 isolated and clustered cases of immediate postoperative obstructing and strangulated internal hernias after a laparoscopic or robotic APR. All hernias developed though a mesh that was laid down high on the pelvic brim to prevent perineal herniation. The hernias were managed laparoscopically as detailed in the section that follows. This case series was pooled from 4 different surgeons with varying surgical training who adopted the practice of placing a prophylactic mesh at different time points.
Case series presentation

All patients presented in this case series were treated with preoperative chemoradiation therapy for distal rectal cancer. During standard robotic or laparoscopic cylindrical APR surgery, attention was paid to avoid any spillage of intestinal content in the abdominal cavity. After having ascertained that the operative field was not contaminated, a nonabsorbable composite mesh was sutured high at the pelvic brim to the periostium of the sacrum, around the pelvic side walls, and to the bladder wall (males) or vaginal wall (females) using intracorporeal interrupted number 2–0 prolene horizontal mattress sutures separated from each other by about 1.5 cm. A perineal closed suction drain was then placed above the sutured gluteal folds. All patients received 7 days of postoperative antibiotics.

Case 1

A 60-year-old man underwent daVinci robot-assisted APR for rectal cancer. The distal margin of the tumour was approximately 1 cm from the anal verge (AV). The carcinoma was classified as differentiated adenocarcinoma and staged as ypT2N0M0 with Mandard grade III. Eight days after the operation, the patient experienced symptoms of intestinal obstruction. The computed tomography (CT) scan showed intestinal obstruction due to internal hernia (Fig. 1). On laparoscopy, there was an anterior defect involving previously sutured mesh through which protruded a strictured and fibrotic small bowel loop (Fig. 2). The incarcerated pelvic hernia was approached by carefully separating the herniated small bowel from the mesh and by reducing it from the pelvic cavity. The original mesh was then removed. Finally, the defect was repaired using a new sheet of composite mesh; however, anchoring sutures were placed more closely, about 0.5 cm apart.

Case 2

A 58-year-old man underwent laparoscopy-assisted APR for rectal cancer (approximately 3 cm from the AV). The carcinoma was classified as differentiated adenocarcinoma and staged as ypT3N0M0 with Mandard grade IV. Seven days after the operation, the patient experienced symptoms of intestinal obstruction. A CT scan featured an intestinal obstruction due to internal hernia. As the patient became hypotensive and fever, abdominal pain and leukocytosis developed, emergency laparoscopic exploration was performed. On laparoscopy, there was a complete disruption of the previously sutured mesh where fibrotic small bowel loops protruded through multiple anterior and posterior defects. The complex hernia was managed by carefully mobilizing the herniated small bowel from the mesh and reducing it from the pelvic cavity. Since one of the reduced small bowel loops showed signs of ischemia, segmental resection with primary anastomosis was performed. The original mesh was removed. No attempt was made to obliterate the pelvic cavity as the pelvic floor was judged to be well solidified and rather shallow.

Case 3

A 63-year-old woman underwent daVinci robot-assisted APR for rectal cancer (approximately 3 cm from the AV). The carcinoma was classified as differentiated adenocarcinoma and staged as ypT2N0M0 with Mandard grade III. Ten days after the operation, the patient experienced symptoms of intestinal obstruction. A CT scan revealed a pelvic internal hernia containing a small bowel transition point. On laparoscopy, there was an anterior defect of previously sutured mesh through which protruded a loop of fibrotic small bowel. The hernia was approached by carefully mobilizing the herniated small bowel from the mesh and then by reducing it from the pelvic cavity.

Fig. 1. Case 1: Computed tomography scan featuring a small bowel loop deep in the pelvic cavity with proximal small bowel loop dilatation.
Despite careful handling of the incarcerated small bowel loop, a rather sizable enterotomy was inadvertently made. Segmental resection with primary anastomosis was therefore performed, and the original mesh was subsequently removed. The pelvic floor was obliterated by suturing the uterine wall to the periosteal tissue of the sacrum with anchoring sutures placed about 0.5 cm apart (Fig. 3).

**Case 4**

An 81-year-old woman underwent laparoscopy-assisted APR for rectal cancer (approximately 6 cm from the AV). The carcinoma was classified as differentiated adenocarcinoma and staged as ypT3N0M0 with Mandard grade IV. Ten days after the operation, the patient experienced symptoms of intestinal obstruction, and a CT scan revealed a pelvic small bowel transition point. At laparoscopy, there was once again an anterior defect involving the previously placed mesh with fibrotic small bowel protruding into this defect. The hernia was dealt with similarly by careful mobilization of the herniated small bowel from the mesh and by reduction of the enteric content from the pelvic cavity. Because this small bowel loop also showed signs of ischemia, segmental resection with primary anastomosis was performed. The original mesh was removed, and no attempt was made to obliterate the pelvic cavity as the pelvic floor was judged to be well solidified and rather shallow.

**DISCUSSION**

Perineal hernia is a rare complication of major pelvic surgery, such as APR, proctectomy and pelvic exenteration. The incidence, anatomy and technique of basic repair have been recently well reviewed and summarized. Radiologic, mildly symptomatic, but not necessarily requiring surgery, perineal hernias following APR have a reported prevalence of up to 7%; perineal hernias requiring surgical intervention have a reported prevalence of 0.2%–0.6%; and perineal hernias after...
pelvic exenteration have been reported more frequently, with an incidence of about 3%, reflecting the magnitude of the operation.12,13

In most cases, the perineal hernias are asymptomatic, but often enough, a dragging feeling and discomfort in the perineum, urinary symptoms and bowel compromise can occur.2–6 Despite the lack of evidence in the literature, some surgeons feel compelled to reinforce the surgically weakened pelvic floor after APR to prevent these complications. Multiple tissue as well as mesh techniques have been described to reinforce a weakened floor post-pelvic surgery.14–19 If sufficient levator muscle tissue remains, the pelvic floor is reapproximated with multiple absorbable sutures. Other ways of reinforcing the pelvic floor in cases where musculature cannot be closed include myocutaneous flaps and mesh techniques.

Multiple case reports and case series have been published on actual perineal hernia repairs. Transabdominal, perineal and combined abdominoperineal approaches as well as laparoscopic transabdominal repairs with mesh have been described. The defect in the pelvic diaphragm can be obliterated either with suturing of remaining muscle tissue or by using autogenous tissues or mesh depending on the surgeon’s expertise and local conditions, such as the lack or presence of contamination.7–11

We present 3 viable laparoscopic options for the management of internal hernias through previously placed reinforcing mesh, depending on patient-specific conditions: 1) hernia reduction with removal of original mesh without any further intervention if the pelvic floor appears well healed and intact; 2) hernia reduction with mesh removal followed by technically improved placement and fixation of new mesh in noncontaminated pelvis with weak pelvic floor; and 3) hernia reduction, resection of compromised bowel and removal of original mesh followed by suture of bladder or vagina to presacral fascia in cases with possible contamination.

Although not yet scientifically scrutinized, several issues need to be considered when contemplating reinforcing the pelvic floor after a laparoscopic or robotic procedure, such as APR. One consideration is whether reinforcing is really necessary in a particular case. It might just be that in cases with a shallow, somewhat supported pelvic floor, the benefits of not performing any additional reinforcement could outweigh possible complications, such as internal hernias and infection. With respect to our series, the cases were pooled from 4 different surgeons with varying surgical training and who adopted the practice of placing a prophylactic mesh at different time points. No statistical risk–benefit conclusions can therefore be made based on this report alone.

As illustrated by the 4 presented cases, if one still chooses to perform a similar reinforcement, some technical details need to be considered. An option is placing a mesh much lower beyond the pelvic brim and fixing it with closely spaced tacks or sutures. This might be an option in some cases especially because this technique allows for very dense placement of anchoring material without damaging autonomic nerve structures. Complete elimination of the small bowel from the pelvis should probably be reserved for patients in whom postoperative radiotherapy is anticipated to decrease the incidence of radiation enteritis. In such cases, an alternative in the form of a silicone rubber prosthesis used to fill the pelvic cavity has also been described.20

Another point to be considered is the fact that 3 of the reported hernias in our series appeared in the anterior region. Since this area is already out of the way of major autonomic nerve structures, one can just place an emphasis on reinforcing this area.

The risk for intra-abdominal infection should be taken into account in all surgical cases where resection of the bowel is performed. Synthetic mesh was used during the initial APR surgeries as no open bowel was handled intraperitoneally. If accidental contamination of the operative field occurs during surgery, we have an even lower threshold to avoiding the use of a mesh altogether or we use a biological mesh.

Finally, there is an issue of placing drains. Although this issue has not been systematically studied in this setting, most surgeons tend to leave a deep pelvic drain. If personal practice is to place a transabdominal drain through a reinforcing mesh, the surgeon must realize that such a drain could leave a potential site for an internal hernia. If a decision is made to leave a deep pelvic drain, we would therefore recommend that the drain be placed transgluteally rather than transabdominally.

**Conclusion**

In no way do we advocate routine use of a mesh for prevention of a perineal hernia. The goal of our review was to generate further discussion on the topic and to allow others to learn from our mistakes.

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**Competing interests:** None declared.

**Contributors:** All authors designed the study. G. Melich and D. Lim acquired and analyzed the data, which N. Kim also analyzed. G. Melich, D. Lim, G. Arena and P. Gordon wrote the article, which all authors reviewed and approved for publication.

**References**


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Financial costs and patients’ perceptions of medical tourism in bariatric surgery

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SUMMARY

Many Canadians pursue surgical treatment for severe obesity outside of their province or country — so-called “medical tourism.” We have managed many complications related to this evolving phenomenon. The costs associated with this care seem substantial but have not been previously quantified. We surveyed Alberta general surgeons and postoperative medical tourists to estimate costs of treating complications related to medical tourism in bariatric surgery and to understand patients’ motivations for pursuing medical tourism. Our analysis suggests more than $560 000 was spent treating 59 bariatric medical tourists by 25 surgeons between 2012 and 2013. Responses from medical tourists suggest that they believe their surgeries were successful despite some having postoperative complications and lacking support from medical or surgical teams. We believe that the financial cost of treating complications related to medical tourism in Alberta is substantial and impacts existing limited resources.

Obesity is a worldwide epidemic and affects 1 in 5 Canadian adults.1 Many strategies, such as diet, weight loss programs and medical therapy, failed to show long-term weight reduction. Bariatric surgery is a cost-effective intervention providing long-term weight loss and can effectively treat comorbid conditions, including diabetes.

Unfortunately, only 1% of eligible patients are offered bariatric surgery owing to limited Canadian health care resources. Extensive wait lists, which average 5 years across Canada,2 have led many patients to travel to another province or country for bariatric surgery; they are often assisted by medical travel companies — a process known as medical tourism. However, most bariatric medical tourists (BMTs) do not receive coordinated, long-term postoperative care from foreign health care services. Consequently, Canadian physicians and surgeons treat them when complications arise. This care is entirely funded by the Canadian health care system.

There is currently no method for tracking BMTs, which leads to challenges estimating short- or long-term costs of medical tourism. Furthermore, qualitative studies on postoperative patients’ perspectives of medical tourism for bariatric surgery are lacking. Although there are ethical implications of medical tourism, such as unequal health care access, our focus is on short-term costs and patients’ perceptions of medical tourism. We used the experience of general surgeons in Alberta to estimate the short-term costs of medical tourism and explore postoperative BMTs’ perceptions of medical tourism.

We sent 2 separate anonymous electronic SurveyMonkey questionnaires to Alberta general surgeons via the Alberta Medical Association and to postoperative BMTs. Further questionnaires were posted on 2 web-based forums (Obesityhelp.ca and Lapbandtalk.com), selecting for BMTs who were Albertans and asking about perspectives of their surgeries.
Costs for medical interventions were estimated and modelled based on our institution costs (Royal Alexandra Hospital [RAH] and Alberta Health Services [AHS]). These costs are listed in Appendix 1 (available at canjsurg.ca): stomach and duodenum imaging series (S&D), gastroscopy, computed tomography (CT), endoscopically inserted stent, revisional surgeries for laparoscopic adjustable gastric band (LAGB), laparoscopic sleeve gastrectomy (LSG) and laparoscopic Roux-en-Y gastric bypass (LRYGB); complications (including surgeon billing costs), and length of stay in the intensive care unit (ICU). Costing was not exhaustive, as some costs were not included (e.g., length of hospital stay, medications, radiography) owing to difficulties of recalling them on questionnaires. We determined cost by first adding the number of interventions administered by surgeons (based on survey responses) × the corresponding costs listed in Appendix 1. Then we added the average consultation fee × number of surgeons to the previous sum to calculate the total treatment cost.

Out of 144 general surgeons, 25 completed questionnaires (17.4%). An average surgeon appears to consult on 2.4 BMTs annually in Alberta. These 25 surgeons saw 59 BMTs in 2012–2013. The procedures involved in 25 surgeons saw 59 BMTs in 2012–2013. The procedures involved in the total treatment cost.

Fourteen Albertan BMTs completed the questionnaire. Common reasons for seeking bariatric surgery via medical tourism included long wait lists (n = 11) and presumed ineligibility for surgery (n = 6) in Alberta. Thirteen respondents believed their bariatric surgeries were successful despite some of them (n = 3) experiencing postoperative complications. Common destinations for BMT were Mexico (n = 9) and the United States (n = 3).

We estimate a minimum cost of CAN$560 000 annually on management of early complications for BMTs in Alberta. This is an extremely conservative estimate, as it did not account for all costs incurred (i.e., health care providers [nurses, dietitians, psychiatrists] and health care costs [total hospital stay, imaging, blood work]). Moreover, no registry exists to identify all BMTs requiring investigations and treatment within Alberta, and we can only surmise that we captured a reasonable sample of BMTs. Our estimated average cost of treating complications was $95 463.6 per medical tourist. In comparison, the average cost of bariatric surgery performed at our institution (2009–2012) was $13 778.20 ± $3129.05. Alberta does not seem to save much money by limiting the annual volume of bariatric surgeries.

Our program offers bariatric surgery, including LAGB, LSG and LRYGB performed by skilled surgeons, providing long-term effectiveness. However, our wait list includes 2632 patients (2014–2015), and the average wait time is 2.3 years from date of referral to surgery. Consequently, many patients turn to medical tourism despite potentially severe complications. A retrospective chart review with summation of costs at our institution (2009–2012) showed a BMT complication rate of 42.2%–56.1% ($37 000 per patient), whereas the local complication rate was 12.3% ($412 per patient).

Medical tourism is further promoted by websites marketing bariatric surgery, luring patients with perioperative vacation opportunities and affordable prices in tourist countries, such as Mexico. Based on electronic forums, people underestimate the incidence of complications from bariatric medical tourism. A surprising finding was that postoperative medical tourists viewed their surgeries as successful, regardless of complications developing, as long as weight loss occurred.

Our survey had a low response rate, which is common for physician surveys; nevertheless, their feedback provided considerable insights into the cost and patient perception of medical tourism. In addition, our focus on acute complicated medical tourists also underestimated the overall denominator and cost of bariatric medical tourism.

Medical tourism for bariatric surgery is a growing phenomenon. A recent physician survey suggested bariatric surgery accounts for a substantial proportion (16%; n = 12 800) of Canadian medical tourism. The cost of treating postoperative complications in BMTs is substantial. Nevertheless, patients view medical tourism in a positive light despite complications. Research is being undertaken at our institution to track medical tourism.

<p>| Table 1: Total intervention costs initiated by 25 surgeons for 59 medical tourists for LAGB, LSG, LRYGB and other bariatric surgery postoperative complications |</p>
<table>
<thead>
<tr>
<th>Medical intervention</th>
<th>Cost, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;D</td>
<td>20 350.74</td>
</tr>
<tr>
<td>Gastroscopy</td>
<td>7 322.24</td>
</tr>
<tr>
<td>CT</td>
<td>34 150.00</td>
</tr>
<tr>
<td>Endoscopy with stent</td>
<td>17 481.52</td>
</tr>
<tr>
<td>Revisional surgery</td>
<td>135 353.06</td>
</tr>
<tr>
<td>ICU stay</td>
<td>335 279.00</td>
</tr>
<tr>
<td>Consultation fee</td>
<td>13 298.60</td>
</tr>
<tr>
<td>Total</td>
<td>563 235.16</td>
</tr>
</tbody>
</table>

CT = computed tomography; ICU = intensive care unit; LAGB = laparoscopic adjustable gastric banding; LSG = laparoscopic sleeve gastrectomy; LRYGB = laparoscopic Roux-en-Y gastric bypass; S&D = stomach and duodenum imaging series.
and to establish the cost-effectiveness of medical tourism versus bariatric surgery completed in Alberta.

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**References**

CJS debate: Is mammography useful in average-risk screening for breast cancer?

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SUMMARY

Given the recent debate over breast cancer screening that was reignited by the 25-year follow-up data from the Canadian National Breast Screening Study, the Canadian Journal of Surgery commissioned a group of Canadian experts to debate the value of screening mammography. We discuss the Canadian study and summarize the arguments in favour of and against screening mammography for average-risk patients. We also provide summary recommendations for the use of mammography.

The recent publication of the 25-year follow-up data from the Canadian National Breast Screening Studies (CNBSS) has once again stirred the debate over breast cancer screening. The CNBSS recruited almost 90,000 Canadian women in 6 provinces to 2 studies between 1980 and 1988. Women aged 40–49 years were randomized to physical breast exam and mammographic screening versus usual care (observation), while women aged 50–59 years were randomized to physical breast exam and mammographic screening versus physical breast exam screening. All women were seen at recruitment for a physical breast exam and were taught how to do a breast self-exam. Women were randomized independent of the clinical findings, and those who were randomized to mammographic screening had a mammogram at the time of recruitment. The usual care group aged 40–49 years was no longer seen, while the remaining screened groups were seen for 4 additional rounds of annual screening. The current CNBSS publication combined the 2 age groups in the analysis.

Two take-home messages were highlighted: there was no difference in survival among mammographically screened women and the control cohort, and screening mammography resulted in harm by overdiagnosing cancers in 22% of women. The Canadian Journal of Surgery commissioned a group of Canadian experts to debate the implications of this study on mammography screening and challenged them to provide advice to the average-risk woman.

Strengths of the CNBSS and resultant arguments against mammographic screening

The CNBSS by Miller and colleagues is 1 of 8 randomized controlled trials evaluating mammography screening, each of which has its own methodological limitations. For this reason, CNBSS sought to overcome these using its individual patient-level randomization schema.

The CNBSS found that annual mammography in women aged 40–59 years does not reduce mortality from breast cancer beyond clinical breast exam or usual care. Further analysis showed that screening mammograms picked up more cancers at a smaller size than did physical examination. The cancers found in the mammography-screened group, especially...
those that were nonpalpable, had a much better prognosis than those found in the group that did not receive mammograms. However, it is important to remember that subgroup analyses using survival statistics are subject to lead-time bias, length bias and overdiagnosis. Miller and colleagues have correctly reported breast cancer–specific mortality as the primary outcome.

Miller and colleagues determined that the rate of overdiagnosis in the mammographically screened group was 22%. This represents the difference in mean number of cancers diagnosed in the screened versus unscreened cohorts over the 5-year intervention period. Overdiagnosis refers to “the possibility that a screen-detected cancer might not otherwise become clinically apparent during the lifetime of the woman.” Detection of these cancers turns women into patients, leads to unnecessary treatment and adversely affects quality of life. The CNBSS is one of the ideal studies to address this critical question. Of note, this estimate does not include ductal carcinoma in situ (DCIS), the incidence of which has increased 500% with the introduction of screening mammography and which now represents approximately 20% of breast cancers. The benefit of screening mammography is in finding smaller tumours that need less treatment (mastectomy or chemotherapy) for women whose cancers are screen-diagnosed. However, if this applies to fewer women than those who are overtreated for their screen-detected malignancies that might never have become clinically symptomatic, the benefits of screening should be questioned.

The radiology literature is harsh in its criticism of the latest CNBSS publication: “... an incredibly misleading analysis based on the deeply flawed and widely discredited Canadian National Breast Screening Study.” Much has been made of concerns that physical examination carried out before randomization may have resulted in an excess of patients with palpable cancers being assigned to the mammography arm of the CNBSS. Careful review of the literature shows that their concerns regarding the randomization have been addressed and are not shared by multiple expert panels from the various systemic reviews on mammographic screening. In fact, if anything, reviewers found that randomization was more fair and transparent in the CNBSS than in any of the other trials. Criticism of the quality of the imaging has also been addressed. Poor-quality mammograms represented a very small fraction of those in the study. Only 1 other randomized study has some form of mammographic quality documentation. Most other studies did 1- rather than 2-view mammography and/or had greater screening intervals of up to 3 years.

All of the randomized trials on mammographic screening have methodological issues that challenge their internal validity, while the time that has passed since they were conducted challenges our ability to compare them to current practice. Screening advocates argue that current mammographic images are superior, so benefits should be greater. Screening opponents argue that improvements in breast cancer survival are associated with systemic therapy, which came into widespread use at the same time as screening.

If one doesn’t accept the evidence from the CNBSS, what benefits and harms do exist? Recognizing these and other methodological issues, several expert panels have performed systematic reviews to assist in policy decisions. The Canadian Task Force on Preventive Health estimated that the relative risk reduction for breast cancer mortality in women aged 50–69 years who were screened for 11 years was 21%. Estimates from the Independent UK Panel on Breast Cancer Screening and the United States Preventive Task Force were similar at 19% and 20%, respectively. A 20% reduction in breast cancer mortality sounds good, but it is helpful to keep the absolute numbers of patients that this represents in mind. Extrapolating to a lifetime of screening for women aged 50–69 years, the UK Panel estimated that inviting 230 women to screen over a period of 20 years would result in 1 breast cancer death averted and 3 women overdiagnosed. These benefits (improved survival) are much smaller and the harms (biopsies and treatments undertaken) are larger than most women and physicians imagine.

The delicate balance of risks and benefits explains why none of the expert panels have strongly recommended screening mammography. For women aged 50–69 years, the Canadian Task Force gives screening with mammography a weak recommendation with evidence of moderate quality, while the US Task Force gives a grade B recommendation owing to the moderate certainty that the net benefit is moderate. Consensus statements stress the importance of clear communication with individual women about the harms and benefits of screening.

LIMITATIONS OF THE CNBSS AND RESULTANT ARGUMENTS IN FAVOUR OF SCREENING MAMMOGRAPHY

The CNBSS is a randomized study that reported no difference in mortality attributed to screening mammography; however, it is important to look only at outcomes from cancers diagnosed during the study period, since breast cancers diagnosed during the decades following the 5-year intervention period cannot and should not be attributed to any perceived benefit from brief mammography screening. When comparing cancer-specific mortality (or conversely, survival) from cancers diagnosed in both groups during the 5-year mammography study period, there was a statistically significant 25-year survival for women in the mammography arm...
of 70.6% versus 62.8% in the control arm ($p = 0.02$). When comparing women for whom the mammogram diagnosed a nonpalpable tumour (the intent of routine screening mammography), the survival was 79.6% versus 62.8% ($p < 0.001$). This study therefore found a statistically significant improvement in survival among women with mammographically versus palpably detected cancers of greater than 27%.

It is accepted that tumour size is correlated with clinical outcome, supported by the finding that nonpalpable tumours in this study were associated with a significantly improved survival. The mean tumour size identified in this study was 2.1 cm for clinically palpated cancers versus 1.9 cm in the mammography cohort. With the advent of digital imaging, it is expected that the size of image-detected cancers will become smaller over time. The rationale for advocating any screening test is to identify disease in its earliest stage, presuming that an early diagnosis interrupts disease progression before it becomes advanced or metastatic. Reduced tumour size at diagnosis results in fewer patients requiring chemotherapy and mastectomy, a clinically meaningful outcome for these patients.

Although the CNBSS methodology is likely one of the fairest designs of any mammography trial, the randomization schema remains one of its methodological shortcomings. Patients underwent a breast examination by a study nurse, and therefore both would have been aware of the findings from this examination. They were then randomized at each centre to either the treatment or the control arm. Imaging researchers directly involved in the study have described the randomization schema as “open book sequential registration” design entered manually by the nurse locally in a log book, and therefore subject to bias due to the physical examination (M. Yaffe, Cambridge, Canada, personal communication, 2015). The authors recognized and addressed this bias in favour of putting more palpable breast cancers into the mammography arm by excluding the first year of breast cancers, since almost 50% more cancers were diagnosed in the mammography arm than the control arm. This cannot be attributed to chance alone. Unfortunately there was no adjustment for cancers diagnosed in the second year (prevalent cancers not identified by poor quality analogue mammograms during the first year), where 23% more cancers were identified in the mammography arm — again, much more than would be expected by chance alone. By discounting the unequal distribution of prevalent cancers in years 1 and 2, the difference between treatment arms remained stable at 15% more cancers per year diagnosed in the mammography screening cohort than the control cohort (years 3–5).

A second source of criticism of this study was that mammograms were of poor quality. Although the CNBSS authors mentioned that mammogram quality was appropriate for that time period, imaging scientists involved in this study have criticized the quality of the images, even for the time period of the study.

While it is widely accepted that some early breast cancers identified by screening imaging may represent a subset of disease that would not otherwise progress or result in clinically relevant disease (resulting in overdiagnosis), we remain unable to identify which patients belong to this group. Overdiagnosis rates can be calculated in screening tests only when enough follow-up time has occurred to allow any clinically relevant cancers to be clinically detected. Miller and colleagues calculated an overdiagnosis rate of 22% at the end of the 5-year study period, which was seen to persist at 15 years as an annual rate of overdiagnosis; however, without following these individual cases for several years, it is difficult to confirm which of these cases might become clinically relevant in subsequent years or decades. In this study, this rate could be recalculated to adjust for bias in the mammography arm to 15% (the mean difference in the number of cancers diagnosed between the screened and unscreened cohorts when the unequally distributed prevalent cancers diagnosed during the first 2 years are not counted), not 22% as quoted by CNBSS. This risk of overdiagnosis needs to be contrasted to the 27% improvement in breast cancer–specific survival in the mammographically detected cancer cohort of average-risk women. The solution to this dilemma is not to eliminate screening, with its associated improved survival for women overall, in order to avoid overdiagnosing a small proportion of them, but rather to continue to engage in clinical trials to determine better methods of stratifying patients who can be followed by active surveillance, as has been the method adopted for prostate cancer patients.

**What can we agree on?**

There have been 8 randomized controlled trials evaluating screening mammography, including the CNBSS, 4 of which were from Sweden. Except for the HIP trial (1963) and the AGE trial (1991), like the CNBSS, all were initiated in the 1970s and 1980s. Major methodological differences in study design included unselected populations versus prescreened volunteers, age groups that were screened, true versus quasirandomization, 1-view versus 2-view mammography, the use of physical examination versus usual care (observation) as a control, screening interval range from 12 to 33 months, the number of screening rounds from 2 to 9 and the duration of follow-up reported between 10 to 25 years. The CNBSS was designed purposefully to overcome as many potential limitations in prior studies as possible.

The foregoing arguments highlight the divergent views that exist regarding breast screening. Mammography
screening at any age is a tradeoff of benefits and harms. For a moment let’s consider what is agreed upon.

No jurisdiction, agency or society recommends screening average-risk women before the age of 40 years. There is little support for screening average-risk women between the ages of 40 and 49 years. While the US Preventative Services Task Force-commissioned meta-analysis\textsuperscript{13} suggested a small survival advantage for women aged 40–49 years, the advantage is offset by an excessive number needed to screen, call-back rates, negative biopsies, and the potential for over-diagnosis. This same 40–49 age group was a large part of the Baines cohort in the CNBSS 25-year update,\textsuperscript{1} and neither the Canadian Task Force\textsuperscript{11} nor the Independent UK Panel\textsuperscript{9} recommends screening in this age group.

Both Task Forces and the Independent UK Panel endorse, with minor variations, screening for average-risk women aged 50–69 years owing to fewer callbacks and a more reasonable number needed to screen to prevent a breast cancer death. The Canadian Task Force emphasizes that the absolute mortality benefits are small, and therefore a greater effort needs to be made to provide women with information about the harms versus benefits in this decision and not just provide encouragement to screen. The UK Independent Panel also discusses the need for clear communication of these harms and benefits. In clinical practice, women can be directed to either the decision aid for breast cancer screening from Health Canada\textsuperscript{28} or posters from the Canadian Task Force.\textsuperscript{29}

There is little support for screening average-risk women older than 74 years. Competing morbidities would increase the harms of screening and make it difficult for screening mammography to provide a survival advantage among older women. However, this group has not been adequately studied.

In North America, the Canadian Preventative Screening Task Force,\textsuperscript{22} Canadian Cancer Society,\textsuperscript{10} and the latest 2015 draft recommendations from the US Preventative Services Task Force\textsuperscript{11} all support the recommendations outlined here. Currently only the National Comprehensive Cancer Network (NCCN) and American Cancer Society\textsuperscript{32} continue to recommend annual screening for all average-risk women beginning at age 40 years.

It is unlikely that breast cancer screening programs will disappear soon, based on the CNBSS update. Heightened awareness of the issues it raises about the value of screening should, however, translate into changes in screening practices. Screening programs should reassess the aggressiveness of their recruitment strategies and uptake targets and make greater efforts to provide informed choice. Screening outside the age guidelines of 50–74 years should decrease. Future research could focus on better stratification of women who might benefit from screening.

Finally, based on our experience with screening mammography, we should avoid systematic implementation of other breast screening modalities (e.g., screening ultrasonography and magnetic resonance imaging) unless rigorously evaluated in a prospective fashion.

**Recommendation**

For women at average-risk for breast cancer, screening mammography is

- not recommended before age 40 years,
- not recommended between ages 40 and 49 years,
- recommended between ages 50 and 74 years, and
- not recommended after the age of 74 years unless more evidence becomes available.

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**Competing interests:** None declared.

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

**References**

Elimination of 24-hour continuous medical resident duty in Quebec

In 2012 Quebec limited continuous in-hospital duty to 16 consecutive hours for all residents regardless of postgraduate (PGY) level. The new restrictions in Quebec appeared to have a profound, negative effect on the quality of life of surgical residents at McGill University and a perceived detrimental effect on the delivery of surgical education and patient care. Here we discuss the results of a nationwide survey that we created and distributed to general surgery residents across Canada to capture and compare their perceptions of the changes to duty hour restrictions.

Survey

We developed our survey based on scales measuring quality of life and sleep, perception of future competency, satisfaction with education and relationship with attending surgeons, and perception of ability to provide safe patient care. The survey included parts of the World Health Organization’s WHOQOL-BREF for quality of life, the Pittsburgh Sleep Quality Index, and a previously published survey to assess education and patient care issues.1 The survey (Appendix 1, available at canjsurg.ca) was distributed to general surgery residents across Canada via the online tool SurveyMonkey. Participants completed the survey anonymously, selecting their level of agreement with various statements using a 5-point Likert scale, between January and March 2013.

In Canada, general surgery residency is a 5-year postgraduate program leading to Royal College certification. Each of the 17 programs accept 3–14 residents per year. The sex distribution of residents in these programs is 55% male and 45% female. The average age of residents in Quebec who responded to our survey was 23.6 ± 6.2 years, compared with 28.2 ± 8.2 years nationally. The response rate in Quebec was 37%, compared with 17.6% nationally (Table 1).
How do residents in Quebec compared with those in the rest of Canada feel about the duty hour model?

In Quebec 13.1% of residents felt that they knew their patients well compared with 80.3% of national respondents. Quebec residents felt less able than residents in other provinces to diagnose and manage their patients effectively (11.9% v. 77.9%).

Quebec residents reported an average of 5.5 ± 1.3 hours of sleep every night compared with an average of 6.5 ± 1.9 hours for residents in other provinces. The weekly sleep average for both Quebec residents and national residents was about 42 hours. The majority (89.6%) of Quebec residents felt sleep-deprived, compared with just over half (53.2%) of residents from other provinces.

Morale differed between residents in Quebec and those in the rest of Canada despite them having similar overall weekly duty hours (71.8 ± 16.7 hours in Quebec v. 75.9 ± 22.3 hours nationally). Only 19.6% of residents working under the limited duty hours felt that morale was good in the program compared with 51.6% of residents nationally.

There were differences in residents’ perceptions of their ability to provide safe and continuous care to patients. Only 16.3% of Quebec respondents (compared with 59.8% of residents in the rest of Canada) felt that they would be able to master the necessary surgical skills needed for practice.

A more detailed breakdown of the residents’ responses (Quebec v. rest of Canada) are available in Appendix 1, Tables S1–S4. To control for the differences inherent to each program in Quebec as well as the different duty hour models at McGill University compared with the other 3 general surgery residency programs in Quebec, we conducted a subgroup analysis by program in Quebec (Fig. 1, Fig. 2 and Appendix 1).

Table 1. Characteristics of survey respondents

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group: no. (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quebec (n = 61)†</td>
</tr>
<tr>
<td>Age, yr, mean ± SD</td>
<td>23.6 ± 6.2</td>
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<tr>
<td>PGY level</td>
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</tr>
<tr>
<td>PGY-1</td>
<td>15 (24.9%)</td>
</tr>
<tr>
<td>PGY-2</td>
<td>17 (27.5%)</td>
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<td>PGY-3</td>
<td>11 (17.7%)</td>
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<td>PGY-5</td>
<td>8 (12.9%)</td>
</tr>
<tr>
<td>PGY-6</td>
<td>3 (5.7%)</td>
</tr>
<tr>
<td>Plan to pursue fellowship</td>
<td>53 (87.6%)</td>
</tr>
</tbody>
</table>

PGY = postgraduate year, SD = standard deviation.

*Unless indicated otherwise.
†Restricted duty hour model (12-hour shifts at McGill University and night float at the other Quebec universities).
‡24-hour duty model.

WHAT SHOULD EDUCATORS TAKE AWAY FROM OUR SURVEY RESULTS?

Quebec is the first jurisdiction in North America to implement very restrictive duty hour limits without examining the possible effects on surgical training.1 Compared with residents in the rest of Canada, those in Quebec report a decreased quality of life and a decreased sense of ownership of patients in their care. The results of our national survey reveal that the protection of residents and patients is an issue that is not simply addressed by mandating reduced duty hours in a “one size fits all” approach.2

Most surgical programs in Canada still function within the framework of an apprenticeship model, where experiential learning is central to skill acquisition and the development of competent and safe surgeons.2,3 The Quebec ruling effectively equates the training needs — procedural or not — of all specialties. Unlike in specialties such as emergency medicine, where duty hour restrictions exist and are necessary, residents in general surgery are not in a perpetual state of concentration or subjected to assessing a constant stream of patients during call.

Programs across Quebec have started to think of unique ways to ensure quality of life beyond duty hours. These include hiring physician extenders, protected nap times, mindfulness meditation programs, and an application to the medical union in Quebec to give general surgery residents an exemption to allow overnight call that lasts 16 hours instead of 12 hours.1,2

Quantifying medical errors or actual operating case volumes was beyond the scope of our survey, and we were not able to control for several confounders, including number of residents in each program and pressures to provide coverage; weather conditions; nature of patients and services in each program; resident salary, noting that this is lower in Quebec; and number of fellows or physician extenders. Despite these confounders and the low response rate from residents outside Quebec, it is increasingly apparent that the problems posed by the new duty hour restrictions go beyond the number of hours worked or spent in the hospital. Studies to measure objective patient outcomes under the new duty hour restrictions are needed. Without other significant changes to the system, we have only added additional pressure to our trainees, expecting them to perform the same amount of work in less time.1,2,5

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References


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Evaluating if Colonoscopies are Essential after a Diverticulitis Diagnosis

It was with great interest that we read the work of George Ou and colleagues1 regarding Colonoscopy after CT-diagnosed acute diverticulitis published June 1, 2015. While this paper explores a very relevant and topical subject there are a few issues we would like to highlight.

Although this paper was published in June 2015 the data were collected for this study from 2005 to 2010. This does make the data potentially outdated, and the authors provide no justification in the paper for what appear to be arbitrarily selected dates. There also appear to be some flaws in the methodology, which could produce some bias. The paper reports 79.6% of the patients received contrast with their CTs; this should have been standardized and the others excluded. There is also no mention of how many clinicians reported the CT scans or if it was a collaborative effort or the work of an individual radiologist, as we know this can differ from generalist to specialist radiologist.2

The paper does not have any follow-up data on 50.9% of the patients, which the authors have recognized as a limitation, but this could be a source of selection bias. The authors also state that 20.2% had premalignant polyps, which they give the endoscopic findings for but do not state if these were picked up on the CT scan. This could imply that not doing a colonoscopy after CT-diagnosed diverticulitis could potentially have led to 32 missed cancers. There is some evidence that CT scans miss around 1 in 29 colorectal cancers.1

The authors’ state that among the patients found to have premalignant adenoma colonoscopy was of benefit, and they go on to suggest that it is conceivable this may have been missed without colonoscopy.

Overall, this study addresses a very relevant clinical question; however, given the points highlighted in this letter, there remains some doubt over the validity of the main conclusions. It would be worth repeating this study, rectifying these issues and those identified by the author. Until the question posed by this study is unequivocally answered, good practice would be to continue to follow-up patients with CT diagnosed diverticulitis with a colonoscopy.

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References

Author response
We appreciate the insightful comments from Herron and colleagues and the opportunity to expand on a few points.

Our retrospective study1 demonstrates that the prevalence of malignancy among patients with diverticulitis diagnosed on high-resolution (64-slice) CT scan was 1.4%, similar to that of average-risk population.2

The data period was chosen based on the time when high-resolution CT came into widespread use. Since then, 64-slice CT has remained the practice standard at our centre as well as at many others, thus maintaining the applicability of our results.

Ideally, contrast-enhanced CT should be used when acute diverticulitis is suspected, but this is often limited by contrast allergies and impaired renal function in practice. Although the quality of the studies are affected by lack of contrast, radiologists can still make the appropriate interpretations based on the clinical context provided by requesting clinician. We fear that excluding patients who were unable to receive contrast would have introduced substantial selection bias. To ensure that the included patients had findings consistent with acute diverticulitis, all of the CT scans in this study were retrospectively reviewed by a single radiologist specialized in abdominal imaging.

The premalignant findings in 23 patients were not specifically compared with the CT scans in this study. Unlike CT colonography, which involves bowel preparation to rid of fecal matter and enteral contrast to distend the colon as well as to enhance the appearance of polyps, plain CT scan is not designed to assess intraluminal pathology.

None of the 23 patients with premalignant findings had undergone colorectal cancer (CRC) screening in the form of endoscopy (it was unknown if they had previous screening in the form of annual fecal occult blood tests) despite a mean age of 61.5 years owing to opportunistic screening being the primary strategy.
at that time. This finding, together with the fact that all 4 patients with malignancy also did not have previous CRC screening, underscores the importance of age-appropriate screening. We therefore recommend endoscopy-naive patients undergo follow-up endoscopic evaluation. On the other hand, if a patient already had high-quality colonoscopy with no evidence of polyp within a reasonable time before diverticulitis was diagnosed, it is conceivable that a repeat colonoscopy would be redundant.

One of the strengths of this study is the use of a provincial cancer registry to capture any CRC that may have risen since the diagnosis of acute diverticulitis. Absence of additional cases of CRC in the registry among those who did not have follow-up endoscopy lends support to the idea that not all patients with acute diverticulitis require follow-up endoscopy to rule out underlying malignancy.

Based on the results of our study, we recommend selective endoscopic evaluation in the following patient populations after a diagnosis of acute diverticulitis on high-resolution CT scan: patients ≥50 years of age who are due for CRC screening/polyp surveillance in the form of colonoscopy based on recommended intervals, and those with suspicious CT findings, such as a mass lesion with obstruction.

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Operative or nonoperative management of Hinchey III purulent acute diverticulitis?

We read with interest the article by Dr. Vennix and colleagues 1 published in Lancet that rekindles the debate on management of severe acute diverticulitis (Hinchey III); the lower early morbidity of surgical resection reported by the authors definitely challenges the recent trend toward mini-invasive management by laparoscopic lavage (LL). 2,3

Interestingly, in the authors’ whole series, major morbidity and 12-month mortality reached 30% and 11% (14% in the resection group [RG]), respectively. Overall, patients underwent 157 operations (88 primary surgeries, 40 reoperations and 29 stoma reversals), accounting for a ratio of 1.8 operations per patient (1.9 in the RG). Moreover, 52% of patients underwent ileo-/coloanostomy (68% in the RG), which was never reversed in 27% of cases. Finally, 15% of patients had fascial dehiscence within 1 year.

Also considering that patients with stercoral peritonitis (Hinchey IV) were excluded, results of surgery in the studied population seem poor and possibly caused by the emergency setting, rather than the purpose of surgery (resection s. nonresection). Admitting that LL is not superior because no difference is recorded between the 2 groups does not mean that performing an emergency sigmoidectomy is the best option in a septic patient with an ongoing acute peritonitis. The real, upcoming question seems to be whether Hinchey III patients (whose results are poor regardless of the performed procedure) really need emergency surgery. Since the study does not include a conservative management group, efficacy of antibiotics alone is not assessed.

We recently reported a 92% successful conservative management of hemodynamically stable patients with diverticulitis-associated pneumoperitoneum and no diffuse colonic perforation at CT (82% and 72% presenting free intraperitoneal fluid and clinical signs of diffuse acute peritonitis, respectively). 4 None died, 3 were reoperated and 7 required percutaneous drainage, which was considered a successful, nonoperative management, and we concluded that most non-Hinchey IV patients may be managed conservatively. Moreover, only 19 patients underwent delayed elective sigmoidectomy (with 2 reoperations), whereas 17 patients completely avoided surgery, with an overall ratio of 0.6 operations per patient.

In accordance with Vennix and colleagues, we believe that an accurate preoperative diagnosis should improve Hinchey III patient selection, not to undergo laparoscopic drainage, but rather to avoid an unnecessary surgery.

Randomized multicentre trials, comparing a surgical and a conservative approach to patients affected by non-Hinchey IV acute diverticulitis are needed to assess if, in this class of patients, less is more.

Renato Costi, MD, PhD; Alban Zarzavadjian le Bian, MD, PhD; Claude Smadja, MD, PhD; Vincenzo Violi, MD, PhD

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RE: RECURRENTCE OF INGUINAL HERNIAS REPAIRED IN A LARGE SURGICAL SPECIALTY HOSPITAL AND GENERAL HOSPITALS IN ONTARIO, CANADA

It is extremely rare, for an article dealing with the lowly hernia to provoke a tremor in the world of surgery. Malik and colleagues have just managed that seismic quality and they are to be congratulated and celebrated.

For 20 years, synthetic meshes have become the mainstay of hernia surgery, thanks to an industry that fostered conferences, societies and free courses, but also flagrant and undaunted marketing. The drawbacks of meshes were always vague and nebulous. The current generation of surgeons can truly be said to have been formed by the industry!

Mesh-based repairs are touted as the ideal in the guidelines of the European, Danish and Swedish Hernia Societies. The American Hernia Society has found no reason to disapprove.

The Shouldice repair, a pure tissue repair, rated a mention only when infected mesh was removed! Sadly, no one performs or knows how to perform a Shouldice repair outside Thornhill. A repair which, barely 20 years ago, was considered the “gold standard.”

The world literature is now replete with publications on chronic postherniorrhaphy inguinoodynia, a condition unknown before the introduction of mesh. In 1964, in Nyhus’ classic hernia, postherniorrhaphy pain did not rate a mention in its index. In Ponka’s equally excellent book, pain is mentioned in half a column as “uncommon” and due to “scar tissue” (1980).

Copious publications are now firming up the statistics on postoperative complications of mesh: 11% of patients will have a history of severe chronic postoperative inguinoodynia severe enough to be detrimental to their quality of life. Another group of patients (3%-4%) will suffer irreversible dysejaculation, which only 20 years ago, without mesh, had an incidence of 1 in 2500 cases and was reversible! A hundred-fold (or 10 000%) increase. Another 10% will manifest severe testicular pain secondary to mesh erosion of the vas, which in some cases will require an orchidectomy. The specter of infertility has not been an issue, unless there is contact between mesh and vas (as in a Lichtenstein or laparoscopic approach) in a young adult with bilateral repairs and who may consider a family 10 years down the road. The delay in reaching the vas lumen is 7–10 years (unpublished data). Transmigration into adjacent organs are commonly reported but not systematically quantified with any accuracy through industrial surveillance. With such evidence, would a “duly informed” patient consent to mesh-based surgery?

To answer our respected authors, mesh is used in 3% of the cases at the Shouldice Hospital. Around the world, mesh is used in 90%–97%.

The better results of the Shouldice repair are not due to legere demain. Their surgeons truly know anatomy. More so than surgeons who do an average of 50 cases a year. In the Swedish registry, 50% of the surgeons did fewer than 7 cases a year. The hackneyed aphorism with vendors that “with mesh, you do not need to know anatomy” is simply untrue.

Professor Volcker Schumpelick, Editor in Chief of the Hernia, in his address to the American Hernia Society (2005) stated that “despite the introduction of mesh and laparoscopy, there has been no reduction in the incidence of hernia recurrences in the last 30 years. That incidence worldwide is 14%.” Why are the European guidelines rushing to be launched as World guidelines?

This thorough, objective, generously followed, massive population-based analysis by our Toronto colleagues has already reached Hernia and the European Hernia Society. The “tailored approach” concept is rather new. This paper will help nail that merciful concept. The figure estimated at 10%–20% could be brought to a mere 5% with simple emphasis of anatomy. The Shouldice Hospital already demonstrated, 20 years ago, that 1%–5% is the magic number depending on the type of hernia.

This paper will become a classic, cited beyond the wildest dreams of its authors. It will awaken many residents to ask why it takes 4–6 years of surgical training if the industry can do it, through vendors, in a matter of minutes.

I would like to think that my learned and respected colleagues of the University of Toronto have revealed a good omen for a return to a saner algorithm and a harbinger of what I like to call a timely revival of a “greener operation.”

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From the Department of Surgery, Shouldice Hospital & University of Toronto, Thornhill, Ontario.
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