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Raising the standard of surgical reporting to increase its impact

The surgeons patiently practised a laborious and unnecessary ritual for the sake of the better results.\(^1\) The quote is not about the surgical safety check routine but about the introduction of Listerism by Thomas Roddick to the Montreal General Hospital. The observation was made by William Osler in a report published in the Canadian Medical Association Journal (CMAJ) regarding the 1912 funeral of Joseph Lister in Westminster Abbey. Osler concluded that as “with everything that is worth preserving in this life there has been evolution, but from the great underlying principle on which Lister acted there has been no departure.”

CMAJ had been founded a year before through the amalgamation of the Montreal Medical Journal and the Maritime Medical News, both of which had been established in 1888. Canada had a robust medical publishing industry with multiple journals competing for a relatively small audience. As a young graduate Osler contributed articles and editorials to Canadian journals. He continued his contributions throughout his career in the United States and England. His article on Lister was 1 of 16 that Osler published in the early years of CMAJ under the banner “Men and Books.”

Just as the New England Journal of Medicine started life as the New England Journal of Medicine and Surgery, the early Canadian journals addressed both sides of the medical house. Medical publishing was initially dominated by surgery until overtaken by medical articles in the 20th century. In 1957, the Canadian Journal of Surgery (CJS) was founded to redress the imbalance. Just as Osler helped CMAJ establish roots, leaders of Canadian surgery published frequently in the CJS. In contrast, I was told recently that the young presenter of a very modest project declined the opportunity to publish in CJS because it would be considered the death knell of his research. The comment must be analyzed, not dismissed.

The impulse that established the CJS was essentially protectionist. Medical articles were preferentially published in generalist journals because they were of higher quality. CJS was to be a safe place to publish surgical articles especially from Canada. For a while, we tried to rationalize that surgery required a different reporting format than medical science. The impact factor (IF) for CJS diminished to a nadir of 0.5; only 1 of every 2 articles published in the preceding 2 years received a single citation. From the beginning, CJS has been a professionally produced, perfectly copyedited journal. It has observed improvements in style as they were developed, such as standardized formats for references and standard units of measurement. The journal introduced authorship regulation and participated in programs to eliminate bias and fraud. Low-impact articles, such as case reports or historical essays, were refused. The number of citations generated by CJS articles has quadrupled over the last decade but the journal’s IF remains resolutely in the second tier of surgical journals at 1.5. While subspecialty surgical journals tend to have a higher IF than generalist journals, the current score does not reflect the quality of Canadian surgery.

In recent years the journal has concentrated on its Canadian impact rather than its IF. The founding collaboration between the Chairs of Surgery, the Royal College of Physicians and Surgeons of Canada and the Canadian Medical Association has been revived. Subscription has been supplemented by an institutional academic program generously supported by the founders and specialty societies led by the Canadian Association of General Surgeons. This has allowed the circulation to grow so that every surgeon in Canada receives the journal. Articles are publicized widely via social media and are available by immediate open access via direct links on scientific registries, such as PubMed, and popular search engines, such as Google. Important developments in Canadian surgery, such as the impact of resident work hour restrictions\(^2\) or the future of generalist general surgery in Canada,\(^3\) are highlighted. A process to develop and report consensus has been developed by the journal.\(^4\)

To answer the challenge made by our young colleague, the only factor limiting the impact of articles published in CJS is the content of each report. The next phase of development will be to raise the standards for reporting surgical research. Reports will only have an impact if they are transparent, accurate and convincing. CJS will promote compliance with the reporting guidelines of the EQUATOR network (www.equator-network.org), an international initiative.
Élever les normes de production de rapports de recherche chirurgicale pour accroître leur impact

L'impulsion à l'origine de la création du *JCC* était essentiellement protectionniste. Les articles médicaux étaient publiés de préférence dans des revues généralistes parce qu'elles étaient de plus haute qualité. Le *JCC* devait être un lieu sûr pour publier des articles en chirurgie, particulièrement du Canada. Pendant un temps, nous avons tenté de rationaliser en disant que la chirurgie nécessite un format de rapport différent de celui de la science médicale. Le facteur d’impact (FI) du *JCC* tomba à un nadir de 0,5; seulement 1 article publié sur 2 était cité, même 1 seule fois, dans les 2 années suivantes. Pourtant, dès le départ, le *JCC* a été produit par des professionnels et la préparation éditoriale était parfaite. Le journal a adopté les améliorations de style à mesure qu’elles ont vu le jour, notamment la normalisation du format pour les références et les unités de mesure. Le journal a aussi adopté des règles au sujet de la qualité d’auteur et participé à des programmes visant à améliorer l’impartialité et à éliminer la fraude. Les articles à faible impact, tels que les rapports de cas ou les essais historiques, ont été refusés. Le nombre de citations générées par les articles du *JCC* a quadruplé au cours de la dernière décennie, mais le FI de la revue demeure résolulement au second rang parmi les jurnaux chirurgicaux, à 1,5. Alors que les journaux chirurgicaux des surspécialités ont tendance à avoir un FI un peu plus élevé que les revues généralistes, le score actuel ne reflète pas la qualité de la chirurgie au Canada.

Au cours des dernières années, le *JCC* a fait porter ses efforts sur son impact au Canada plutôt que sur son FI. La collaboration entre les présidents des

**References**


Le Journal canadien de chirurgie (JCC) met en évidence les importants développements en chirurgie au Canada, tels que l’impact de la restriction des heures de travail des médecins résidents2 ou l’avenir de la chirurgie générale au Canada3. Le JCC encouragera la conformité aux directives de présentation de rapports mises de l’avant par le réseau EQUATOR (www.equator-network.org), une initiative internationale qui vise à améliorer la fiabilité des rapports de recherche en santé.

Vivian C. McAlister MD
Co-rédacteur, Journal canadien de chirurgie
Interêts concurrents : Aucuns déclaré
DOI: 10.1503/cjs.010015

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A tribute to Lloyd D. MacLean

Roger G. Keith, MD

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Correspondence to:
R. Keith
Department of Surgery
University of Saskatchewan
Saskatoon SK S7N 0W8
roger.keith@usask.ca

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Summary

Dr. Lloyd D. MacLean, long-time co-editor of the Canadian Journal of Surgery passed away earlier this year at the age of 90. In order to appreciate the contributions of Dr. MacLean to the journal, this commentary recognizes him as a humble surgeon–scientist who was one of — if not the — most outstanding Canadian ambassadors to academic surgery in North America.

In order to appreciate the contributions of Lloyd MacLean to the Canadian Journal of Surgery (CJS), it is obligatory to recognize a humble surgeon–scientist who was one of — if not the — most outstanding Canadian ambassadors to academic surgery in North America.

A native Calgarian, Dr. MacLean’s formative years occurred in Alberta during The Great Depression, the dust bowl and World War II. Those were hard times in the Prairies. “When the going gets tough, the tough get going.” Dr. MacLean graduated from the post-war Faculty of Medicine of the University of Alberta in 1949. His next 12 years of training, research and academic clinical practice occurred at the University of Minnesota. He obtained his doctorate there through research in shock and sepsis, which became a career-long study. In 1962, Dr. MacLean returned to Canada, not the West but to Montreal, where he was recruited as surgeon-in-chief at the Royal Victoria Hospital, an office he held for 26 years. As professor of surgery at McGill University, Dr. MacLean served as chairman of the department for intervals between 1968 and 1988. In 1987 he was named the first Edward W. Archibald Professor in the Department of Surgery.

Leadership is recognized in numerous ways. Within the Royal Victoria Hospital and McGill University, Dr. MacLean established programs of clinical excellence and research in shock, sepsis, transplantation and bariatric surgery, which all gained international recognition. His trainees and colleagues from McGill were appointed university heads of surgery in Canada and the United States. In 1985 Dr. MacLean was appointed Officer of the Order of Canada, and in 1989 he received the Gairdner Wightman Award — both for outstanding contributions to Canadian medicine. In 1992 he was elected president of the prestigious American Surgical Association, and the following year he was appointed president of the American College of Surgeons. These offices have been held by few other Canadians. The Department of Surgery at McGill University has established the L. D. MacLean Visiting Professorship in General Surgery, and recently a second...
award in his name was created to honour lifetime contributions to the department by an individual.

During the more than 30 years of Dr. MacLean’s academic surgical career at McGill, one would not expect less than his acceptance of yet another responsibility to guide Canadian surgeons. In 1970 Fred Kergin of Toronto sought his successor as editor of *CJS*. By 1972 Barber Mueller of McMaster University and Dr. MacLean were appointed as the first coeditors of *CJS* — the only indexed Canadian surgery journal. It was owned and published by the Canadian Medical Association, which provided management and editorial support. The direction for the journal, the quality of its content, the communication with the readership and the continuity of scientific merit became the responsibility of the editors and their board. Drs. MacLean and Mueller sustained this role for an incredible 20 years. The common thread between these coeditors during their tenure was the voluntary contribution of time devoted to *CJS* despite massive work hours required to chair their respective university departments.

Dr. MacLean was responsible for sustaining the bilingual content of *CJS*, maintaining this vehicle as a means for the Royal College to communicate with Canadian surgeons and eliciting resident research contributions. He was responsible for continuing the “Quill on Scalpel” section, started by Fred Kergin, for publication of Canadian specialty society symposia and the publication of nationally invited presentations. Drs. MacLean and Mueller continuously endeavored to promote publication of Canadian surgical research. To accomplish this goal, both editors would personally pursue contributors from annual meetings, from special lectures, from symposia chairs and state of the art presentations. Dr. MacLean encouraged communication from readers through the “Correspondence” section. Their overall drive through 20 years of dedication to *CJS* was to sustain a publication that would stimulate knowledge, enlighten new directions in surgery and encourage contributions and communications from and for Canadian surgeons.

Unrelated to their planned resignation as coeditors, the *CJS* came upon financial constraint beginning in the 1990s. Increasing costs of publication, combined with loss of fiscal contributions from the Royal College and advertising revenue threatened the viability of *CJS*. As president and secretary, respectively, of the Canadian Association of General Surgeons at that time, Jean Couture and I presented a long-negotiated solution for sponsorship of the journal by selected surgical specialty societies. This formula was accepted and to this date has helped sustain Canada’s only indexed surgery journal. Continuous publication of *CJS* has enabled the readership to understand the incredible personal contributions of Lloyd MacLean and Barber Mueller from 1972 to 1992.

In memory of Lloyd D. MacLean

Jonathan Meakins, MD

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May 22, 2015

Correspondence to:
J. Meakins
1509 Sherbrooke St. W, Apt. 21
Montreal QC H3G 1M1
jonathan.meakins@videotron.ca

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Canadian surgery has lost one of its great leaders. Dr. Lloyd Douglas MacLean died in his sleep on Jan. 14, 2015, at 90 years of age. This commentary highlights his contributions to Canadian surgery.

In memory of Lloyd D. MacLean

Jonathan Meakins, MD

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Correspondence to:
J. Meakins
1509 Sherbrooke St. W, Apt. 21
Montreal QC H3G 1M1
jonathan.meakins@videotron.ca

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Canadian surgery has lost one of its great leaders. Dr. Lloyd Douglas MacLean died in his sleep on Jan. 14, 2015, at 90 years of age. A native of Calgary, Dr. MacLean’s academic record was exceptional; he earned his Bachelor of Science and Doctor of Medicine degrees from the University of Alberta on scholarships. Following a rotating internship in Alberta, he entered the surgical training program at the University of Minnesota where he thrived in the intellectual and investigative atmosphere generated by Dr. Owen Wangenstein. A Markle Scholar, Dr. MacLean moved directly from the residency program to be chief of surgery at the Ancker Hospital in St. Paul, Minnesota, where his clinical and academic career flourished. In 1962, he came to McGill University as a professor of surgery and chief of surgery at the Royal Victoria Hospital, where he established during his 26 years...
in that position an outstanding academic surgical program. His accomplishments were recognized universally as he became the Archibald Professor of Surgery at McGill, a Fellow of the Royal Society of Canada, an Officer of the Order of Canada, the 1988 Sims Commonwealth Traveling Professor and recipient of the Gairdner Wightman Award in 1989. Honorary doctorates in science from McGill University and the University of Alberta and visiting professorships to most Canadian medical schools and many in the United States and around the world.

An outstanding clinician who was board-certified in general and thoracic surgery, Dr. MacLean’s investigative interests touched all of the important developments in surgery during his lifetime. Early studies in gastric physiology, transplant immunology, infection and nutrition preceded his interests in septic shock and organ failure, clinical transplantation, host resistance and the physiologic evaluation of the critically ill surgical patient. He was a pioneer in clinical transplantation, the development of surgical critical care units and the study of bariatric surgery. He was arguably Canada’s leading academic surgeon and a wonderful role model for all in his department. All of these interests and others are reflected in his bibliography, which included more than 350 publications. He recreated the scholarship that was so much a part of his experience in Minnesota in Montreal. It influenced all who worked in his department and was a significant component of his role at the *Canadian Journal of Surgery* (*CJS*).

Dr. MacLean was a member of all the important surgical associations. He held high office in many and was president of the American College of Surgeons, the American Surgical Association, the Central Surgical, the International Surgical Group and the James IV Association. His presidential address to the American College of Surgeons, entitled “Wangensteen’s surgical forum: a legacy of research,” is worth re-examining. By outlining Professor Owen Wangensteen’s career, Dr. MacLean made clear the link between a restless intellect constantly asking questions on the clinical problems of his patients and then finding solutions and publishing the results. He believed that if it was not published, it did not exist. At conferences or rounds, unsubstantiated opinions were not accepted, and the phrase “in my experience” rated poorly. Dogma was the enemy. It is with these thoughts that he entered into coeditorship of *CJS* with Dr. Barb Mueller in 1972.

In the July 1972 issue, Dr. MacLean’s Quill on scalpel article, “*CJS* — a reappraisal,” outlines many of the issues facing the journal at that time, which continue today and are being addressed by the current coeditors, but importantly, 42 years later. That duration clearly indicates the vibrant and ongoing nature of the journal, which Dr. MacLean coedited for 20 years. He pointed out the importance of the clinical side of our lives and that there was great significance to clinical trials, which have become an important component of Canadian academic surgery. He also indicated that the journal needed support from the broad community of Canadian surgeons, and this area has seen progress. He gave up the coeditorship with some reluctance but recognized in his characteristic way that 20 years was a good run. He, together with Dr. Mueller, maintained the standards of the journal, lifted it to another level and left it healthy for their successors.

As a leader, Dr. MacLean’s integrity, scholarship and devotion to the physiological approach to patient care and the data provided for the residents the role model of a caring academic surgeon. It was most apparent to the department when it was his turn to do Journal Club. A lifetime subscriber of *The New England Journal of Medicine* and *The Lancet*, he would review 5–8 articles of surgical interest with his extraordinary ability to, in few sentences, capture the important kernels in each article. This habit of constant perusal of good journals was passed on to many of his residents. He brought stature and academic credibility to *CJS* and did so for 20 years. He and Barb Mueller were a hard act to follow.


Competing interests: None declared.
Colonoscopy after CT-diagnosed acute diverticulitis: Is it really necessary?

Background: Computed tomography (CT) scans are commonly used to diagnose acute diverticulitis, but there are overlapping features between diverticulitis and colorectal cancer (CRC) on imaging studies. Hence, colonoscopy is typically recommended after an episode of acute diverticulitis to rule out underlying malignancy. Currently, 64-slice multidetector CT scanners are capable of providing higher-resolution images and may be able to distinguish malignancy from diverticular inflammation. We aimed to determine the prevalence of CRC among patients with CT-diagnosed acute diverticulitis.

Methods: We performed a retrospective study of patients with acute diverticulitis diagnosed on CT scan between December 2005 and December 2010 at St. Paul’s Hospital, Vancouver, BC. Nonresidents were excluded. We reviewed CT scan reports that included the term “diverticulitis,” reports of follow-up colonic evaluation within 1 year of diagnosis and pathology results. We queried the provincial cancer registry to ensure no cases of CRC were missed.

Results: A total of 293 patients had acute diverticulitis diagnosed on CT scan, but 8 were nonresidents and were excluded. Of the 285 included in the analysis, the mean age was 59.4 ± 15.1 years, and 167 (58.6%) were men. Among the 114 patients who underwent follow-up evaluation, malignancy was diagnosed in 4 (3.5%). The overall prevalence of malignancy among patients with CT-diagnosed diverticulitis was 1.4%.

Conclusion: Routine endoscopic evaluation after an episode of diverticulitis diagnosed with high-resolution CT scan does not appear to be necessary. Selective approach in patients with protracted clinical course or those with mass lesion/obstruction on CT scan may be of benefit.

Contexte: La tomodensitométrie (TDM) est couramment utilisée pour le diagnostic de la diverticulite aiguë, mais des caractéristiques sont communes à la diverticulite et au cancer colorectal (CCR) aux épreuves d’imagerie. On recommande donc en général la colonoscopie après un épisode de diverticulite aiguë pour écarter un diagnostic de cancer sous-jacent. À l’heure actuelle, les appareils de TDM multidétecteurs à 64 barrettes peuvent fournir des images de haute résolution et permettent même de distinguer le cancer d’une inflammation diverticulaire. Nous avons voulu déterminer la prévalence du CCR chez les patients ayant présenté une diverticulite aiguë diagnostiquée par TDM.


Résultats: En tout, 293 patients ont reçu un diagnostic de diverticulite à l’aide de la TDM; 8 étaient des non-résidents et ont été exclus. Parmi les 285 patients inclus dans l’analyse, l’âge moyen était de 59,4 ± 15,1 ans et 167 (58,6 %) étaient des hommes. Parmi les 114 patients qui ont subi un examen de suivi, le cancer a été diagnostiqué chez 4 (3,5 %). La prévalence globale du cancer chez les patients porteurs d’un diagnostic de diverticulite posé par TDM était de 1,4 %.

Conclusion: L’évaluation endoscopique de routine après un épisode de diverticulite diagnostiquée à l’aide d’une TDM de haute résolution ne semble pas nécessaire. Une approche sélective chez les patients qui présentent une évolution clinique lente ou ceux qui présentent une lésion ou obstruction tumorale à la TDM pourrait être utile.
It is estimated that up to 20%–25% of patients with colonic diverticula will progress to diverticulitis. The diagnosis of acute diverticulitis is typically made using a combination of history, clinical exam, biochemical investigations and diagnostic imaging. Computed tomography (CT) has emerged as the imaging modality of choice given its high sensitivity and specificity for the diagnosis of diverticulitis, with some studies reporting up to 100% in either measure. Computed tomography findings of diverticula, inflammation of pericolic fat, bowel wall thickness greater than 4 mm and/or pericolic fluid/abscess are highly suggestive of acute diverticulitis. A CT scan also provides prognostic information and guides management by determining whether the diverticulitis is complicated by abscess, fistula formation, stricture/obstruction or free rupture. While most cases of uncomplicated diverticulitis respond well to conservative treatment, complicated diverticulitis requires surgical intervention.

There is overlap in the findings of acute diverticulitis and colorectal cancer (CRC), and CT findings alone are insufficient to exclude malignancy approximately 10% of the time. As a result, the American Society of Colon and Rectal Surgeons recommend performing a colonoscopy to exclude a potential malignancy after an episode of acute diverticulitis has resolved. However, since the advent of multidetector CT scanners that are capable of capturing images more quickly and thus reduce motion artifacts, the image qualities and diagnostic accuracy of CT scans have improved substantially. With increased resolution of the newer 64-slice CT scans that are currently in widespread use, acute diverticulitis can be diagnosed more accurately and it may be possible to adequately distinguish acute diverticulitis from malignancy based on radiological features alone. Routine follow-up colonoscopy may no longer be required in patients with acute diverticulitis. The primary aim of this study was to determine the prevalence of colon cancer in patients with diverticulitis diagnosed on high-resolution CT scan to determine the need for follow-up colonoscopy in this patient population.

METHODS

We performed a retrospective chart review of all patients with acute diverticulitis diagnosed on CT scan between December 2005 and December 2010 at St. Paul’s Hospital, Vancouver, BC, a university-affiliated tertiary care centre. We queried the CT scan report database for the term “diverticulitis” and then reviewed reports for findings consistent with acute diverticulitis. The CT images were obtained with the patients in the supine position using a LightSpeed VCT Scanner (General Electric). Images were acquired with the following specifications: collimation 40 mm, pitch 1.375:1, matrix 512 × 512, field of view to fit the patient, MA Noise index 35, tube rotation 0.5 s and peak voltage 120 kV. The images were reconstructed using a standard algorithm with thicknesses of 1.25–2.50 mm. Intravenous and oral contrast dye were administered unless contraindicated owing to renal insufficiency or a documented allergy to contrast dye, or if the imaging was initially indicated to rule out nephrolithiasis. Rectal contrast was not routinely administered.

Patients who were not residents of British Columbia were excluded owing to lack of availability of medical records. We collected baseline demographic and pathology reports from the hospital’s electronic medical record system. Reports of lower endoscopy performed before and after CT scan were retrieved from the hospital’s electronic medical record and/or requested from the patient’s family physician. We compared the findings identified at colonoscopy and the CT scan reports of the included patients to determine the prevalence of colonic neoplasia in patients with acute diverticulitis. Because not all patients had available follow-up colonoscopy reports, we queried the provincial cancer registry at the British Columbia Cancer Agency (BCCA) in February 2014 to capture all incident cases of CRC after the diagnosis of diverticulitis. Our study was approved by the University of British Columbia Providence Health Research Ethics Board.

Statistical analysis

Baseline demographic characteristics are summarized as means with standard deviations or medians with interquartile ranges (IQR) for continuous variables. Categorical variables are expressed as frequencies and percentages. We performed 2-sample $t$ tests using Microsoft Excel 2007. Where statistical analyses were not appropriate, the results of this retrospective chart review were analyzed descriptively.

RESULTS

Between December 2005 and December 2010, 293 patients had acute diverticulitis diagnosed on CT scan; 8 of them were not residents of British Columbia and were thus excluded from analysis (Fig. 1). Of the remaining 285 patients, 58.6% ($n = 167$) were men, and the mean age of patients was 59.4 ± 15.1 years. The majority of the CT scans were performed using intravenous contrast media ($n = 227$, 79.6%; Table 1). Diverticulitis involving the sigmoid colon accounted for 74.4% ($n = 212$) of the cases.

Nine patients (3.2%) required emergent surgery within the same hospital admission. Seven of them underwent surgery owing to severe perforated diverticulitis, and 2 underwent surgery owing to worsening clinical status despite initial conservative treatment. Seventeen patients (6.0%) underwent nonurgent resection of the affected colonic segment before any follow-up endoscopic evaluation (Fig. 1). All surgical pathology reports were negative for malignancy.

A total of 114 patients (40%) underwent further evaluation of the colon within 1 year of the CT scan: 91 had
colonoscopies, 22 had flexible sigmoidoscopies and 1 underwent CT colonography. The median time from CT scan to subsequent colonic evaluation was 3 (IQR 2.0–5.5) months. Within this cohort of patients, the mean age was 56.8 ± 15.2 years, and 71 (62.3%) were men. Colonic polyps/masses were identified in 42 patients. No adverse events from postdiverticulitis endoscopic evaluation were identified.

Four patients (3.5%; 3 women and 1 man) were found to have colorectal adenocarcinoma at the location identified on CT scan. The mean age of the patients with malignancy was 67.3 ± 14.8 years, which was not significantly different from that of the patients without malignancy (59.3 ± 15.1 yr, \( p = 0.15 \); Table 2). None of these 4 patients had undergone any prior CRC screening by endoscopic evaluation.

Twenty-three patients (20.2%) had premalignant polyps: 2 had sessile serrated adenoma, 17 had tubular adenoma, 1 had villous adenoma and 3 had tubulovillous adenoma. Of the 17 patients with tubular adenoma, 4 had lesions 1 cm or larger and none had high-grade dysplasia. The mean age of patients with premalignant findings was 61.5 ± 12.8 years, which was not significantly different from that of the patients who did not have premalignant findings (59.1 ± 15.3 yr, \( p = 0.45 \); Table 3). Of the remaining patients, 11 had hyperplastic adenoma, 1 had benign colon mucosa (\( n = 1 \)), and the pathology result was unavailable for 4.

Querying the provincial cancer registry identified the same 4 patients who were found to have malignancy on follow-up endoscopy. There were no additional cases of CRC among the remaining 281 patients, resulting in an overall prevalence of colon cancer of 1.4% in this group of patients with acute diverticulitis.

**DISCUSSION**

Although there is no definitive evidence to suggest patients with diverticular disease are at higher risk of cancer, historically the overlapping features of diverticulitis and colon cancer on CT scan made exclusion of malignancy difficult. As a result, endoscopic evaluation of the colon after an episode of acute diverticulitis is currently recommended. The advent of high-resolution CT scanning has improved its diagnostic accuracy and has

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>59.4 ± 15.1</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>61 (49–70)</td>
</tr>
<tr>
<td>Male sex</td>
<td>167 (58.6)</td>
</tr>
<tr>
<td>Female sex</td>
<td>118 (41.4)</td>
</tr>
<tr>
<td>CT scan contrast</td>
<td>227 (79.6)</td>
</tr>
<tr>
<td>Intravenous</td>
<td>22 (7.7)</td>
</tr>
<tr>
<td>Oral/rectal</td>
<td>36 (12.6)</td>
</tr>
<tr>
<td>None</td>
<td>11 (3.2%)</td>
</tr>
</tbody>
</table>

CT = computed tomography; IQR = interquartile range; SD = standard deviation.

*Unless otherwise indicated.
challenged the requirement for routine colonoscopy after CT-diagnosed acute diverticulitis.

In our study, initial analysis showed a colon cancer prevalence of 3.5% among the 114 patients who underwent colonic evaluation within 12 months of receiving a CT scan diagnosing diverticulitis. To minimize selection bias, we included patients who underwent surgical resection owing to recurrent/persistent disease and patients who either had a follow-up investigation elsewhere or who had none at all. As none of the patients who underwent surgery had any evidence of malignancy, the prevalence further decreased to 2.9% among those who had direct evaluation of the affected colon segment (i.e., endoscopic and surgical specimen). In order to capture the data for patients who did not undergo direct colonic evaluation and patients whose endoscopic results were not available, we further queried the provincial cancer registry and did not identify any additional cases of malignancy. The combination with population data allowed a nearly 100% follow-up rate for patients included in our study, thus providing an accurate assessment of the prevalence of malignancy among those with CT-diagnosed diverticulitis. The overall CRC prevalence of 1.4% and the adenoma detection rate of 20.2% among those who underwent endoscopic evaluation are both comparable to rates reported previously.16

It is worth noting that, although only 91 of the follow-up examinations were full colonoscopies, the patients who underwent flexible sigmoidoscopies were known to have sigmoid/descending colon diverticulitis. One patient underwent CT colonography, which may be a reasonable alternative to endoscopy for colonic evaluation following acute diverticulitis.17 Of the 4 patients with malignancy identified, 3 had lesions located in the sigmoid colon and 1 patient had synchronous lesions in the transverse colon and cecum. The locations of the lesions during endoscopic examination matched well with those seen on the CT scans. The CT scan findings suggestive of obstruction due to mass-like lesions were present in all 4 patients. Among the patients found to have premalignant adenoma, colonoscopy after diverticulitis was of benefit because none of these patients had undergone any prior endoscopic evaluations. Given that the mean age of these patients was 61.5 years, it is conceivable that had they undergone age-appropriate screening, endoscopic evaluation after the diverticulitis was diagnosed would not have had added benefit.

Recently, several systematic reviews and meta-analyses have demonstrated similar findings to ours, leading the authors of these studies to conclude that routine colonoscopy after an episode of acute diverticulitis is not necessary.18–21 In these studies, the prevalence of CRC among patients with radiologically diagnosed diverticulitis ranged from 1.0% to 2.1%. However, 3 of these studies excluded patients with complicated diverticulitis and patients who underwent surgical management for their diverticular disease.18–20 The exclusion of patients with complicated diverticulitis may introduce selection bias, as the prevalence of CRC was determined only in patients with uncomplicated cases who underwent follow-up colonoscopy. The prevalence of CRC was found to be higher in patients with complicated diverticulitis diagnosed radiologically, leading some authors to conclude that only complicated diverticulitis requires follow-up colonoscopy. Two systematic reviews also included diverticulitis diagnosed on ultrasound,18,19 which is operator-dependent and generally considered inferior to CT scans in terms of diagnostic accuracy, particularly for complicated disease.13,22

**Table 2. Endoscopic findings in the whole study sample (n = 285)**

<table>
<thead>
<tr>
<th>Finding</th>
<th>No. (%) patients</th>
<th>Sex, no. (%) male</th>
<th>Age, mean ± SD, yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenocarcinoma</td>
<td>4 (1.4)</td>
<td>1 (25)</td>
<td>67.3 ± 14.8</td>
</tr>
<tr>
<td>Noncancerous lesion</td>
<td>281 (98.6)</td>
<td>166 (59.1)</td>
<td>59.3 ± 15.1</td>
</tr>
<tr>
<td>Premalignant lesion</td>
<td>23 (8.1)</td>
<td>18 (78.3)</td>
<td>61.5 ± 12.8</td>
</tr>
<tr>
<td>Non-neoplastic lesion</td>
<td>258 (90.5)</td>
<td>148 (57.4)</td>
<td>59.1 ± 15.3</td>
</tr>
</tbody>
</table>

SD = standard deviation.

**Table 3. Malignant and premalignant findings by colonic segment**

<table>
<thead>
<tr>
<th>Finding*</th>
<th>Detection rate, no.</th>
<th>Location, no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenocarcinoma</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Tubular adenoma</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Sessile serrated adenoma</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Tubulovillous adenoma</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Villous adenoma</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hyperplastic polyp</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Descending colon/ sigmoid colon/rectum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Tubular adenoma</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Sessile serrated adenoma</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Tubulovillous adenoma</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Villous adenoma</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Hyperplastic polyp</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

*Endoscopic finding classified based on highest-grade lesion.
It is also not clear whether all the CT scans in the included studies were 64-slice high-resolution scans, as used in our study, which may affect the ability to distinguish malignancy from inflammatory changes.

Brar and colleagues reported an overall prevalence of malignancy in CT-scan diagnosed diverticulitis of 1.6%, but complicated diverticulitis with pericolic or pelvic abscess was associated with a higher rate of invasive malignancy: 5.4%. Although our study did not distinguish between complicated and uncomplicated diverticulitis by examining specific radiological features, our results are in line with those of the aforementioned study. It is possible that in our study, patients with more serious clinical presentation/course were followed more closely and thus were more likely to be assessed endoscopically after the CT scan. This may explain why all the colon cancers were found in the group that underwent endoscopic examination and would, in fact, support that selective follow-up endoscopy suffices to exclude malignancy if high-resolution CT scan findings clearly favour uncomplicated diverticulitis.

The fact that none of the patients with malignancy had any previous endoscopic CRC screening suggests the importance of follow-up after CT-diagnosed diverticulitis in endoscopy-naive patients, who represent a substantial proportion of the population despite CRC screening programs. In addition, similar to the findings of a previous report, suspected mass lesion with obstruction was a common high-resolution CT scan feature shared in all 4 patients with malignancy; this feature could be used in the strategy to identify appropriate patients for follow-up endoscopy.

Taken together, the results from our study suggest that patients with diverticulitis diagnosed on high-resolution CT scan are not at increased risk for colon cancer, and thus routine endoscopic evaluation following the acute episode of diverticulitis to exclude malignancy may not be necessary for all patients. Instead, a more selective approach in which only patients with complicated, severe or recurrent cases of diverticulitis would undergo follow-up colonoscopy seems more appropriate. This approach would allow a more efficient use of limited resources for CRC screening given the current long wait times for colonoscopy in Canada. Using a selective approach, colonoscopy would be offered to those 50 years of age or older who had not undergone previous CRC screening, those with a protracted course or recurrence of diverticulitis despite medical therapy and those with suspicious CT findings, such as a mass lesion with obstruction.

Limitations

Limitations of our study include the retrospective and single-centre design and the relatively low rate of follow-up colonoscopy, which is likely secondary to multiple contributing factors. As our institution is a tertiary care centre providing care to patients from across the province, the patients may have had follow-up evaluation at a local facility closer to home. The low rate is further complicated by the referral-based system and wait time for elective outpatient procedures, resulting in delayed investigation. We chose 1 year as the cut-off because it is felt endoscopic findings past that period of time may not accurately represent the colonic state at the time of diverticulitis diagnosis. However, no additional malignancy was identified in 20 patients who underwent endoscopic evaluation more than 12 months after the diagnosis of diverticulitis. It is also possible that a repeat endoscopic procedure was deemed unnecessary if there had been an endoscopic evaluation within 1 year before the CT scan, as was the case for 20 patients. Ultimately, to address the issue of missing or late colonic evaluations, we queried the provincial cancer registry (which captures more than 99% of all cancers in the province) to identify all patients with a tissue diagnosis of colon cancer. The group of patients at risk of being missed by this method would be those who were not referred to the cancer agency in favour of conservative palliative approach. It should also be noted that the registry did not provide information on colonic polyps.

CONCLUSION

The present study lends further support to a selective approach to determining who should undergo follow-up colonoscopy after resolution of acute diverticulitis diagnosed on CT scan. By performing colonoscopy selectively in patients who have not undergone screening colonoscopy, patients with recurrent/protracted diverticulitis and patients with high-resolution CT findings suggestive of mass lesion with obstruction, we can potentially reduce the number of unnecessary procedures and optimize the utilization of limited resources. Additional prospective research to further define the impact of such a selective approach is warranted.

Affiliations: From the Department of Medicine, Division of Gastroenterology (Ou, Rosenfield, Bressler) and the Department of Radiology (Brown), St. Paul’s Hospital, University of British Columbia, Vancouver, BC; the Department of Medicine, Vancouver General Hospital, University of British Columbia, Vancouver, BC (Chan); the Department of Family Medicine, University of Calgary, Calgary, Alta (Hong); and the Department of Medical Oncology, British Columbia Cancer Agency, University of British Columbia, Vancouver, BC (Lim).

Competing interests: None declared.

Contributors: G. Rosenfeld, J. Brown, N. Chan and B. Bressler designed the study. G. Ou, J. Brown, N. Chan, T. Hong and H. Lim acquired the data, which G. Ou, G. Rosenfield, N. Chan and B. Bressler analyzed. G. Ou, G. Rosenfeld and B. Bressler wrote the article, which all authors reviewed and approved for publication.

References

Traffic in the operating room during joint replacement is a multidisciplinary problem

Background: Door openings disrupt the laminar air flow and increase the bacterial count in the operating room (OR). We aimed to define the incidence of door openings in the OR during primary total joint arthroplasty (TJA) surgeries and determine whether measures were needed and/or possible to reduce OR staff traffic.

Methods: We recorded the number of door openings during 100 primary elective TJA surgeries; the OR personnel were unaware of the observer’s intention. Operating time was divided into the preincision period, defined as the time from the opening of surgical trays to skin incision, and the postincision period, defined as time from incision to dressing application.

Results: The mean number of door openings during primary TJA was 71.1 (range 35–176) with a mean operative time of 111.9 (range 53–220) minutes, for an average of 0.64 (range 0.36–1.05) door openings/min. Nursing staff were responsible for 52.2% of total door openings, followed by anesthesia staff at 23.9% and orthopedic staff at 12.7%. In the preincision period, we observed an average of 0.84 door openings/min, with nursing and orthopedic personnel responsible for most of the door openings. The postincision period yielded an average of 0.54 door openings/min, with nursing and anesthesia personnel being responsible for most of the door openings.

Conclusion: There is a high incidence of door openings during TJA. Because we observed a range in the number of door openings per surgery, we believe it is possible to reduce this number during TJA.

Contexte : Les ouvertures de porte perturbent le flux laminaire et accroissent la numération bactérienne au bloc opératoire. Nous avons voulu mesurer l’incidence des ouvertures de porte au bloc opératoire durant les chirurgies pour prothèse articulaire totale (PAT) et déterminer si des correctifs étaient requis ou s’il était possible de réduire la circulation du personnel au bloc opératoire.


Résultats : Le nombre moyen d’ouvertures de porte par intervention pour PAT primaire a été de 71,1 (entre 35 et 176) et la durée moyenne des interventions a été de 111,9 (entre 53 et 220) minutes, pour une moyenne de 0,64 (entre 0,36 et 1,05) ouverture/minute. Le personnel infirmier était responsable de 52,2 % du nombre total d’ouvertures de porte, suivi du personnel d’anesthésie avec 23,9 % et du personnel d’orthopédie avec 12,7 %. Durant la période pré-incision, nous avons observé une moyenne de 0,84 ouverture de porte/minute, le personnel infirmier et d’orthopédie ayant été responsable de la majorité des ouvertures de porte. La période post-incision a donné lieu à une moyenne de 0,54 ouverture de porte/minute, le personnel infirmier et d’anesthésie ayant été responsable de la majorité des ouvertures de porte.

Conclusion : On observe un nombre important d’ouvertures de porte durant les interventions pour PAT. Étant donné que ce nombre varie, nous croyons qu’il est possible de le réduire.

Martin Bédard, MD
Rémi Pelletier-Roy, BSc
Mathieu Angers-Goulet, BSc
Pierre-Alexandre Leblanc, BSc
Stéphane Pelet, MD, PhD

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Correspondence to:
M. Bédard
CHU de Québec
Hôpital de l’Enfant Jésus de Québec
1401, 18e rue
Québec QC G1J 1Z4
martinbedard@videotron.ca

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Infection following total joint arthroplasty (TJA) remains a disastrous complication for both the patient and surgeon. The total cost for a prosthetic joint infection (PJI) has been calculated by Sulco to be as high as $50,000–$60,000 per case. Revision following PJI is 2.8 times more expensive than for loosening and 4.8 times more expensive than primary TJA.2 The incidence of PJI, 1%–2% for primary TJA, is a major concern and warrants a concerted effort to reduce patient morbidity and improve global health care efficacy.

Patient-related and environmental factors3 have been studied in order to reduce PJI. The number of staff in the operating room (OR) is exponentially linked to the incidence of door openings during surgical interventions.4 Door opening is believed to disrupt the laminar flow5 and could thus lead to more bacteria and contamination over the wound and possibly lead to intraoperative infection.4,6–11 Thus far, only 1 study has measured the incidence of door opening during TJA.11 Other studies defining OR traffic patterns were either not specific to orthopedic procedures or had a very limited number of orthopedic cases.5

In order to reduce the infection rate in our centre, we sought to define the incidence of door openings in the OR during primary TJA and to determine whether measures were needed and/or possible to reduce staff traffic.

Methods

In a 2-month period beginning in August 2013, 100 consecutive TJAs (59 total knee [TKA] and 41 total hip [THA] arthroplasties) were performed at our institution and were included in this study. At our institution, TJAs are performed simultaneously in 3 different ORs, with each room having 2 doors, 1 opening in a sterile corridor (internal) and 1 opening in a nonsterile corridor (external). Anesthesia equipment is located close to the external door and surgical equipment close to the internal door. There is agreement at our institution that the external door should be locked during TJA. Equipment close to the external door and surgical equipment is located close to the internal door. Patient positioning is performed by OR attendants. For every procedure, the surgeon is present in the OR immediately after the patient’s arrival in the OR. Every room is equipped with a vertical laminar air flow.

To perform the study, we used a Microsoft Excel spreadsheet to record data. Patient-related and environmental factors3 have been studied in order to reduce PJI. The number of staff in the operating room (OR) is exponentially linked to the incidence of door openings during surgical interventions.4 Door opening is believed to disrupt the laminar flow5 and could thus lead to more bacteria and contamination over the wound and possibly lead to intraoperative infection.4,6–11 Thus far, only 1 study has measured the incidence of door opening during TJA.11 Other studies defining OR traffic patterns were either not specific to orthopedic procedures or had a very limited number of orthopedic cases.5

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Three observers (R.P.R., P.A.L. and M.A.G.) were responsible for recording every door opening on a standardized sheet; 1 observer was present during each surgery. The OR staff were blinded to the real intention of the observers and were told the observers were medical school students on an observational arthroplasty rotation. This strategy was implemented in order to reduce any impact the observers could have on the behaviour of OR staff and thus on the true incidence of door opening. Also, none of the observers participated in any door opening as they were on site well before the trays were opened and after the closure of the surgical site. Surgeries were performed by a group of 10 orthopedic surgeons practising TJA at our institution. Data were recorded using a Microsoft Excel spreadsheet.

The primary data recorded were the number of door openings for both OR doors (internal and external). Door opening was defined as the opening of the door itself, regardless of how many people passed by or how long the door remained open. Every door opening was then classified by 2 other characteristics: the time period in which it occurred (preincision or postincision) and by the type of OR personnel who opened the door. The preincision period was defined as the time from the opening of surgical trays to skin incision, and the postincision period was defined as the time from incision to dressing application. The personnel categories were orthopedic, nursing, anesthesia, sales representative, radiology and other. The OR attendants were classified as “other.” In the case of multiple types of staff entering the OR at the same time, the opening was attributed only to the person who opened the door. The observers also collected secondary data, including date, preparation time, duration of surgery, case number, type of surgery (TKA or THA) and body side, surgeon’s name and the number of staff present for each specialty. Preparation and operating duration were recorded to allow us to determine a door opening rate per minute.

Statistical analysis

Using the descriptive data recorded, we performed a univariate analysis. The arithmetic mean was the central tendency method used to describe the number of door openings, the duration of each period (preincision, postincision and total duration of surgery) and the number of staff per personnel type present in the OR. The specific door opening rate ratios were obtained by dividing the mean number of door openings per period by the mean duration of each period. The statistical dispersion of the data is shown according to its range. We used frequency tables and a histogram to represent the frequency distribution of door openings per period, per door type and per personnel type.

Data analysis was performed using Microsoft Excel.

Results

A total of 7110 door openings were recorded for 100 primary TJA surgeries. With an average total duration of surgery of 111.9 (range 53–220) minutes and an average number of door openings of 71.1 (range 35–176), the average rate was 0.64 (range 0.36–1.05) door openings/min (Table 1). The door opening rate for all TJA surgeries was 0.84 (range 0.42–1.76) door openings/min during the preincision period and 0.54 (range 0.19–0.89) door openings/min during the postincision period. For THA surgeries alone, the rate was 0.82 (range 0.47–1.73) door openings/min in the preincision period, 0.58 (range 0.32–0.89) in the postincision period and 0.66 (range 0.37–1.05) for both periods. For TKA surgeries alone, the
rate was 0.87 (range 0.42–1.76) door openings/min in the preincision period, 0.51 (range 0.19–0.87) in the postincision period, and 0.62 (range 0.36–0.93) for both periods. The difference in the rate of door openings between THA surgeries and TKA surgeries was not statistically significant ($p=0.60$).

The internal door accounted for 95.6% of the openings, while the external door accounted for 4.4%. A total of 40.4% of the door openings occurred during the preincision period compared to 59.6% in the postincision period (Table 2). The preincision period lasted an average of 34.1 (range 16–94) minutes, for a rate of 0.84 door openings/min was calculated. The postincision period lasted an average 77.8 (range 35–161) minutes, with 0.54 door openings/min. The difference in the absolute number of door openings can be explained by the duration of these 2 periods (Table 3).

Different door opening patterns were observed in the OR with respect to a specific time period or door type. Nursing staff were responsible for 52.2% of total door openings during primary TJAs. Anesthesia personnel came second with 23.9% of total door openings and 69% of external door openings. Orthopedic staff contributed to 12.7% of total door openings and 30% of internal door openings during the preincision period (Table 4).

There was an average of 12 (range 7–19) people in the OR for each performed TJA. Nursing personnel were a mean of 4 (range 2–9) people and were responsible for a mean of 37.1 (range 11–104) door openings, for a mean of 10.0 door openings per nurse per case. Anesthesia personnel were a mean of 3 (range 2–9) people and were responsible for a mean of 17.0 (range 1–46) door openings, for a mean of 5.2 door openings per anesthesia personnel per case. Orthopedic surgery personnel were a mean of 3 (range 2–6) people and were responsible for a mean of 9 (range 2–22) door openings, for a mean of 3.3 door openings per orthopedic personnel per case. Although sales representatives are not frequently present for routine TJAs cases at our institution, they were responsible for an average of 8.0 door openings per case. Table 5 depicts further details about OR personnel population and average door openings by individual.

**Discussion**

Door opening is thought to disrupt the positive laminar flow system of the OR, possibly introducing more bacteria into the OR and potentially contributing to contamination of the wound. Furthermore, the number of people in the OR is known to be one of the most important factors related to the bacterial count in the OR and has been found to be exponentially linked to the number of door openings. With the combination of these 2 factors, OR traffic could be associated with a higher infection rate, although this link has not yet been proven. With infection rates close to 1% for primary TJA and occurrence of infection depending on many variables, a study designed to measure the direct influence of OR traffic on PJI would require an enormous study population and would be technically difficult to realize. The main objective of our study was to define the incidence of door openings in the OR during primary elective TJA.

<table>
<thead>
<tr>
<th>Table 1. Rate of door openings for total joint arthroplasties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>THA</td>
</tr>
<tr>
<td>TKA</td>
</tr>
<tr>
<td>Overall</td>
</tr>
</tbody>
</table>

THA = total hip arthroplasty; TKA = total knee arthroplasty.

<table>
<thead>
<tr>
<th>Table 2. Door openings by door type and time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door type</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Internal</td>
</tr>
<tr>
<td>External</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Variables used to calculate the rate of door openings per period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>No. of door openings</td>
</tr>
<tr>
<td>Duration</td>
</tr>
<tr>
<td>Door opening/min</td>
</tr>
</tbody>
</table>
The rate of door openings recorded in our study was 0.64 door openings/min. This represents an extremely high incidence of door openings during TJA even though such a procedure is known to need a particularly aseptic environment. The high variation of door openings for the same operation duration (range 0.36–1.05 door openings/min) shows that reduction of the OR traffic should be possible.

Some specialties were more frequently involved in door openings during a specific time period or for a particular door. Whereas nurses accounted for more than half of the door openings (52% for both the pre- and postincision periods), anesthesia staff were responsible for more than 69% of the external door openings. Orthopedic staff were responsible for about 28% of the door openings in the preincision period. Although we did not record the reasons for door openings in this study in order to preserve confidentiality, some of the reasons included leaving to retrieve a necessary instrument or implant, staff rotation for breaks, checking with OR staff to confirm that the surgery can proceed, talking with colleagues in the corridor, and coordinating nursing and anesthesia personnel. Some of these reasons are justified, while others represent bad behaviours that offer an opportunity to reduce the number of door openings during surgery.

A previous study reported a door opening rate of 0.65 door openings/min for primary TJA, which is similar to the rate of 0.64 door openings/min found in our study. The weakness of the previous study was a change during the investigation regarding counting start time, which could have modified their true rate of door openings per minute. Lynch and colleagues compared OR traffic in different surgical subspecialties and found a rate of 19–50 door openings/hr. A rate of 0.32 door openings/min was found to be unacceptable in cardiac surgery (average of 19.2 door openings/hour)9. These data confirm that OR traffic is alarmingly high and that this situation is present not only in our particular OR, but also in other institutions. Unfortunately, the few published articles on this topic do not allow for the creation of a norm regarding OR personnel traffic.

**Limitations**

There were some limitations to our study. Classification of door opening by specialty was ambiguous when different staff was entering the OR at the same time. We attributed the opening to the first person going through the door, but this could be a hazardous classification. In addition, we did not report the reason for each door opening in order to avoid the OR personnel becoming aware of the nature of our study. While in some instances the reason was obvious, at other times it was not. In these latter cases, we would not have been able to inquire about the reason for the door opening without raising the suspicions of the OR personnel and risk revealing the goal of our study.

One variable that was not taken into account was the cumulative time for which the door remained open. Instead of opening the door 2 times to leave and return, OR staff would sometimes hold the door open. This was recorded as only 1 door opening, while it could have been more damaging than 1 or even 2 shorter door openings. In addition, the speed at which the door was opened could

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Preincision, %</th>
<th>Postincision, %</th>
<th>Total duration</th>
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</thead>
<tbody>
<tr>
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<td>External</td>
<td>Total</td>
<td>Internal</td>
</tr>
<tr>
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<td>66</td>
<td>18</td>
</tr>
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<td>Nursing</td>
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<td>18</td>
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</tr>
<tr>
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<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Radiology</td>
<td>0</td>
<td>7</td>
<td>0.6</td>
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<tr>
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<td>21.4</td>
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<table>
<thead>
<tr>
<th>Personnel</th>
<th>No. staff, mean (range)</th>
<th>No. door openings, mean (range)</th>
<th>No. door openings per individual, mean</th>
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</thead>
<tbody>
<tr>
<td>Orthopedic</td>
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<td>9.0 (2–22)</td>
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</tr>
<tr>
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<td>17.0 (1–46)</td>
<td>5.2</td>
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<tr>
<td>Nursing</td>
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<td>37.1 (11–104)</td>
<td>10.0</td>
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<tr>
<td>Representative</td>
<td>0.1 (0–2)</td>
<td>0.8 (0–26)</td>
<td>8.0</td>
</tr>
<tr>
<td>Radiology</td>
<td>0.2 (0–2)</td>
<td>0.5 (0–16)</td>
<td>2.5</td>
</tr>
<tr>
<td>Others</td>
<td>1.9 (0–5)</td>
<td>6.7 (0–21)</td>
<td>3.5</td>
</tr>
<tr>
<td>Total</td>
<td>11.8 (7–19)</td>
<td>71.1 (35–176)</td>
<td>6.0</td>
</tr>
</tbody>
</table>
not be recorded in this study. It is known that the faster the door opens, the more air displacement occurs in the OR.\(^1\) Having 3 different observers could have introduced an interobserver bias, so the data to be collected were deliberately simple to classify. Omitting the more complex variables (eg, multiple staff entry, time and speed of door opening) was standardized by a protocol sheet provided to every observer to reduce such possible error.

While we recognize that reducing the number of door openings is the number of unnecessary door openings can be greatly reduced to achieve a cleaner operating environment. First and foremost, decreasing the number of door openings requires better education of all OR personnel, as personnel from several disciplines were involved in the high rate of door openings recorded at our institution. Personnel should be made aware of the potential link between OR traffic and infection rates. They should also be made aware of the alarmingly high rate of door openings and how this disrupts airflow in the OR, potentially introducing microbes into the surgical site. More specifically, OR staff need to be educated about their own personal implication with regards to which door they opened during which period and for what reason. We propose suggestions that may further reduce the number of unnecessary door openings. Locking the external door immediately after the entry of the patient into the OR should be emphasized. Staff schedule should be organized in such a way that staff rotation during each TJA is minimized and ideally reduced to zero. Rotation of scrubbed staff should not be tolerated. Having attendants specifically assigned to a particular OR could potentially decrease the incidence of door openings, especially in the preincision period. Bad behaviours, such as opening the door to check if the case is ready for the surgeon or getting more anesthetic supply for the next case should be eliminated. If someone’s presence in the OR does not directly benefit the patient, this person should not enter.

Although education is the best way to make personnel aware of the problem of high OR traffic, monitoring OR traffic may be a method of discouraging staff from entering or leaving the OR unnecessarily. This could be achieved either by video-recording personnel entering and leaving the OR during surgery or by installing automatic meters that record who enters and leaves the OR during surgery. While it would seem that personnel might alter their behaviour knowing that their entering and leaving the OR was being monitored, 1 study reported no difference in the time between door swings and no difference in the maximum or minimum number of people in the OR during surgical procedures when OR personnel knew their movements were being monitored.\(^8\)

**CONCLUSION**

There is a high incidence of door openings during TJA. This situation can increase the risk of PJI. High variations in door openings for the same duration of surgery show that reduction of the OR traffic is feasible and should be a priority. Education of OR personnel is the key to reducing door openings during TJA and potentially help decrease associated PJI.

**Affiliations:** From the Department of Orthopedic Surgery, CHU de Québec, Hôpital de l’Enfant-Jésus, Québec, Que. (Bédard, Pelet); and the Faculty of Medicine, Université Laval, Québec, Que. (Bédard, Pelletier-Roy, Angers-Goulet, Leblanc, Pelet).

**Competing interests:** None declared.

**Contributors:** M. Bédard and S. Pelet designed the study. R. Pelletier-Roy, M. Angers-Goulet, P.A. Leblanc and S. Pelet acquired the data, which M. Bédard, R. Pelletier-Roy and S. Pelet analyzed. M. Bédard and R. Pelletier-Roy wrote the article, which all authors reviewed and approved for publication.

**References**

Prognostic value of lymph node ratio in survival of patients with locally advanced rectal cancer

Di Zhou, MS  
Ming Ye, MS  
Yongrui Bai, MD  
Ling Rong, BS  
Yanli Hou, BS

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Correspondence to:  
M. Ye  
Department of Radiation Oncology, Renji Hospital  
Shanghai Jiaotong University School of Medicine  
Shanghai 200127, China  
sammy0804@sina.com

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Background: The lymph node ratio (LNR) has been shown to be an important prognostic factor in patients with gastric, breast, pancreatic and colorectal cancer. We investigated the prognostic impact of the LNR in addition to TNM classification in patients with locally advanced rectal cancer.

Methods: We retrospectively analyzed patients who underwent curative resection for locally advanced rectal cancer between July 2005 and December 2010. We determined the LNR cutoff value using a receiver operating characteristic curve. The Kaplan–Meier method was used to estimate survival curves, while Cox regression analyses were used to evaluate the relationship between LNR and survival.

Results: We included 180 patients aged 28–83 years with median follow-up of 41.8 months. The median number of lymph nodes examined and lymph nodes involved were 11.5 and 4, respectively, and the median LNR was 0.366. An LNR of 0.19 (19%) was the cutoff point to separate patients with regard to median overall survival. Median overall survival was 64.2 months for patients with an LNR of 0, 59.1 for an LNR of 0.19 or less and 37.6 for an LNR greater than 0.19 (*p* = 0.004). The median disease-free survival was 32.9 months for patients with an LNR of 0, 30.4 for an LNR of 0.19 or less and 17.8 for an LNR greater than 0.19 (*p* = 0.002).

Conclusion: Our results suggest that LNR should be considered an additional prognostic factor in patients with locally advanced rectal cancer.

Contexte : Il a été démontré que le ratio de ganglions lymphatiques positifs est un important facteur pronostique chez les patients atteints de cancer de l’estomac, de cancer du sein, de cancer du pancréas et de cancer colorectal. Nous avons étudié l’incidence pronostique de l’utilisation de ce ratio en plus de la classification TNM chez les patients présentant un cancer du rectum localement avancé.

Méthodes : Nous avons analysé rétrospectivement des patients ayant subi une résection curative visant à traiter un cancer du rectum localement avancé entre juillet 2005 et décembre 2010. Nous avons déterminé la valeur seuil du ratio de ganglions lymphatiques positifs à l’aide d’une courbe caractéristique de la performance. La méthode de Kaplan-Meyer a été utilisée pour estimer les courbes de survie, tandis que le modèle de régression des hasards proportionnels de Cox a servi à évaluer la corrélation entre le ratio et l’étude et la survie.

Résultats : Notre étude a porté sur 180 patients de 28 à 83 ans dont la durée médiane du suivi était de 41,8 mois. Les nombres médians de ganglions lymphatiques examinés et de ganglions lymphatiques positifs étaient de 11,5 et 4, respectivement, et le ratio médian de ganglions lymphatiques positifs était de 0,366. Nous avons utilisé une valeur seuil de 0,19 (19 %) pour séparer les patients en ce qui a trait à la survie globale médiane. Cette mesure était de 64,2 mois pour les patients présentant un ratio de 0, de 59,1 mois pour ceux présentant un ratio de 0,19 ou moins, et de 37,6 mois pour ceux dont le ratio était supérieur à 0,19 (*p* = 0,004). La survie sans récidive médiane était de 32,9 mois pour les patients présentant un ratio de 0, de 30,4 mois pour ceux présentant un ratio de 0,19 ou moins, et de 17,8 mois pour ceux dont le ratio était supérieur à 0,19 (*p* = 0,002).

Conclusion : Nos résultats indiquent que le ratio de ganglions lymphatiques positifs devrait être envisagé comme facteur pronostique supplémentaire pour les patients atteints d’un cancer du rectum localement avancé.
Colorectal cancer (CRC) is 1 of the 3 most commonly diagnosed malignant tumours worldwide. Its incidence in China has shown an increasing trend in recent years, especially in Shanghai. Epidemiological statistics in 2012 showed that the number of new cases increased from the sixth most numerous to the second most numerous since the 1970s. The morbidity of CRC increased from 12 per 100 000 to 56 per 100 000, and the average annual growth rate was greater than 4%. More than half of the patients had locally advanced CRC at the time of diagnosis.

Currently, the American Joint Committee on Cancer (AJCC)/Union for International Cancer Control (UICC) TNM staging system is considered the most robust tool for predicting prognosis. The lymph nodes (LN) classification of metastasis (pN) is established on the basis of the number of LNs involved (Box 1). A population-based large-scale study revealed that node-negative patients with rectal cancer in whom 7 or fewer LNs were examined had a lower recurrence-free interval than patients in whom at least 8 LNs were examined (17.0% v. 10.7%, p = 0.016). The National Cancer Institute guidelines recommended a minimum of 12 LNs to stage LN-negative CRC. The greater number of LNs retrieved, the greater the chance that metastatic LNs can be found. This results in more accurate disease staging, which would allow more appropriate adjuvant treatment planning and better calculation of a patient’s long-term prognosis.

Berger and colleagues were the first to analyze the LN ratios (LNRs) of patients enrolled in a large adjuvant chemotherapy trial following complete colon cancer (stages II and III) resection using LNR groups based on quartiles. Outcomes included overall survival (OS), cancer-specific survival (CSS) and disease-free survival (DFS). Survival decreased significantly as LNR increased for all 3 outcomes. When a subgroup analysis was performed of the number of positive LNs, this variable was significant only in predicting survival in those who had fewer than 10 LNs in their pathological sample; for those with an LN count of 10–15 or greater than 15, the LNR was once again the most significant predictor of survival.

The LNR has also been shown to be an independent prognosticator in patients with rectal cancer. Peng and colleagues were the first to demonstrate the association between LNR and survival rate in patients with rectal cancer. They reported that LNR was an independent risk factor for local recurrence, DFS and OS. In these studies, the LNR cutoff values were 0.01–0.61. Some studies used LNR quartiles, while others used median LNR. This may be related to cancer stage, patient race, sample size and other factors.

It is well known that the survival rate for locally advanced rectal cancer, especially stage III, varies widely. According to the seventh edition of the TNM classification, patients with stage III cancer are classified based on the number of positive nodes. Intuitively, it seems safe to believe that the prognostic significance of 5 positive nodes out of a total of 5 will be completely different from 5 positive nodes out of a total of 30. The LNR has been shown to be an important prognostic factor in gastric, breast, pancreatic and CRC.10,11

In this study, we sought to evaluate the prognostic impact of the LNR in patients with locally advanced rectal cancer.

**METHODS**

**Patients and pretreatment evaluation**

We retrospectively analyzed patients who underwent curative resection for locally advanced rectal cancer between July 2005 and December 2010 at Renji Hospital, Shanghai Jiaotong University of Medicine. We excluded patients who underwent local excision. All of the participants underwent a digital rectal examination, colonoscopy with biopsy, abdominal and pelvic computed tomography (CT) and chest radiography.

**Treatment**

All patients underwent radical resection. Abdominoperineal resection or low anterior resection was performed according to the surgeon’s preference. Adjuvant chemoradiotherapy (CRT) was scheduled for 4–8 weeks after surgery. Postoperative radiotherapy consisted of a total dose of 45 Gy delivered to the pelvis in 25 fractions or 46 Gy delivered to the pelvis in 23 fractions. The clinical target volume was demarcated as follows: the superior border was located 1.5 cm above the sacral promontory (L5 level), the inferior border was located below the perineal scar, the lateral border was located 1.5 cm lateral to the bony pelvis, the anterior border included one-quarter to one-third of the posterior wall of the bladder, and the posterior border was located 0.5 cm posterior to the sacral surface. Chemotherapy included a bolus injection of fluorouracil (5-FU) and leucovorin (LV) for the first and last week of radiotherapy or capecitabine administered daily during radiotherapy.

**Follow-up**

All of the patients who were registered in the prospective rectal database attended postoperative follow-up visits every 3 months for 2 years. Physical examinations, serum carcinoembryonic antigen level measurements, chest radiography and abdominal and pelvic CT were performed at each follow-up visit. Bone scintigraphy and colonoscopy

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**Box 1. Lymph nodes (LN) classification of metastasis (pN)**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
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<tbody>
<tr>
<td>pN1a</td>
<td>Metastases in 1 regional LN</td>
</tr>
<tr>
<td>pN1b</td>
<td>Metastases in 2–3 regional LNs</td>
</tr>
<tr>
<td>pN1c</td>
<td>Tumour deposits in the subserosa, mesentery, or nonperitonealized pericolic or perirectal tissues without regional nodal metastasis</td>
</tr>
<tr>
<td>pN2a</td>
<td>Metastases in 4–6 regional LNs</td>
</tr>
<tr>
<td>pN2b</td>
<td>Metastases in 7 or more regional LNs</td>
</tr>
</tbody>
</table>

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procedures were performed annually. After 2 years, follow-up visits occurred every 6 months. Follow-up lasted until the cutoff date (Dec. 31, 2013) or until the patient died.

Response evaluation

Treatment outcomes were evaluated as follows. Local failure was defined as any recurrence in the pelvic radiation field, and distant metastasis was defined as recurrence outside the radiation field. Recurrence, whether locoregional or distant, was confirmed histologically or clinically (i.e., tumour that may be associated with clinical deterioration identified on imaging studies and verified with increases in serum carcinoembryonic antigen level). Disease-free survival was defined as the duration from the end of treatment to the time of recurrence, and OS was defined as the duration from the end of treatment to the time of death or to the end of the follow-up period.

Statistical analysis

We analyzed the LNR cutoff value using a receiver operating characteristic (ROC) curve. Survival curves were generated using the Kaplan–Meier method, and differences between the curves were analyzed by the log-rank test. We used the Cox regression model for the multivariate analysis of risk factors for survival outcomes in patients with locally advanced rectal cancer. All statistical tests were 2-sided, and we considered results to be significant at \( p < 0.05 \). We analyzed data using the Statistical Package for the Social Sciences for Windows version 19.0.

Results

Patients

During the study period, a total of 197 patients with locally advanced rectal cancer underwent curative resection at our hospital. We excluded 17 patients (9 had local excision and 8 were lost to follow-up). The remaining 180 patients were included in our analysis. Patient demographic characteristics and pathological features are summarized in Table 1. The study cohort consisted of 111 men and 69 women with an average age of 59 (range 28–83) years. The median numbers of harvested and metastatic LNs were 11.4 (range 3–46) and 4 (range 0–36), respectively. More than 12 LNs were harvested in 97 (53.9%) patients, whereas fewer than 7 were harvested in 32 (17.8%) patients. Most patients received postoperative chemotherapy, and half received postoperative CRT.

LNR

The metastatic LNR is the ratio of pathologically involved LNs to total number of resected LNs. The median LNR was 0.366. We used ROC curves to analyze the predictive value of the LNR (Fig. 1). The cutoff value of LNR was 0.19, at which we observed the most significant difference in OS. Its sensitivity was 51.9% and specificity was 67.3%. The patients were divided into 3 groups based on LNR: LNR = 0 (\( n = 50 \)), LNR ≤ 0.19 (\( n = 15 \)) and LNR > 0.19 (\( n = 115 \)).

Survival analysis

The median duration of follow-up was 41.8 (range 5.4–97.1) months. The 3-year OS and DFS for the 180 patients with locally advanced rectal cancer were 63% and 33%, respectively. The 3-year local recurrence-free survival (LRFS) and distant metastasis-free survival (DMFS) were

<table>
<thead>
<tr>
<th>Table 1. Patient characteristics</th>
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<tbody>
<tr>
<td>Category</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Male</td>
</tr>
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</tr>
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<td>≥ 65</td>
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<tr>
<td>Distance from anal verge, cm</td>
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<td>&lt; 7</td>
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<td>≥ 7</td>
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<tr>
<td>Type of surgery</td>
</tr>
<tr>
<td>APR</td>
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<tr>
<td>LAR</td>
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</table>

APR = abdominoperitoneal resection; LAR = low anterior resection; pN = metastasis classification of lymph nodes; pT = primary tumour classification; TNM = tumour-node-metastasis.
60% and 53%, respectively. The OS curves of the 3 LNR groups differed significantly (Fig. 2). The median OS was 64.2 months for patients with an LNR of 0, 59.1 months for an LNR of 0.19 or less and 37.6 months for an LNR greater than 0.19 \((p = 0.004)\). In addition, the DFS curves of the 3 LNR groups differed significantly (Fig. 3). The median DFS was 32.9 months for patients with an LNR of 0, 30.4 months for an LNR of 0.19 or less and 17.8 months for an LNR greater than 0.19 \((p = 0.002)\). There was no significant difference in LRFS among the 3 groups (Fig. 4).

**Fig. 1.** Receiver operating characteristic (ROC) curve.

**Fig. 2.** The overall survival curve according to the groups by lymph node ratio (LNR). The median overall survival was 64.2 months for patients with an LNR of 0, 59.1 months for an LNR of 0.19 or less and 37.6 months for an LNR greater than 0.19 \((p = 0.004)\).

**Fig. 3.** The disease-free survival (DFS) curve according to the groups by lymph node ratio (LNR). The median DFS was 32.9 months for patients with an LNR of 0, 30.4 months for an LNR of 0.19 or less and 17.8 months for an LNR greater than 0.19 \((p = 0.002)\).

**Fig. 4.** The local recurrence-free survival curve according to the groups by lymph node ratio (LNR). There was no significant difference among the 3 groups \((p = 0.64)\).
The median DMFS was 30.4 months for patients with an LNR of 0.19 or less and 31.3 months for patients with an LNR greater than 0.19 (p = 0.006; Fig. 5).

Univariate analysis showed that sex, age, tumour location and postoperative chemotherapy were not associated with improved OS (Table 2). However, the log-rank test showed that pathology, tumour differentiation, number of harvested LNs, LNR, N stages, TNM stage and postoperative radiotherapy had significant prognostic value in OS and DFS. Mucinous adenoma, poorly differentiated tumours, inadequate LN dissection (<7 harvested LNs), higher LNR, higher N stage, higher TNM stage and no postoperative radiotherapy were associated with significantly decreased OS and DFS. The Cox regression analysis for OS showed that tumour differentiation (p = 0.026), LN examined (p = 0.030), LNR (p = 0.017) and postoperative radiotherapy (p < 0.001) were independent prognostic factors (Table 3).

**DISCUSSION**

Lymph node involvement is one of the most important prognostic factors in rectal cancer. The N stage is established according to the number of involved regional nodes based on AJCC/UICC criteria. There is increasing evidence that the number of LNs alone may not enable adequate rectal cancer staging. Several factors may influence the total LN status, including surgeon skill in achieving total mesenteric excision and the quality assessment of their standard operating procedure, especially for preoperative neoadjuvant therapy, which might downgrade or upgrade pathological stage. Attention has now turned to more accurate pathological markers to help determine prognosis following rectal cancer resection. The metastatic LNR is the ratio of pathologically involved LNs to total resected LNs. The LNR has been shown to be an important prognostic factor in gastric, breast, pancreatic and CRC, but the value of LNR in different studies varies. The purpose of our study was to assess the impact of metastatic LNR on survival in patients with locally advanced rectal cancer, especially on OS, DFS, local failure and distant metastasis.

Huh and colleagues analyzed the data from a total of 514 patients who underwent curative surgery for CRC with proven LN metastases. Patients were categorized into 4 groups on the basis of quartiles: LNR1 (<0.09), LNR2 (0.09–0.18), LNR3 (>0.18 but <0.34), and LNR4 (≥0.34). With a median follow-up of 48.5 months, the 5-year OS rates of patients with LNR1, LNR2, LNR3 and LNR4 were 79%, 72%, 62% and 55%, respectively (p < 0.001), while the 5-year DFS rates were 73%, 67%, 54% and 42%, respectively (p < 0.001). In the multivariate analysis, the LNR was an independent prognostic factor for both OS (p = 0.012) and DFS (p = 0.009), as were pT and pN. The LNR remained significant in patients with fewer than 12 or 12 or more retrieved LNs. Similarly, Lee and colleagues evaluated the prognostic effect of LNR in 154 patients with node-positive rectal cancer and found a prognostic impact of LNR (<0.15, 0.16–0.3 and >0.3) on 5-year OS (90.3%, 75.1%, and 45.1%, p < 0.001) and DFS (66.7%, 55.8%, and 21.9%, p < 0.001) in patients with fewer than 12 or 12 or more harvested LNs. In a study of 180 patients with stage III CRC, Xue and colleagues selected an LNR cutoff point of 0.17 because there was significant distant metastasis difference at that LNR. The LNR correlated independently with distant organ metastasis of CRC and serves as an important predictive factor for estimating prognosis.

In our study, the LNR was once again shown to be an independent predictor of survival in patients with locally advanced rectal cancer following multivariate analysis. Here we focused only on locally advanced rectal cancer (T3/4 or N+), used ROC curves to analyze the predictive value of the LNR, and determined a cutoff value of 0.19. We found that the OS and DFS curves of the 3 LNR groups differed significantly. The median OS was 64.2 months for patients with an LNR of 0, 59.1 months for an LNR of 0.19 or less and 37.6 months for an LNR greater than 0.19 (p < 0.004). In addition, the median DFS was 32.9 months for patients with an LNR of 0, 30.4 months for an LNR of 0.19 or less and 17.8 months for an LNR greater than 0.19 (p < 0.002). Most of the patients enrolled in our study were stage T3 or T4; in contrast, those who were stage T1 or T2 accounted for only 7.8% of the cohort. Perhaps this selection bias was the reason for there being no significant difference between
the 2 groups in LRFS. However, we still found a difference between the 2 groups in DMFS. We guessed that T stage could have a more important impact on local recurrence than N stage. Moreover, we demonstrated that the cutoff of 12 LNs proposed by the AJCC/UICC as a prognostic threshold for correct nodal staging and stratification influences the OS and DFS. The LNR also significantly influenced the OS and DFS, as shown by both univariate and multivariate analysis. The LNR might be more accurate in predicting survival than pathology type and pN stage.

When stratified by LNR, such significant differences in survival for patients with similar pathological staging suggest marked heterogeneity of patients at each stage. Therefore, the LNR could be used to identify high-risk patients who are likely to benefit the most from adjuvant therapy. Following a retrospective analysis of 1098 patients who underwent CRC resection, Thomas and colleagues found that 41% were staged as Dukes C. Sixty-four percent of their patients received chemotherapy. Of the patients who received chemotherapy, 5-year survival was

| Table 2. Univariate analysis according to clinicopathological factors in advanced rectal cancer patients. |
|---|---|---|---|---|
| Factor | No. of patients | Median OS, mo | p value | Median DFS, mo | p value |
| Sex | | | | | |
| Male | 111 | 46.7 | 0.22 | 20.3 | 0.08 |
| Female | 69 | 40.2 | 20.2 |
| Age, yr | | | | | |
| < 65 | 117 | 43.0 | 0.60 | 17.8 |
| ≥ 65 | 63 | 57.9 | 29.6 |
| Distance from anal verge, cm | | | | | |
| < 7 | 111 | 44.7 | 0.98 | 21.9 |
| ≥ 7 | 69 | 42.2 | 19.5 |
| Pathological type | | | | | |
| Canalicular adenoma | 157 | 45.5 | 0.042 | 23.2 |
| Mucinous adenoma | 23 | 34.5 | 16.4 |
| Differentiation | | | | | |
| Well | 28 | 67.5 | 0.007 | 11.2 |
| Moderate | 138 | 46.7 | 0.022 |
| Poor | 14 | 33.4 | 17.7 |
| LNs examined | | | < 0.001 | < 0.001 |
| < 12 | 83 | 39.4 | 15.8 |
| ≥ 12 | 97 | 59.1 | 32.2 |
| LNR | | | 0.004 | 0.002 |
| 0 | 51 | 64.2 | 32.9 |
| ≤ 0.19 | 15 | 59.1 | 30.4 |
| > 0.19 | 114 | 37.6 | 17.8 |
| pN stage | | | < 0.001 | < 0.001 |
| N0 | 46 | 68.5 | 35.4 |
| N1a | 10 | 52.9 | 15.8 |
| N1b | 36 | 59.1 | 16.4 |
| N1c | 12 | 26.7 | 12.7 |
| N2a | 35 | 46.7 | 34.0 |
| N2b | 41 | 27.2 | 20.2 |
| TNM stage | | | < 0.001 | 0.001 |
| II | 46 | 68.5 | 35.4 |
| IIIA | 6 | 75.7 | 24.7 |
| IIIB | 66 | 45.6 | 17.7 |
| IIIC | 62 | 29.7 | 15.8 |
| Postoperative chemotherapy | | | 0.48 | 0.22 |
| Yes | 168 | 45.2 | 20.2 |
| No | 12 | 19.7 |
| Postoperative radiotherapy | | | < 0.001 | < 0.001 |
| Yes | 101 | 59.6 | 34.0 |
| No | 79 | 37.6 | 15.1 |

DFS = disease-free survival; LNs = lymph nodes; LNR = lymph node ratio; OS = overall survival; pN = metastasis classification of lymph nodes; TNM = tumour-node-metastasis.
69.3% for those with an LNR of 0.1 or less and 23.6% for those with an LNR of 0.61 or more. When no chemotherapy was given, the 5-year survival was 43.1% for those with an LNR of 0.1 or less and 8.7% for those with an LNR of 0.61 or more.

According to the current TNM staging system, at least 12 LNs are needed for accurate nodal staging. Neoadjuvant CRT with total mesorectal excision is the standard treatment for T3/4 and/or N1/2 rectal cancer, especially for low rectal cancer. Recent studies\textsuperscript{2,11,18–21} have demonstrated fibrosis and lymphocyte depletion were caused by radiotherapy and/or chemotherapy, probably because of LN atrophy;\textsuperscript{22} and the number of harvested LNs was frequently less than 12. Lee and colleagues\textsuperscript{15} found that fewer than 12 LNs were harvested in 30.5% of patients after preoperative CRT. A study based on the Surveillance, Epidemiology, and End Results registry showed that only 19% of patients with stage III rectal cancer had at least 12 retrieved LNs after preoperative CRT.\textsuperscript{1,3} The decreased LN yield in rectal carcinoma specimens after neoadjuvant radiochemotherapy has no prognostic relevance. In a study by Kang and colleagues\textsuperscript{24} involving 75 node-positive patients who underwent preoperative CRT followed by curative resection, patients were categorized into 2 groups based on a median LNR of 0.143. Patients with lower LNR had better OS. There was no difference in the survival rates of patients with higher LNR and those with N2 stage. We wonder if it is necessary to administer postoperative chemotherapy to those patients who achieve complete pathological response after neoadjuvant CRT. The LNR may help us select more suitable treatment for those patients, and these issues are additional future topics to be validated.

Limitations

Our study had several important limitations, including its relatively small sample size and retrospective design. However, there have been few reports on the prognostic value of LNR in patients with locally advanced disease. Moreover, LNR showed prognostic significance on multivariate analysis, and there were noticeable disparities among the LNR groups in the OS and DFS curves. In contrast to postoperative CRT, preoperative treatment has been shown in several studies to decrease LN yield, whereas other studies reported that preoperative treatment had no effect on LN yield. These results need further validation through a large-scale prospective study.

CONCLUSION

We have shown the LNR to be an important prognostic factor for both the OS and DFS of patients with rectal cancer. We also demonstrated that a ratio of 19% represents the LNR cutoff point for predicting the prognosis of patients with rectal cancer. The LNR can be used with pathological differentiation and pN stage to identify high-risk patients for postoperative treatment.

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Affiliations: All authors are from the Department of Radiation Oncology, Renji Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China.

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Contributors: D. Zhou and M. Ye designed the study. D. Zhou and L. Rong acquired the data, which D. Zhou, Y. Bai, L. Rong and Y. Hou analyzed. D. Zhou and M. Ye wrote the article, which all authors reviewed and approved for publication.

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Patient and observer scar assessment scores favour the late appearance of a transverse cervical incision over a vertical incision in patients undergoing carotid endarterectomy for stroke risk reduction

Background: Carotid endarterectomy (CEA) is a very common operation, but there is no agreement on the appropriate orientation of the surgical incision.

Methods: We retrospectively reviewed the charts of patients who had undergone CEA between Jul. 1, 2010, and Dec. 31, 2013. We contacted patients identified in the review to solicit participation in a clinical follow-up examination, during which the esthetic outcome of the scar was evaluated using the Patient and Observer Scar Assessment Scale (POSAS).

Results: During the study period 237 CEAs were performed. Nine patients refused the use of their personal health information in this study. There were no significant differences in the neurologic outcomes of patients based on the incision orientation (perioperative stroke and death 1.4% with transverse incision v. 0% with a vertical incision, \( p = 0.44 \)). Fifty-two patients presented for follow-up examination. Thirty-three had a transverse incision and 19 had a vertical incision. Results of the POSAS significantly favoured the transverse incision \( (p = 0.03) \). Vertical incisions were more often associated with persistent, mild marginal mandibular nerve dysfunction \( (p = 0.04) \).

Conclusion: Carotid endarterectomy performed through a transverse skin incision compared with a vertically oriented skin incision is associated with improved esthetic outcome, as measured by the POSAS, without an observed statistically significant difference in the risk of perioperative stroke or death between the 2 techniques.

Contexte : L’endartériectomie de la carotide est une intervention chirurgicale très courante. Toutefois, il n’existe aucun consensus sur l’orientation de l’incision.

Méthodes : Nous avons analysé rétrospectivement les dossiers de patients ayant subi une endartériectomie de la carotide entre le 1er juillet 2010 et le 31 décembre 2013. Nous avions communiqué au préalable avec les patients concernés pour solliciter leur participation à un examen de suivi clinique au cours duquel le résultat esthétique de leur cicatrice serait évalué au moyen de l’échelle d’évaluation des cicatrices par les patients et les observateurs (POSAS).

Résultats : Au cours de la période visée, 237 endartériectomies de la carotide ont été pratiquées. Neuf patients ont refusé l’utilisation de leurs renseignements médicaux dans le cadre de l’étude. Aucune différence significative n’a été observée quant aux capacités neurologiques des patients selon l’orientation de leur incision chirurgicale (décès et accident vasculaire cérébral périopératoires : 1,4 % avec incision transversale contre 0 % avec incision verticale, \( p = 0,44 \)). Au total, 52 patients se sont présentés pour un examen de suivi : 33 avaient eu une incision transversale et 19, une incision verticale. Les résultats à la POSAS étaient nettement meilleurs pour les incisions transversales \( (p = 0,03) \). Les incisions verticales étaient plus souvent associées à un dysfonctionnement léger, mais persistant de la branche marginale de la mandibule du nerf facial \( (p = 0,04) \).

Conclusion : Notre étude indique que d’après la POSAS, l’endartériectomie de la carotide est associée à un meilleur résultat esthétique lorsqu’elle est pratiquée au moyen d’une incision cutanée transversale qu’au moyen d’une incision verticale. Par ailleurs, aucune différence statistiquement significative n’a été observée quant aux risques de décès et d’accident vasculaire cérébral périopératoires associés à l’une ou l’autre de ces 2 techniques.
The utility of carotid endarterectomy (CEA) in preventing transient ischemic attack (TIA) and stroke has been demonstrated in patients with symptomatic and asymptomatic carotid artery stenosis caused by atherosclerosis. Although CEA is very common and has been performed for more than 50 years, the specific surgical technique is variable from surgeon to surgeon with respect to the use of general or local anesthesia, eversion or conventional endarterectomy, use of intraoperative shunt and carotid artery patching.

In addition, there is no agreement on the appropriate orientation of the surgical incision. The standard operative approach uses an incision oriented parallel with the anterior border of the sternocleidomastoid muscle. Some surgeons, however, prefer to expose the operative site through an incision that follows the transverse skin creases of the neck. Surgical principles suggest that a transverse incision may provide the patient with a better cosmetic outcome because the scar is oriented along Langer’s lines.

The Patient and Observer Scar Assessment Scale (POSAS) was developed and validated in patients with burn scars and has demonstrated validity in the assessment of linear surgical scars. The POSAS observer score rates the scar on a scale of 1 (normal skin) to 10 (worst scar imaginable) in 5 categories: vascularization, pigmentation, thickness, relief and pliability. Similarly, for the patient component score, the patient self-rates the scar in 6 categories: pain, itching (on a scale of 1 [no complaints] to 10 [worst imaginable]), colour, stiffness, thickness and irregularity (on a scale of 1 [normal skin] to 10 [very different]). The POSAS has previously been used to report on scar outcomes following neck surgery (parathyroidectomy and thyroidectomy), but to our knowledge it has not been applied previously to study differences in the outcomes of vertical and transverse incisions for CEA.

METHODS

Within the geographic region of this study, all CEAs were performed within a single, 3-surgeon vascular surgery practice that provides care to a population of approximately half a million individuals. Carotid endarterectomies performed between Jul. 1, 2010, and Dec. 31, 2013, form the basis of our study.

Cases were identified through a computerized query of the discharge abstract database maintained by the region’s health records department, and hospital charts fitting the inclusion criteria were retrospectively reviewed. We collected data on patient sex, age, date of hospital admission, date of surgery, operating surgeon, operative side, operative indication, degree of internal carotid artery stenosis as documented by ultrasound and/or computed tomography angiography (CTA), presence of diabetes, history of coronary artery disease, presence of atrial fibrillation, history of valvular heart disease, presence of hypertension, hypercholesterolemia or dyslipidemia, renal failure, smoking history, anesthetic type, use of intraoperative neurologic monitoring, use of intraoperative shunt, combination of CEA with another operative intervention under the same anesthetic, neurologic outcome to 30 days postoperatively, postoperative cardiac complications, wound complications (hematoma or infection), date of discharge, and death. Vertical incisions were defined as those oriented parallel to the anterior border of the sternocleidomastoid muscle. Transverse incisions were defined as those parallel to the skin creases of the neck.

All eligible participants identified in our chart review were contacted by telephone to obtain informed consent to participate in the study. Patients who agreed to the retrospective use of hospital chart data were also invited to attend a follow-up visit. During the study follow-up visit, all participants were interviewed and examined by a single observer (M.D.). Participants were asked to complete the patient questionnaire portion of the POSAS and the observer completed the observer portion of the POSAS. The observer also confirmed the orientation of the participants’ surgical scars, confirmed the retrospectively abstracted chart data, and performed a physical examination of the marginal mandibular nerve ipsilateral to the surgical site. Marginal mandibular nerve weakness was classified as absent, mild or severe.

This study was approved by the Research Ethics Boards of Regina Qu’Appelle Health Region and the University of Saskatchewan through a harmonized ethics review process.

Statistical analysis

All data were stored in an anonymized electronic database for analysis, and we analyzed the data using Microsoft Excel. Study subgroups were compared statistically using the Fisher exact test for categorical variables and the Student t test for continuous variables. We used analysis of variance (ANOVA) to compare multiple means and regression analysis to examine possible correlations between continuous variables. Results were considered to be significant at \( p < 0.05 \).

RESULTS

During the study period 237 CEAs were performed. Nine patients refused the use of their personal health information in this study and were excluded from analysis. Of the remaining 228 CEAs performed, 193 were undertaken for symptomatic carotid stenosis, and 35 (15%) were performed in asymptomatic patients. The majority of patients (147 [64%]) had 80%–99% internal carotid stenosis on the operative side, as measured by duplex ultrasonography and/or CTA. The remaining 81 patients had 50%–79% stenosis of the internal carotid artery. All patients who underwent surgery for 50%–79% internal carotid artery...
stenosis had recent ipsilateral, focal neurologic symptoms. The operative indication for symptomatic patients included stroke in 51 (26%) patients, TIA in 95 (49%) and amaurosis fugax in 47 (24%).

Carotid endarterectomies were performed according to the preference of the attending surgeon with regards to the orientation of the incision. One of the 3 surgeons consistently used a vertical incision for all carotid surgeries. The remaining 2 surgeons used both vertical and transverse skin incisions (32% transverse incision and 78% transverse incision, respectively). For 1 patient, a vertical incision was chosen to specifically accommodate a long common carotid artery plaque that extended into the lower neck. In 2 other patients, the incision followed a scar from previous surgery. In the remaining patients, there was no documented reason why the surgeon chose a vertical or transverse incision.

New postoperative strokes within the 30 days after surgery occurred in 4 (1.8%) patients. Three patients died within 30 days of surgery (1.3%). One patient with stroke also died, yielding a combined stroke/death rate of 2.6%.

Eight patients underwent carotid endarterectomies combined with another operative intervention (7 coronary artery bypass grafting, 1 thoracotomy/lobectomy for lung cancer), and 220 patients received CEA alone. Within the group undergoing CEA alone, we observed a stroke rate of 1.4% and a combined stroke/death rate of 2.3%.

We identified 70 patients with a transverse incision on the basis of follow-up observation or clear documentation in the operative report. Similarly, we identified 89 patients with vertical incisions on the basis of follow-up examination or clear documentation in the operative report. A definite incision orientation could not be determined in 69 patients, as these individuals did not present for follow-up, and the incision orientation could not be determined unequivocally from the operative record.

All postoperative strokes occurred in patients in whom the incision orientation could not be determined. Of the patients with a transversely oriented incision, there were no strokes and 1 death (1.4%). In the group of patients with a vertical incision, there were no strokes and no deaths. The difference in the mortality between the groups was not significant ($p = 0.44$).

Most operations were performed with the patients under local anesthesia (72%) and the remainder (28%) were done with the patients under general anesthesia, based on patient preference. Of the operations performed under general anesthesia, approximately half had a planned carotid shunt placed for cerebral protection, while the other half had selective shunting on the basis of intraoperative electroencephalography (EEG) monitoring. The choice of planned shunting or intraoperative monitoring for patients under general anesthesia was based on surgeon preference. Seventy percent of all cases were performed without carotid shunting, 15% had a planned shunt, and 15% of cases had a shunt on the basis of EEG criteria or declining neurologic status in a patient under local anesthesia. A planned carotid shunt did not appear to be associated with the choice of incision orientation. Among patients undergoing planned carotid shunting, a vertical incision was documented in 34% of patients and a transverse incision was documented in 23%; the incision orientation could not be determined in 43%. These findings did not differ significantly from those in which a shunt was not planned (vertical incision 40%, transverse incision 32%, unknown incision 28%, $p = 0.23$).

Of the 228 patients who consented to the use of their health information for this study, 52 patients volunteered for follow-up examination and scar assessment at a mean follow-up of 25.9 ± 3.1 (range 7–48) months after surgery. In this subgroup, 3 patients had transverse incisions and 19 had vertical incisions. None of the 52 patients presenting for follow-up evaluation had CEA combined with another surgery, and none had prior ipsilateral neck surgery, radiation exposure or steroid use. All wound closures had been done with a subcuticular, absorbable, monofilament closure (Monocryl, Ethicon). The outcomes in relation to the incision orientation are shown in Table 1. Observer assessment of the patient’s surgical scar showed a nonsignificant trend favouring the appearance of a transverse scar, whereas patient assessment scores showed a significant preference for the appearance of a transverse scar. The total POSAS score showed a significant result favouring the late appearance of the transverse incision. Severe dysfunction of the ipsilateral marginal mandibular nerve was not observed in any patients presenting for follow-up. We identified mild marginal mandibular nerve dysfunction in 3 of 19 patients with a vertical incision (15.7%) and none of the patients with a transverse incision ($p = 0.044$).

Within this subgroup of 52 patients, there were no observed correlations between the POSAS score and patient age ($R^2 = 0.04$), sex ($p = 0.70$), diabetes ($p = 0.71$), history of coronary artery disease ($p = 0.34$), hypertension ($p = 0.90$), history of hypercholesterolemia ($p = 0.12$), renal insufficiency ($p = 0.85$), smoking ($p = 0.62$), aesthetic type (general v. local; $p = 0.69$), or duration of follow-up ($R^2 = 0.09$). The only variables that showed significant correlation with

### Table 1. Patient outcomes related to the orientation of the carotid endarterectomy incision

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Incision, mean ± SD*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transverse, $n = 33$</td>
</tr>
<tr>
<td>Observer score (out of 50)</td>
<td>9.0 ± 2.7</td>
</tr>
<tr>
<td>Patient score (out of 60)</td>
<td>7.5 ± 2.1</td>
</tr>
<tr>
<td>Total POSAS score (out of 110)</td>
<td>16.5 ± 3.9</td>
</tr>
<tr>
<td>Marginal mandibular nerve dysfunction, no</td>
<td>0 3</td>
</tr>
</tbody>
</table>

POSAS = Patient and Observer Scar Assessment Scale; SD = standard deviation.

*Unless otherwise indicated.
POSAS score were incision orientation ($p = 0.034$) and surgeon ($p = 0.011$). There was a significant covariance between these last 2 factors ($p < 0.001$).

Of the 52 patients for whom a POSAS score was obtained, 34 had surgery under the care of a single surgeon who showed preference for the use of a transverse incision (27 transverse incisions, 5 vertical incisions); 8 patients were under the care of a surgeon who used both types of incisions (4 transverse incisions and 4 vertical incisions), and the remaining 10 patients were under the care of a surgeon who only used the vertical incision. There were no significant differences in POSAS score among the 3 surgeons when considering only patients with vertical incisions ($p = 0.48$), nor was there a significant difference in POSAS score between the 2 surgeons who used transverse incisions when considering only those patients ($p = 0.24$). Owing to the small numbers of patients in the subgroups, we were unable to determine the individual impact of surgeon and incision orientation.

Discussion

In order for an individual patient to benefit from CEA, the long-term stroke reduction afforded by the procedure must outweigh the risk of procedural complications in that individual. This demands technical excellence in the conduct of each CEA to keep the risk of procedural complications low. To satisfy the technical demands of the surgery, intraoperative visualization of the region of the carotid bifurcation must not be compromised. Many carotid surgeons, therefore, prefer the traditional vertical incision that is oriented along the anterior border of the sternocleidomastoid muscle and provides excellent exposure of the surgical site. The vertical incision, however, compromises the surgical principle of orienting an incision along Langer’s lines when possible, to improve wound healing. Our data are consistent with the principle of better healing of incisions parallel to Langer’s lines, with significantly better POSAS scores associated with transversely oriented skin incisions.

There were no significant differences in stroke and mortality rates between the cohorts of patients undergoing surgery with transverse or vertical incisions. We were able to determine stroke and mortality rates from retrospective chart review of 228 patients. Within this sample, we could compare only 70 patients with transverse incisions and 89 patients with vertical incisions. The lack of a measurable difference in stroke and death is reassuring that a transverse incision can afford a good technical outcome from the operation. The strength of this observation, however, is compromised by the inability to determine the incision orientation in 69 patients (30% of the total); all 4 strokes and 2 deaths were observed in this group.

We hypothesized that exposure of the distal internal carotid artery through a transverse neck incision would require greater retraction force on the upper wound edge than a vertically oriented incision and that this would be associated with crushing of the marginal mandibular nerve against the margin of the jaw. However, our observations demonstrated no late marginal mandibular nerve dysfunction in patients with transverse incisions. Marginal mandibular nerve defects were mild and uncommon, and they were observed only in patients with vertical incisions. The reason for the association between vertical incisions and persistent marginal mandibular nerve dysfunction is not clear.

Limitations

There are a number of important limitations to our study that require caution when interpreting the results. This study is limited by its retrospective nature. The choice of vertical or transverse incision was not randomly assigned. With the exception of 1 case in which a vertical incision was selected because of a known common carotid plaque that required extended proximal exposure and 2 cases in which the incision followed a previous surgical scar, there was no documentation to justify the selection of incision orientation. One might consider that planned shunting might be a factor that would favour a vertical incision, but our data did not demonstrate a correlation. It is possible that the choice of incision orientation could be based on factors that are associated with scar cosmesis, but these factors are not apparent in our data, and the elimination of these factors would require a prospective, randomized study.

Nine of 237 (3.8%) patients who underwent CEA during the study period refused the use of their personal health information for this research. Similarly, only 52 of 228 (23%) patients volunteered for follow-up examination using the POSAS. These are potential sources of selection bias that could influence our results.

We did not account for the potential confounding factor of incision length in this study. In the past, other investigators have addressed esthetic outcomes from CEA by using short incisions. Some have demonstrated an increase in transient cranial nerve injury following limited exposure. None of the 3 surgeons performing CEA in our study used incisions of limited length to expose the operative site, and both vertical and transverse incisions were extended as needed to provide adequate exposure of the carotid bifurcation. It is, however, possible that vertical incisions are associated with a greater scar length than transverse incisions, and this could be a confounding factor in scar outcome. Further study will be required, as our data do not address this question.

Finally, within our data set there was covariance between the incision orientation and the operating surgeon. One surgeon used only vertical incisions, whereas another surgeon used mainly transverse incisions. Because of small numbers in the subgroups, we were unable to
ascertain whether total POSAS is determined primarily by the orientation of the incision or by the operating surgeon.

In terms of clinical relevance, our POSAS scores ranged from 11 to 39. The majority of scores were clustered near the reported means. However, the relatively high POSAS scores above 30 were observed only in a subset of patients with vertical incisions. This suggests that vertical and transverse incisions can afford comparable cosmetic outcomes in many patients; however, vertical incisions have a higher risk of an unfavourable cosmetic outcome associated with a high POSAS score.

Other authors have promoted the use of transverse incisions for surgical exposure in CEA. To our knowledge, this is the first study of CEA scar outcomes using the validated POSAS.

CONCLUSION

Carotid endarterectomy performed through a transverse skin incision compared with a vertically oriented skin incision is associated with improved esthetic outcome, as measured by the POSAS, without a significant observed difference in the risk of perioperative stroke or death between the 2 techniques. Vertically oriented incisions may be associated with an increased risk of mild, persistent marginal mandibular nerve dysfunction.

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Affiliations: From the University of Saskatchewan College of Medicine (Deck); the Department of Surgery, Section of Vascular Surgery, University of Saskatchewan (Kopriva); and the Regina Qu’Appelle Health Region (Kopriva), Regina, Sask.

Competing interests: None declared.

Contributors: Both authors designed the study and analyzed the data. D. Kopriva wrote the article, which both authors reviewed and approved for publication.

References

A survey of current practices and preferences for internal fixation of displaced olecranon fractures

Background: Olecranon fractures represent 10% of upper extremity fractures. There is a growing body of literature to support the use of plate fixation for displaced olecranon fractures. The purpose of this survey was to gauge Canadian surgeons’ practices and preferences for internal fixation methods for displaced olecranon fractures.

Methods: Using an online survey tool, we administered a cross-sectional survey to examine current practice for fixation of displaced olecranon fractures.

Results: We received 256 completed surveys for a response rate of 31% (95% confidence interval [CI] 30.5–37.5%). The preferred treatment was tension band wiring (78.5%, 95% CI 73–83%) for simple displaced olecranon fractures (Mayo IIA) and plating (81%, 95% CI 75.5–85%) for displaced comminuted olecranon fractures (Mayo IIB). Fracture morphology with a mean impact of 3.31 (95% CI 3.17–3.45) and comminution with a mean impact of 3.34 (95% CI 3.21–3.46) were the 2 factors influencing surgeons’ choice of fixation method the most. The major deterrent to using tension band wiring for displaced comminuted fractures (Mayo IIB) was increased stability obtained with other methods described by 75% (95% CI 69–80%) of respondents. The major deterrent for using plating constructs for simple displaced fractures (Mayo IIA) was better outcomes with other methods. Hardware prominence was the most commonly perceived complication using either method of fixation: 77% (95% CI 71.4–81.7%) and 76.2% (95% CI 70.6–81.0%) for tension band wiring and plating, respectively.

Conclusion: Divergence exists with current literature and surgeon preference for fixation of displaced olecranon fractures.

Contexte : Les fractures de l’olécrâne représentent 10 % des fractures des membres supérieurs. On trouve dans la littérature de plus en plus d’articles à l’appui de l’utilisation d’une fixation avec plaque pour les fractures déplacées de l’olécrâne. Le but de cette enquête était d’évaluer les pratiques et les préférences des chirurgiens canadiens en ce qui concerne les méthodes de fixation internes dans les cas de fractures déplacées de l’olécrâne.

Méthodes : À l’aide d’un outil de sondage en ligne, nous avons mené une enquête transversale afin de vérifier les pratiques actuelles en matière de fixation des fractures déplacées de l’olécrâne.

Résultats : Nous avons reçu 256 questionnaires dûment remplis, pour un taux de réponse de 31 % (intervalle de confiance [IC] de 95 % 30,5–37,5 %). Le traitement préféré pour les fractures déplacées simples de l’olécrâne (Mayo IIA) était le cerclage-haubanage (78,5 %, IC de 95 % 73–83 %), et pour les fractures déplacées comminutives de l’olécrâne (Mayo IIB), la fixation par plaque (81 %, IC de 95 % 75,5–85 %) des répondants. Un impact moyen de 3,31 (IC de 95 % 3,17–3,45) exercé par la morphologie de la fracture et un impact moyen de 3,34 (IC de 95 % 3,21–3,46) exercé par la comminution ont été les 2 facteurs ayant le plus influé sur le choix des chirurgiens quant à la méthode de fixation. Le principal argument contre l’utilisation du cerclage-haubanage pour une fracture comminutive déplacée (Mayo IIB) était la stabilité accrue obtenue avec d’autres méthodes décrites par 75 % (IC de 95 % 69–80 %) des participants. Le principal argument contre l’utilisation des plaques pour les fractures simples déplacées (Mayo IIA) était l’obtention de résultats meilleurs avec d’autres méthodes. La complication la plus souvent perçue en lien avec l’une ou l’autre des méthodes de fixation avait trait au matériel : 77 % (IC de 95 % 71,4–81,7 %) et 76,2 % (IC de 95 % 70,6–81,0 %) pour le cerclage-haubanage et la fixation par plaque, respectivement.

Conclusion : Il existe des divergences entre la littérature actuelle et les préférences des chirurgiens en ce qui concerne la fixation des fractures déplacées de l’olécrâne.
Olecranon fractures are a common injury representing 10% of upper extremity fractures. The standard treatment for displaced olecranon fractures is open reduction and internal fixation (ORIF), with typical methods including tension band wiring or plating. The chosen method of surgical intervention depends on many factors, including the amount of bone loss, the amount of comminution, the stability of the joint and the ability to reduce the articular surface.

Displaced noncomminuted olecranon fractures were traditionally treated using tension band wiring, which was first described by Weber and Vasey. This method was designed with the theory that early mobilization would create tensile forces across the fracture that would be converted to compression forces and prevent nonunion, while minimizing the loss of range of motion. It has recently been shown that this principle is applicable only during active extension through a range of 30–120° of elbow flexion. However, tension band wiring remains a popular method of internal fixation of olecranon fractures. The advantages of tension band wiring compared with plate fixation include shorter surgery and lower cost. Surgeons who use this technique have shown good fracture healing and acceptable range of motion. However, the rates of hardware removal following tension band wiring are significant and reported to be as high as 80%.

Plating techniques have been used for both comminuted and noncomminuted fractures of the olecranon. Plating offers the advantage of increased stability and may be associated with lower rates of hardware prominence. However, such a construct may be considered too bulky for simpler noncomminuted fractures, be associated with longer surgery and be more costly. There is controversy about which internal fixation method for displaced olecranon fractures provides optimal stability, range of motion and lack of complications (e.g., hardware prominence). There are clear advantages and disadvantages to each method, but owing to variability in patient population and injury pattern (simple v. comminuted), determining the best method presents a challenge. We administered a survey to gauge Canadian surgeons’ practices and preferences for internal fixation methods for displaced olecranon fractures. The survey results will help elucidate how surgeons are making treatment decisions and what factors are perceived to be important in choosing an appropriate fixation construct and the complications they experience with them.

**METHODS**

**Survey design**

We created a 10-item survey to assess the preferences and practices of Canadian orthopedic surgeons for the internal fixation of displaced olecranon fractures in adults. The questionnaire addressed surgeons’ preference of methods for internal fixation of displaced noncomminuted versus displaced comminuted fractures as well as the factors dictating their choice of method using a scale from 0 (no impact) to 4 (most impact). The survey differentiated fracture type using the Mayo classification of olecranon fractures, with type IIA described as simple displaced and IIB as comminuted displaced fractures. Notably, type IIA includes both simple transverse and simple oblique fractures, which may be managed differently. Question 5 of the survey asked surgeons to comment on the impact of fracture morphology on treatment decisions in order to account for the broad classification system. Respondents were also surveyed on the factors that deterred them from using a given fixation method for a specific fracture type as well as the most frequently encountered complication with such methods. The questions were closed-ended with multiple-choice options or Likert scales. An “other” option was included when applicable to allow respondents to specify the answer most appropriate for them.

All questions were vetted by experts in the field (B.R, B.P) for clarity and comprehensiveness. In addition, 3 surgeons piloted the survey (face validity), and revisions were made according to their feedback on fixation methods, complications and classification (content validity).

**Survey distribution**

The survey was distributed to orthopedic surgeons belonging to the Canadian Orthopaedic Trauma Society (COTS) and Canadian Orthopaedic Association (COA). An email was sent to all members of COTS and COA (833 in total) with a cover letter describing the objectives of the study and providing a link to the survey. We sent 2 follow-up emails, approximately 5 weeks apart, to all nonresponders to remind them to complete the survey.

**Sample size calculation**

To sufficiently power our analysis, we assumed that approximately 75% of surgeons surveyed used tension band wiring or plating for fixation of displaced olecranon fractures. It was calculated that 125 completed questionnaires would be required to produce a 95% confidence interval (CI) of ± 7% for the use of tension band wiring or plating, with an α level of 0.05.

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Statistical analysis

We calculated relative frequencies of the survey questions with their corresponding CIs. We used the Wilson method to calculate CIs for the proportions. We calculated the means and the CIs for the questions that participants were asked to rank on a scale of 0 to 4. We reported percentages and means with their corresponding CIs for survey questions. We used SPSS and Confidence Intervals Analysis software (www.som.soton.ac.uk/research/sites/cia/) for data analysis.

RESULTS

Respondents

There were 833 registered members of the COA and the COTS eligible to participate in this survey. Overall, 256 members responded to our email invitation to complete our survey yielding a response rate of 31% (95% CI 30.5–37.5%). The sample size of 256 completed surveys allowed a 95% CI of ± 4.4%. Of those who completed the survey, 55.5% had an academic practice and 46.5% had a community practice. Of the surgeons surveyed, 94.9% performed 0–20 olecranon surgeries a year (65.6% performed 0–10, and 29.3% performed 10–20).

Management preferences and factors influencing choice

The preferred treatment for simple displaced olecranon fractures (Mayo IIA) according to the surgeons surveyed was tension band wiring (frequency 78.5%, 95% CI 73–83%; Fig. 1). The preferred treatment for displaced comminuted olecranon fractures (Mayo IIB) was plating (frequency 81.0%, 95% CI 75.5–85%; Fig. 2). The 2 most important factors (on a scale of 0 to 4, where 0 indicates no impact and 4 indicates major impact on management) influencing the decision of which fixation method to use were fracture morphology (mean impact 3.31, 95% CI 3.17–3.45) and comminution (mean impact 3.34, 95% CI 3.21–3.46; Fig. 3).

Deterrents to choosing fixation construct

The major deterrents to using plating constructs for simple displaced fractures (Mayo IIA) were decreased time required for alternative methods, as reported by 32.4% (95% CI 27.0–38.4%) of respondents; 35.2% (95% CI 29.6–41.2%) of respondents felt that they had better outcomes with other methods (Fig. 4). “Other” was selected by 29.7% (95% CI 24.4–35.6%) of respondents, who listed cost (n = 43), hardware irritation (n = 20), simplicity/speed (n = 6) and no difference with tension band wiring (n = 7) as deterrents. The major deterrent to using tension band wiring for displaced comminuted fractures (Mayo IIB) was increased stability obtained with other methods of fixation, as described by 75% (95% CI 69–80%) of respondents (Fig. 5).

Complications

Out of all the surgeons surveyed, 77% (95% CI 71.4–81.7%) reported symptomatic hardware prominence as their patients’ major perceived complication with tension band wiring, followed by fracture displacement at 9.4% (95% CI 6.4–13.6%; Fig. 6). For plating, 76.2% (95% CI 70.6–81.0%) of surgeons surveyed stated that symptomatic hardware prominence was the most frequent patient-perceived complication (Fig. 7); approximately 8.2% (95% CI 5.4–12.2%) of surgeons stated “other” as being the most frequent. Specified complications were skin breakdown (n = 3) and longer duration of surgery (n = 3). Eight respondents stated there were no major perceived complications when using plating for displaced olecranon fractures.

Community versus academic setting

Surgeons in academic settings were more likely than those at community hospitals to use plating for noncomminuted olecranon fractures.

![Fig. 1: Responses to the question, “What is your preferred method for the internal fixation of a displaced noncomminuted (Mayo Class IIA) olecranon fracture?”](image)

![Fig. 2: Responses to the question, “What is your preferred method for the internal fixation of a displaced comminuted (Mayo Class IIB) olecranon fracture?”](image)
Fig. 3: Responses to the item, “Please rate the following factors according to their impact on your preferred management of olecranon fractures. Please specify how each factor impacts your management decisions.”

Fig. 4: Responses to the question, “Which factors would deter you from using plating for displaced noncomminuted (Mayo Class IIA) olecranon fractures?”

Fig. 5: Responses to the question, “Which factors would deter you from using tension band wiring for the fixation of displaced comminuted (Mayo Class IIB) olecranon fractures?”
(Mayo class IIA) olecranon fractures (22.5% v. 10.1%). For the treatment of comminuted fractures (Mayo class IIB), in the academic setting 83.1% chose plating and 7.8% chose tension band wiring versus 77.3% and 11.8%, respectively, in the community.

**Discussion**

There is controversy regarding which internal fixation method provides optimal stability, range of motion, cost and lack of complications, including hardware prominence, for displaced olecranon fractures. There are clear advantages and disadvantages to each method, but owing to variability in patient population (age, bone quality), relying on fracture pattern and surgeon preference to determine the best method of fixation presents a challenge. Our survey aimed to gauge surgeons’ practices and decision-making on internal fixation methods for displaced olecranon fractures and compare these practices to the current trends reported in the literature.

According to the literature, many surgeons believe tension band wiring may not be as easy as previously thought, given the high rate of loss of reduction and overall hardware prominence, which has been reported to be as high as 80%.\(^4\)\(^1\)\(^2\)\(^2\)\(^2\) This belief is also reflected by our survey results, which showed the 2 most commonly perceived complications were symptomatic hardware prominence and fracture displacement. Moreover, in our survey the majority of surgeons responded that the optimal fixation of simple displaced olecranon fractures is with an “easy” and “time
efficient” construct: tension band wiring. Authors such as Mullette and colleagues, have emphasized that technical considerations (e.g., engaging the anterior cortex of the ulna using a transcortical approach) of tension band wiring compared with intramedullary wiring help to prevent pin migration and hardware prominence. Interestingly, the major deterrent for using tension band wiring for comminuted fractures was that other constructs, such as plating, were deemed more stable for those patterns.

Proponents of plating state that although it requires more time — it was shown in 1 study to be 25 minutes longer than tension band wiring — plating is generally better at achieving and maintaining anatomic reduction. In our survey, the majority of surgeons responded that the optimal fixation of displaced comminuted olecranon fractures is with plating. Although variability exists in the type of plate and technique used, overall patient satisfaction is high. Many surgeons feel plating is a good fixation method for olecranon fractures, yielding acceptable range of motion, minimal discomfort and good results when used for simple and comminuted olecranon fractures. There was also measurable loss of reduction in the tension band wiring group than the plating group (42% v. 5%). There was also measurable loss of reduction in the tension band wiring group compared with essentially none in the plating group. It was concluded that “settling” of the fracture reduction occurs in many cases with tension band wiring and that, overall, plating should be strongly encouraged when fixing displaced olecranon fractures. Close to 10% of surveyed surgeons stated that when fixing comminuted displaced olecranon fractures they preferred to use tension band wiring. As a principle, tension band wiring is relatively contraindicated when there is comminution of the articular surface. In these cases, a higher degree of stability is required to maintain integrity of the articular surface and in turn maximize functionality of the joint, suggesting the use of plate fixation. Therefore, this indicates a discrepancy between the literature and current practice.

Based on the current evidence, we believe that plating techniques should be used for both displaced noncomminuted and displaced comminuted fractures. However, based on our survey, 78.5% of surgeons use tension band wiring for simple displaced olecranon fractures and believe this technique is more stable (20%), produces better outcomes (35.2%) and requires less time to perform (35.2%). Thus, the beliefs and practices of the Canadian surgeons surveyed may not be completely supported by the existing evidence. In our survey 17% of surgeons felt plating was too expensive for use in simpler fractures. But according to the literature, rates of surgical removal for hardware prominence are significantly higher when using tension band wiring than when using plating, contributing to a higher overall cost. Interestingly, most surgeons (> 75%) felt that when using either construct, the complication most often experienced by patients was hardware prominence. As a result of the substantial rate of hardware prominence requiring surgical removal, as seen in our survey and in the literature, critical evaluation of all options for olecranon fixation is warranted. Only 4% of those surveyed used screw fixation or intramedullary fixation. An economic analysis evaluating cost differences between plating and tension band wiring taking into account additional surgeries should be undertaken, keeping in mind different institutional costs.

Limitations

A limitation of our study was the reliance on surgeons to recall the most frequently experienced complications, which may have led to bias.

Conclusion

Our survey shows that surgeons prefer to fix simple displaced olecranon fractures using tension band wiring and displaced comminuted fractures with plating. Furthermore, the percentage of surgeons preferring tension band wiring was higher in the community than in academic settings for both noncomminuted and comminuted fractures. Fracture morphology and comminution were most influential for guiding their treatment. The major deterrent to using plating for simple fractures was the perception of increased cost, longer duration of surgery and equivalent outcomes using other methods. Likewise, deterrents for using tension band wiring for displaced comminuted fractures were that other constructs available provided better stability. The most common perceived complication experienced using either method was hardware prominence. Our survey results demonstrate that surgical decision-making, in regards to fixation of displaced olecranon fractures, may not be supported by the literature and suggests a discrepancy between Canadian surgeons’ beliefs and practices and the current evidence.

Affiliations: From the Michael G. DeGroote School of Medicine, McMaster University (Thomas); the Department of Surgery, McMaster University (Wood, Farrokhyar, Ristevski, Bhandari, Petrisor); the Division of Orthopedic Surgery, McMaster University (Wood, Ristevski, Bhandari, Petrisor); and the Department of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ont. (Farrokhyar).

Competing interests: None declared.

Contributors: T. Wood, K. Thomas and F. Farrokhyar designed the study. T. Wood and K. Thomas acquired the data, which all authors analyzed. T. Wood and K. Thomas wrote the article, which all authors reviewed and approved for publication.

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References

Reduced time to surgery improves mortality and length of stay following hip fracture: results from an intervention study in a Canadian health authority

Eric Bohm, MD, MSc
Lynda Loucks, PT, MSc
Kristy Wittmeier, PT, PhD
Lisa M. Lix, PhD
Luis Oppenheimer, MD, PhD

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Correspondence to:
E. Bohm
310-1155 Concordia Ave
Winnipeg MB R2K 2M9
ebohm@cjrg.ca

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Background: Existing literature demonstrating the negative impact of delayed hip fracture surgery on mortality consists largely of observational studies prone to selection bias and may overestimate the negative effects of delay. We conducted an intervention study to assess initiatives aimed at meeting a 48-hour benchmark for hip fracture surgery to determine if the intervention achieved a reduction in time to surgery, and if a general reduction in time to surgery improved mortality and length of stay.

Methods: We compared time to surgery, length of stay and mortality between pre- and postintervention patients with a hip fracture using the Kaplan–Meier estimator and Cox proportional hazards model adjusting for age, sex, comorbidities, type of surgery and year.

Results: We included 3525 pre- and 3007 postintervention patients aged 50 years or older. The proportion of patients receiving surgery within the benchmark increased from 66.8% to 84.6%, median length of stay decreased from 13.5 to 9.7 days, and crude in-hospital mortality decreased from 9.6% to 6.8% (all p < 0.001). Adjusted analyses revealed reduced mortality in hospital (hazard ratio [HR] 0.68, 95% confidence interval [CI] 0.57–0.81) and at 1 year (HR 0.87, 95%CI 0.79–0.96). Independent of the intervention period, having surgery within 48 hours demonstrated decreased adjusted risk of death in hospital (HR 0.51, 95%CI 0.41–0.63) and at 1 year postsurgery (HR 0.72, 95% CI 0.64–0.80).

Conclusion: Coordinated, region-wide efforts to improve timeliness of hip fracture surgery can successfully reduce time to surgery and appears to reduce length of stay and adjusted mortality in hospital and at 1 year.

Contexte : La littérature actuelle qui démontre l’impact négatif d’un report de la chirurgie pour fracture de la hanche sur la mortalité repose en bonne partie sur des études d’observation sujettes à des biais de sélection et pourrait surestimer cet impact négatif. Nous avons réalisé une étude interventionnelle pour évaluer des mesures visant à faire respecter un délai maximum de 48 heures avant l’intervention pour fracture de la hanche afin de voir si elles avaient effectivement raccourci le délai avant la chirurgie et si l’abréviation général du délai avant la chirurgie avait réduit la mortalité et la durée du séjour hospitalier.


Résultats : Nous avons recruté respectivement 3525 et 3007 patients de 50 ans ou plus, avant et après l’imposition des mesures. La proportion de patients qui ont été opérés à l’intérieur du délai préconisé a augmenté de 66,8 % à 84,6 %, la durée médiane du séjour hospitalier a diminué de 13,5 à 9,7 jours et le taux brut de mortalité perhospitalière a diminué de 9,6 % à 6,8 % (tous, p < 0,001). Les analyses ajustées ont révélé une réduction de la mortalité perhospitalière (risque relatif [RR] 0,68, intervalle de confiance [IC] de 95 % 0,57–0,81) et à 1 an (RR 0,87, IC de 95 % 0,79–0,96). Indépendamment de la période (avant ou après l’imposition des mesures), le fait d’être opéré dans les 48 heures s’est accompagné d’une diminution du risque ajusté de mortalité en cours d’hospitalisation (RR = 0,51, IC de 95 % 0,41–0,63) et dans l’année suivant la chirurgie (RR 0,72, IC de 95 % 0,64–0,80).

Conclusion : Des efforts coordonnés à l’échelle des régions visant à accélérer l’accès à la chirurgie pour fracture de la hanche peuvent réduire avec succès le délai avant la chirurgie et abréger le séjour hospitalier, en plus de diminuer la mortalité ajustée en cours d’hospitalisation et après 1 an.
Every year, nearly 30,000 Canadians older than 50 years are admitted to hospital with an osteoporosis-related hip fracture. The incidence of hip fracture begins to rise at age 50 and peaks in the eighth decade of life, with the greatest proportion occurring in women. Following fracture, mortality ranges from 4% at 1 month to 33% at 1 year, with approximately 70% of deaths at 1 year attributed to the hip fracture. Thus, in Canada there are an estimated 7000 deaths related to hip fracture every year.

Unless there is decision to palliate, the principal treatment for hip fracture is surgery, using either internal fixation (IF) or total hip arthroplasty (THA) according to fracture pattern. The immediate goals of surgery include pain control, early mobilization and avoidance of further complications. In our health region, these surgical procedures were traditionally done after hours, competing with other acute and emergent surgical cases for operating theatre time, which frequently resulted in patients with hip fractures waiting several days for surgery despite longstanding concerns about the potential consequences of delay on postsurgical outcomes, including mortality.

Efforts to reduce the morbidity and mortality associated with hip fracture have focused on 2 main areas: fracture prevention through falls reduction and osteoporosis treatment and improved timeliness of surgery. Acknowledging the risks associated with delayed hip fracture surgery, the 2004 Canadian First Ministers’ 10-Year Plan to Strengthen Health Care established the path toward evidence-based benchmarks and public reporting of wait times for hip fracture surgery. In 2005, this national benchmark was set at 48 hours from the time of patient admission to the time of surgery. Two years later, the Canadian Institute for Health Information (CIHI) released its national indicator report showing that only 65% of patients in Canada met the benchmark. This report also showed that Manitoba had the lowest percentage of patients receiving surgery within the benchmark (53%). Motivated by this report, in 2008 Manitoba Health and the Winnipeg Regional Health Authority (WRHA) undertook a multifaceted year-long initiative to improve the timeliness of surgery within the WRHA, culminating in a mandatory benchmark.

While many clinicians and administrators now accept that unnecessary delays in hip fracture surgery result in poorer outcomes, the current literature actually provides weak evidence for the association between timely surgery and decreased mortality because it comprises almost exclusively nonintervention, retrospective observational studies that compare patients who received timely surgery to those who did not. The findings are therefore susceptible to selection bias, as one would expect medically complicated patients to have their surgery delayed while they undergo preoperative investigations or treatments, thus tending to overestimate the risk of death associated with delayed surgery. Published prospective intervention studies are small and therefore underpowered to detect differences in mortality.

The purpose of the present study was to determine if our improvement intervention achieved the intended reduction in time to surgery and if a reduction in time to surgery improved mortality and length of stay (LOS). We believe that this work is unique in that it is, to our knowledge, the first adequately powered intervention study that examines the association between timely hip fracture surgery and mortality.

**METHODS**

**Study design**

We used a pre-/postintervention design using administrative data to compare time to surgery, length of stay and mortality in all patients admitted to our health region with a hip fracture between January 2004 and March 2012.

**Patient population**

Our preintervention group consisted of all patients aged 50 years or older who were admitted to hospitals in the WRHA with a hip fracture during the 48 months between Jan. 1, 2004, and Dec. 31, 2007, inclusive. Our postintervention group consisted of all hip fracture patients aged 50 years or older who were admitted during the 39 months between Jan. 1, 2009, and Mar. 31, 2012, inclusive. Patients admitted during the year the improvement initiative was being implemented (Jan. 1–Dec. 31, 2008) were excluded. We obtained clinical, demographic and administrative data from WRHA’s discharge abstract database (DAD) and mortality data from the provincial client registry database. Hip fracture diagnoses included were femoral neck, intertrochanteric and subtrochanteric fractures (ICD-10-CA codes: S72.010, S72.080, S72.081, S72.090, S72.091, S72.100, S72.101, S72.190, S72.200, & S72.900). To avoid possible bias from excluding patients who may have died while waiting for surgery, we included all patients with these fractures, not just those who underwent surgery.

**Setting**

The WRHA is Manitoba’s largest health authority, serving a large portion of the province’s population of 1.2 million people. It includes 2 tertiary hospitals, 4 community hospitals, 5 community health centres, personal care homes, community-based health facilities and a number of clinical and community programs. Canadian provinces each have a single-payer health care system that provides all necessary hospital, medical and surgical services; this characteristic allows for a population-based study of all hip fracture patients.

**Intervention**

In late 2007, our year-long improvement intervention began with a prospective audit of several hundred hip
fracture patients by the WRHA surgical leadership and Orthopaedic Standards & Quality Committee. The audit revealed multiple sources of delay along the often convoluted care trajectory of these frail patients en route to surgery. Seven potential contributors to delay in delivery of surgical care were identified, against which actions were taken during the latter half of 2008 (Table 1).

**Study outcomes**

We compared the pre- and postintervention groups based on the outcomes of time to surgery, LOS, in-hospital mortality and 1-year mortality. Time to surgery was defined as the interval between the time of hospital admission and time of surgery. Prior to 2008, 2 of the 6 hospital sites did not consistently capture the exact time of surgery, resulting in 1766 cases (50% of the pre-intervention group) with a date but not an exact time of surgery. For these cases, we used nonmissing surgery time data, stratified by weekday and weekend, to estimate the site’s missing data. We defined LOS as the time from hospital admission to discharge for the hip fracture stay, in-hospital mortality as a death associated with the hip fracture that occurred during the hospital stay, and 1-year mortality as death within 12 months of the index admission. We calculated the Charlson Comorbidity Index using the coding algorithm reported by Quan and colleagues based on comorbidities present at the time of admission. The Charlson Index was then dichotomized into presence/absence of comorbidities. Patients were also categorized according to type of surgical procedure: internal fixation (IF) or total hip arthroplasty (THA).

**Statistical analysis**

We compared patient demographics, time to surgery, mortality (in-hospital and 1-yr) and LOS between the pre- and postintervention groups. We used the Student t test to compare means, the Wilcoxon rank-sum test to compare medians and the χ² test to compare proportions. In-hospital and 1-year survival were assessed using the Kaplan–Meier estimator; the log rank statistic was used to test for differences between the groups. The Cox proportional hazards multiple regression model was used to estimate risk of death with and without adjustment for the covariates of age, sex, type of surgery and presence of comorbidities. To control for possible pre-existing or underlying changes in time to surgery and mortality, we created a centred year of surgery variable that was also included in the Cox model. Similar to the existing literature, we also stratified patients into those who received surgery within 48 hours and those who did not. We compared the in-hospital and 1-year mortality between these 2 groups using the same Cox multiple regression model. The assumption of proportionality of the hazards function for the Cox models was assessed graphically using the Kaplan–Meier survival functions, functional forms for continuous variables and cumulative Martindale residuals for categorical and dichotomous variables. We assessed Schoenfeld residuals for any variables appearing to violate proportional hazards assumptions, and Supremum tests of functional form and the proportional hazards assumption were also used. Hazard ratios (HRs) are reported along with 95% confidence intervals (CIs). We carried out all statistical analyses using SAS version 9.2 (SAS Institute).

The University of Manitoba Health Research Ethics Board approved our study protocol.

### Table 1. Seven potential sources of delay to surgical repair of hip fracture identified during a WRHA audit in 2008 along with the actions taken to address sources of delay

<table>
<thead>
<tr>
<th>Potential sources of delay</th>
<th>Actions taken to address sources of delay</th>
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<tbody>
<tr>
<td>i) Time required to transfer patients from rural hospitals without surgical facilities to WRHA hospitals with surgical facilities</td>
<td>i) Development of an orthopedic surgery coverage algorithm that matched WRHA hospitals with rural hospitals and required WRHA hospitals to accept rural patients regardless of bed availability</td>
</tr>
<tr>
<td>ii) Routing rural patients through the receiving hospital’s emergency department rather than going directly to the surgical ward</td>
<td>ii) Direct transfer of patients from rural hospitals’ emergency departments to the surgical ward at the accepting hospital</td>
</tr>
<tr>
<td>iii) Availability of operating room time</td>
<td>iii) Creation of additional daytime orthopedic trauma slates to accommodate patients during regular working hours and clarification of prioritization rules so that hip fracture patients who are “bumped” from surgery one day receive high priority the next day</td>
</tr>
<tr>
<td>iv) Lack of uniform understanding among all care providers of the association between delayed time to surgery and outcome</td>
<td>iv) Education in the form of combined orthopedics, anesthesia and internal medicine rounds on the importance of timeliness of surgery and common reasons for delay</td>
</tr>
<tr>
<td>v) Lack of consensus between surgeons and anesthesiologists about the timing of surgery in patients on clopidogrel</td>
<td>v) A collaborative determination by the WRHA anesthesia and orthopedic standards committees that clopidogrel in and of itself need not delay surgery</td>
</tr>
<tr>
<td>vi) Mandatory internal medicine consultations in order to be cleared for surgery</td>
<td>vi) The use of internal medicine consultations only when a correctable serious medical condition was identified preoperatively (e.g., an uncontrolled arrhythmia or congestive heart failure)</td>
</tr>
<tr>
<td>vii) Difficulties repatriating patients to home hospitals after surgery, resulting in a functional bed shortage for new patients</td>
<td>vii) WRHA surgery program collaborated with rural health regions to improve repatriation of patients once fit for transfer following surgery</td>
</tr>
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</table>

WRHA = Winnipeg Regional Health Authority.
RESULTS

We included 6542 patients in the study: 3535 in the pre-intervention group and 3007 in the postintervention group. The mean age of patients was 81.4 ± 10.1 years, 71% were women and 37.2% had 1 or more comorbidities at the time of admission. The postintervention group had a higher rate of comorbidities and a higher proportion of patients who underwent THA than the preintervention group (Table 2).

Comparison between the pre- and postintervention groups demonstrated improvements in the proportion of cases meeting the 48-hour benchmark, reduced LOS and improved in-hospital crude mortality; however, the trend toward improved 1-year crude mortality did not reach statistical significance (Table 3). Older age, male sex, presence of comorbidities and internal fixation of fracture (as opposed to THA) were all associated with increased risk of death in hospital and at 1 year (Table 4 and Table 5).

The observed reduction of crude in-hospital mortality was confirmed using Kaplan–Meier survival curves (log rank statistic $p < 0.001$; Fig. 1); the trend toward improved crude mortality at 1 year still did not reach statistical significance (log rank statistic $p = 0.17$; Fig. 2). However, once adjusted for confounding variables, a significant reduction in risk of death in the postintervention group was observed both in-hospital (HR 0.68, 95% CI 0.57–0.81) and at 1 year (HR 0.87, 95% CI 0.79–0.96; Table 4 and Table 5).

Regardless of membership in the pre- or postintervention groups, once adjusted for the same confounders, patients who received surgery within 48 hours had decreased risk of death both in hospital (HR 0.51, 95% CI 0.41–0.63) and at 1 year (HR 0.72, 95% CI 0.64–0.80).

DISCUSSION

Coordinated, multifaceted region-wide efforts to improve the timeliness of hip fracture care can successfully reduce the time to surgery. This reduction in time to surgery appears to reduce both LOS and adjusted mortality in-hospital and at 1 year.

We are aware of 3 other studies that incorporated a control group to study the effectiveness of similar interventions. These studies were limited by small sample sizes and did not detect an effect on mortality. There are 2 important considerations when interpreting the results of meta-analyses evaluating the effects of surgery within 48 hours. First, they mainly analyzed studies that included only patients who underwent surgery, excluding surgical candidates who died while awaiting surgery. Effects of delayed surgery on risk of death would likely be underestimated as a result. Second, they rely overwhelmingly on observational studies that simply stratify patients into those who received timely surgery and those who did not, thus overlooking the impact of delays in medically complicated patients undergoing preoperative

<table>
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<th>Table 2. Demographic characteristics of pre- and postintervention groups</th>
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<tr>
<td><strong>Characteristic</strong></td>
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<tr>
<td>Sex, % female</td>
</tr>
<tr>
<td>Age, yr</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>Femoral neck fracture, %</td>
</tr>
<tr>
<td>Arthroplasty, %</td>
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<tr>
<td>Patients with ≥ 1 preadmission comorbidities, %</td>
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</tbody>
</table>

*SD = standard deviation. *Unless otherwise indicated.

<table>
<thead>
<tr>
<th>Table 3. Benchmark, time to surgery and crude mortality rate comparisons</th>
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<tbody>
<tr>
<td><strong>Variable</strong></td>
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<tr>
<td>% Meeting 48-h benchmark</td>
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<tr>
<td>Median time to surgery, d</td>
</tr>
<tr>
<td>Median length of stay, d</td>
</tr>
<tr>
<td>In-hospital mortality (all patients)</td>
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<tr>
<td>In-hospital mortality (only those undergoing surgery)</td>
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<tr>
<td>1-yr mortality (all patients)</td>
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</table>

*Unless otherwise indicated.
investigations. This would tend to overestimate the risk of death associated with delaying surgery. Our findings actually support this overestimation: the adjusted HR for 1-year mortality when we simply compared patients who received surgery within 48 hours to those who did not (in essence an observational study) was 0.51; when we reduced this selection bias by comparing patients in the postintervention group to the preintervention group, the adjusted HR for 1-year mortality rose to 0.72. This is likely a more accurate assessment of the effect of timely surgery on mortality. Other limitations of the existing literature include the lack of a uniform definition of surgical delay (24, 48 or 72 h) and variability in duration of follow-up when determining mortality.

Our findings are generally consistent with those found by Holt and colleagues in their investigations from the Scottish Hip Fracture Audit database. In their examination of the association between patient and management variables and risk of death in 18,817 patients, they found that older age, male sex and preoperative comorbidities (assessed with American Society of Anesthesiologists score) were all strongly associated with greater risk of death. However, they found that management variables, such as time to surgery and seniority of surgeon and anesthesiologist, played a much smaller role, with only the interval from fracture to surgery (and not the interval between admission and surgery) and

### Table 4. Hazard ratios for in-hospital mortality by intervention period

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period (post v. pre)</td>
<td>0.73 (0.62–0.87)</td>
<td>0.68 (0.57–0.81)</td>
</tr>
<tr>
<td>Age, yr</td>
<td>—</td>
<td>1.04 (1.03–1.05)</td>
</tr>
<tr>
<td>Sex (male v. female)</td>
<td>—</td>
<td>2.05 (1.73–2.44)</td>
</tr>
<tr>
<td>Presence of comorbidities (≥ 1 v. 0)</td>
<td>—</td>
<td>4.02 (3.34–4.84)</td>
</tr>
<tr>
<td>Procedure type (internal fixation v. arthroplasty)</td>
<td>—</td>
<td>1.66 (1.37–2.01)</td>
</tr>
<tr>
<td>Centred year of surgery (last v. first)</td>
<td>—</td>
<td>0.91 (0.83–1.01)</td>
</tr>
</tbody>
</table>

CI = confidence interval; HR = hazard ratio.

### Table 5. Cox analysis of hazard ratios for 1 year mortality risk by intervention period

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period (post v. pre)</td>
<td>0.935 (0.85–1.03)</td>
<td>0.87 (0.79–0.96)</td>
</tr>
<tr>
<td>Age</td>
<td>—</td>
<td>1.05 (1.04–1.05)</td>
</tr>
<tr>
<td>Sex (male v. female)</td>
<td>—</td>
<td>1.87 (1.69–2.07)</td>
</tr>
<tr>
<td>Presence of comorbidities (≥ 1 v. 0)</td>
<td>—</td>
<td>2.57 (2.33–2.84)</td>
</tr>
<tr>
<td>Procedure type (internal fixation v. arthroplasty)</td>
<td>—</td>
<td>1.20 (1.08–1.33)</td>
</tr>
<tr>
<td>Centred yr of surgery (last v. first)</td>
<td>—</td>
<td>0.98 (0.94–1.03)</td>
</tr>
</tbody>
</table>

CI = confidence interval; HR = hazard ratio.

Fig. 1: Kaplan–Meier survival curves for in-hospital mortality comparing survival rates before and after the initiative.

Fig. 2: Kaplan–Meier survival curves for 1-year mortality comparing survival rates before and after the initiative.
the negative effect of delay. It is very likely that the improvements we saw in the proportion of patients meeting benchmark (from 66.8% to 84.6%) was largely a result of reducing unnecessary delays in medically fit patients.

We feel that our interventional study design incorporating a control group and a large sample size, using a consistent 48-hour Canadian benchmark, including patients who died before surgery and adjusting analysis for both in-hospital and 1-year risk of death addresses many of the deficiencies that exist in the current literature.

Limitations

Although our study adds to the existing literature by being interventional and not observational in nature, we acknowledge some limitations. The use of administrative data did not allow us to exclude nonsurgical patients from our analysis. However, since the majority of hip fracture patients are treated surgically, with nonoperative treatment typically reserved for the small proportion who are critically ill with very short life expectancy, the latter group of patients would represent only a small proportion and be unlikely to alter our findings. Furthermore, the postintervention group had a higher rate of comorbidities than the preintervention group (39.8% vs. 34.9%), potentially increasing the proportion of patients who were palliative and therefore strengthening our findings of improved crude mortality with improved timeliness of surgery.

Although it is possible that changes in coding practice over such a long timeframe studied could have resulted in the comorbidity differences, the ICD-10 was fully implemented in Manitoba by 2004, and we therefore feel this is unlikely. The other difference between the 2 groups was the higher rate of THA in the postintervention group. However, this difference was not unexpected, given the slightly higher proportion of femoral neck fractures in this group, combined with recent trends toward increased use of arthroplasty for displaced femoral neck fractures. It is important to note that the possible confounding effects of these differences between the groups were controlled with the use of the Cox model.

We acknowledge that our decision not to compare complications between the groups could be a critique. Others have reported reductions in postoperative complications with timely surgery, and the effects of complication rates should ultimately be reflected in our measures of mortality and LOS.

A possible shortcoming was the need for us to estimate the exact time of surgery at 2 of the 6 hospital sites before 2008. This arose because only the date, and not the exact time, of surgery was recorded in the DAD. As a face validity check of the estimated times, we were reassured to find that weekend cases typically occurred around noon, and weekday cases typically occurred around 4 pm. These estimations seem reasonable. The times were comparable to sites with nonmissing data; on the weekend hip fractures would be delayed until midday by the more urgent cases that came in during the preceding night, and on weekdays they would start at the end of the elective slate. A further check, we performed a sensitivity analysis by setting all the missing time data to 12 am — the best possible scenario, although highly unlikely as hip fracture cases are not typically started after midnight. In this best case scenario, our overall findings did not change.

Finally, it is not possible for us to say with certainty which of our intervention initiatives ultimately led to the observed improvements, or to measure the effect of other unrecognized changes on the improvements. It is possible that at least part of the observed reduction in LOS is attributable to improved repatriation of patients to their home hospitals after surgery. Nonetheless, our findings of reduced adjusted risk of death in those patients undergoing surgery within 48 hours, regardless of time period, underscore the role of timely surgery in reducing mortality.

Generalizability

Although the demographics of patients with a fragility fracture of the hip are similar around the world, it is difficult to make direct comparisons of our patient demographics, LOS and crude mortality rates owing to variations in methodology and reporting among existing Canadian studies. Other reports have excluded patients who died while awaiting surgery, included younger patients and relied on data for LOS and comorbidity status that are collected and categorized in a manner unique to their setting. Comparison of crude rates to non-Canadian data presents similar challenges and underscores the importance of comparing adjusted analyses. Our findings of improved adjusted risk of death both in-hospital (HR 0.68) and at 1 year (HR 0.87) are similar in magnitude to those found in meta-analyses using data derived largely from studies without a control group. Moja and colleagues reported an OR of 0.74, while Simunovic and colleagues reported a relative risk of 0.81 with shorter times to surgery. Despite the difficulties in making direct comparisons, we feel that our findings have direct relevance to jurisdictions with universal health care coverage.

Conclusion

Region-wide changes directed at meeting a 48-hour benchmark for hip fracture surgery can result in shorter time to surgery, decreased LOS and improved in-hospital and 1-year mortality. This has direct health implications for patients and resource implications for the health systems and further highlights the need to overcome administrative delays for hip fracture surgery. Adequately powered prospective studies that examine the role of emergent versus urgent surgery are warranted to provide further clarity around the exact timing of surgery and its effect on complications and health system costs.
Authority (Bohm, Loucks); the Department of Surgery, University of Manitoba and Winnipeg Regional Health Authority (Bohm, Oppenheimer); the Department of Pediatrics and Child Health, University of Manitoba (Wittmeier); and the Department of Community Health Sciences, University of Manitoba (Bohm, Lix), Winnipeg, Man.

Competing interests: None declared.

Contributors: E. Bohm, L. Loucks and L. Lix designed the study. E. Bohm and L. Loucks acquired the data, which all authors analyzed. E. Bohm and L. Loucks wrote the article, which all authors reviewed and approved for publication.

References
Laparoscopic-assisted percutaneous endoscopic gastrostomy: insertion of a skin-level device using a tear-away sheath

Michael H. Livingston, MD
Daniel Pepe, MD
Sarah Jones, MD, PhD
Andreana Büttner, MD, MSc
Neil H. Merritt, MD

Background: This study describes our experience with the placement of a skin-level gastrostomy device (MIC-KEY) in a single procedure.

Methods: We identified infants, children and young adults who underwent laparoscopic-assisted percutaneous endoscopic gastrostomy (LAPEG) tube insertion between October 2009 and June 2013. The steps of this procedure include upper endoscopy, single-port laparoscopy, gastropexy via percutaneous T-fasteners and placement of a skin-level gastrostomy device (MIC-KEY) using a “push” technique with a tear-away sheath.

Results: We included 92 patients in our study. Mean age was 3.7 years (range 3 wk–5 yr), and mean weight was 11.2 (range 2.8–54) kg. Median procedural time was 20 (range 12–76) minutes. Total median duration for the most recent 25 procedures was lower than that of the first 25 (62 v. 79 min, \(p = 0.004\)). There were no intraoperative complications or conversions to open surgery. Postoperative complications were observed in 6 (6.5%) patients. Three retained T-fasteners were assessed endoscopically (\(n = 1\)) or removed via local excision (\(n = 2\)). Two patients experienced early dislodged feeding tubes that were replaced via interventional radiology (\(n = 1\)) or repeat LAPEG (\(n = 1\)). There was also 1 intra-abdominal fluid collection that was drained percutaneously but ultimately required a laparotomy and washout. There were no major complications in the most recent 50 procedures.

Conclusion: Our results suggest that LAPEG is a safe, minimally invasive procedure for infants, children and young adults. This approach allows for immediate use of a skin-level gastrostomy device without the need for postoperative tube exchanges.

Contexte : Cette étude décrit notre expérience avec la pose d’un dispositif de gastrostomie au niveau de la peau (MIC-KEY) en une seule intervention.

Méthodes : Nous avons recensé les nourrissons, enfants et jeunes adultes ayant subi l’insertion d’un tube de gastrostomie par voie endoscopique percutanée sous laparoscopie (GEPL) entre octobre 2009 et juin 2013. Les étapes de cette intervention incluent une endoscopie haute, une laparoscopie à trocart unique, une gastropexie avec ancre en T percutanées et la pose d’un dispositif de gastrostomie au niveau de la peau (MIC-KEY) à l’aide de la technique « push » et d’une pellicule amovible.

Résultats : Nous avons inclus 92 patients dans notre étude. L’âge moyen était de 3,7 ans (de 3 semaines à 5 ans) et le poids moyen était de 11,2 (de 2,8 à 54) kg. La durée médiane de l’intervention a été de 20 minutes (entre 12 et 76 minutes). La durée totale médiane des 25 plus récentes interventions a été plus brève que celle des 25 premières (62 c. 79 minutes, \(p = 0,004\)). On n’a observé aucune complication peropératoire ni conversion vers une chirurgie ouverte. Des complications postopératoires ont été observées chez 6 (6,5 %) patients. Trois ancrés en T persistantes ont été évaluées par voie endoscopique (\(n = 1\)) ou extraites par excision locale (\(n = 2\)). Les tubes d’alimentation se sont déplacés tôt chez 2 patients et ont été remplacés en radiologie interventionnelle (\(n = 1\)) ou avec une nouvelle GEPL (\(n = 1\)). On a également noté un cas d’épanchement de liquide intra-abdominal qui a pu être drainé par voie percutanée, mais qui a finalement nécessité une laparotomie et un lavage. Aucune complication majeure n’a été signalée lors des 50 plus récentes interventions.

Conclusion : Selon nos résultats, la GEPL est une intervention sécuritaire et minimaliste efficace pour les nourrissons, les enfants et les jeunes adultes. Cette approche permet l’utilisation immédiate d’un dispositif de gastrostomie au niveau de la peau sans nécessiter de changements de sondes après l’intervention.

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Gastrostomy tube insertion in children can be performed via open surgery, percutaneous endoscopic gastrostomy (PEG), laparoscopic gastrostomy, or percutaneous radiologic gastrostomy.1-5 Percutaneous endoscopic gastrostomy insertion remains popular in many centers because it can be performed quickly and does not require incisions.1,2 This approach provides visualization of the stomach but not the peritoneal cavity, which can lead to injuries to the colon, small bowel, liver and spleen.6-11 Another disadvantage is that the long PEG tube must be left in place for a few months before it can be exchanged for a skin-level device. This requires additional sedation, general anesthetic, or endoscopic retrieval. Another option is to remove the PEG tube in clinic, but this can be painful and unpleasant, especially for young children.

To avoid these issues, some surgeons have advocated using a laparoscopic approach, or a combination of laparoscopy and endoscopy.12-26 The combined approach is known as laparoscopic-assisted PEG insertion (LAPEG).3,12 This technique appears to be associated with reduced complications, but does not necessarily negate the need for postoperative tube exchanges for a skin-level device.5,12 As a result, there have been recent efforts to perform LAPEG in a single procedure.13 This approach requires a single anesthetic and allows for placement of a skin-level device that can be used immediately.

The purpose of the present study is to describe our experience with a 1-step LAPEG insertion using a skin-level device in, to our knowledge, the largest case series reported to date. We describe how this technique is performed and report our outcomes, including duration of surgery, length of stay in hospital (LOS) and complications.

Methods

Participants

This study received approval from the Health Sciences Research Ethics Board at Western University. All participants were treated by 1 of 3 pediatric surgeons at the Children’s Hospital, London Health Sciences Centre, between September 2009 and June 2013. Participants were identified prospectively and data were collected retrospectively from the electronic medical record.

Operative technique

Laparoscopic-assisted PEG insertion is performed in the operating room with the patient under general anesthesia. Necessary equipment includes a laparoscope, endoscope, MIC-KEY gastrostomy tube and MIC-KEY G introducer kit (Halyard Digestive Health).37 We used a 14-French MIC-KEY and introducer kit for infants and small children and a 16-French for older children and adolescents. The kit includes an introducer needle, guidewire, scalpel, dilator, tear-away sheath and 4 percutaneous T-fasteners (SAF-T-PEXY) with dissolvable monofilament suture material (Biosyn).

Following induction and intubation, the anticipated gastrostomy site is marked on the skin in the epigastri area. A medial location is chosen to prevent the gastrostomy site from migrating laterally as the child grows. The first assistant then inserts an appropriately sized endoscope into the oropharynx and advances into the stomach. The primary surgeon prepares the abdomen with a chlorhexidine solution and drapes in a sterile fashion. The unscrubbed first assistant operates the endoscope and remains positioned at the patient’s head.

The primary surgeon then makes a small incision below the umbilicus and inserts a 3 or 5 mm trochar and laparoscope using a Hasson technique. Once an adequate view is established, the laparoscope is operated by a second assistant. In practice, this person can be a medical student or the scrub nurse. The stomach is inspected laparoscopically, and a potential gastrostomy site is chosen along the greater curvature. Care must be taken to ensure that the gastrostomy is situated proximally enough to avoid obstruction of the pylorus and distally enough not to impede future Nissen fundoplication.

The primary surgeon then affixes the stomach to the abdominal wall using 2 or 3 percutaneous T-fasteners. The T-fasteners are passed first into the abdominal cavity (confirmed laparoscopically) and then into the lumen of the stomach (confirmed endoscopically). The use of laparoscopy prevents injury to intra-abdominal structures and ensures that part of the omentum does not become interposed between the stomach and abdominal wall. If this occurs, the gastrostomy tract may not mature properly and dehiscence may result. The use of upper endoscopy ensures that the T-fasteners are not passed “through and through” the anterior and posterior walls of the stomach.

The introducer needle is inserted between the T-fasteners and passed into the lumen of the stomach. A guidewire is inserted through the introducer needle, then the needle is removed, and a small incision is made on the skin at the guidewire exit site. The dilator and tear-away sheath are placed over the guidewire and passed into the stomach as a single unit using the Seldinger technique. The position of the tear-away sheath is confirmed endoscopically and the guidewire and plastic dilator are removed.

The balloon of the skin-level gastrostomy device (MIC-KEY) is tested with sterile water and deflated before placement. We use a MIC-KEY with a 1 cm stem for infants and small children and a 2 cm stem for older children and adolescents. Measurement of the tract length before insertion (to ensure a precise fit) is not required because the stomach is kept adherent to the abdominal wall by the T-fasteners rather than the gastrostomy balloon. The stem of the gastrostomy tube is lubricated with sterile jelly and then pushed into the gastrostomy site as the sheath is torn away.
After being advanced into the stomach, the balloon is inflated with sterile water. In general, only 3–5 mL of sterile water should be used, particularly with small children, where a large balloon can obstruct the pylorus. The position of the balloon is confirmed endoscopically, then the laparoscopic port and camera are removed, and the umbilical fascia is closed with a single dissolvable stitch. The skin is closed with a dissolvable stitch and covered with a dry dressing (Fig. 2). The gastrostomy site does not need to be closed with any additional sutures (other than the percutaneous T-fasteners placed at the beginning of the procedure). We give all patients local anesthetic around the umbilicus at the end of the procedure as well as pre- and postoperative acetaminophen and ibuprofen. Patients may receive morphine postoperatively if required. Feeding can be started within 4 hours and advanced as tolerated.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21.

RESULTS

Participant characteristics

We identified 92 infants, children and young adults who underwent LAPEG performed by 1 of 3 pediatric surgeons at our centre during our study period. Reasons for gastrostomy tube insertion included failure to thrive and/or oropharyngeal aspiration (90%), cystic fibrosis (8%), traumatic brain injury (2%) and oral aversion (1%). There were 45 male and 47 female patients, and their mean age was 3.7 ± 5.1 years (range 3 wk–25 yr). Their mean weight was 11.2 ± 8.8 (range 2.8 to 54) kg. Sixty-seven (73%) procedures were performed electively and 25 (27%) were performed on inpatients admitted to hospital for other reasons.

Outcomes

The median LOS for elective procedures was 4.3 ± 4.2 (range 1.4–31.3) days. The median skin-to-skin procedural time was 20 (range 12–72) minutes, the median anesthesia preparation and induction time was 18 (range 3–55) minutes, and the total median operating room time was 66 (range 30–126) minutes. Total operating room time decreased from a median of 79 minutes for the first 25 procedures to a median of 62 minutes for the most recent 25 procedures ($p = 0.004$).

Complications

There were no intraoperative complications or conversions to an open procedure. Six (6.5%) patients experienced...
postoperative complications that required repeat interventions. These included 2 (2.2%) patients who experienced early dislodged feeding tubes that required replacement. The first occurred approximately 3 weeks after insertion. There were no signs of leakage or peritonitis, so the patient underwent successful percutaneous radiologic gastrostomy under fluoroscopic guidance in the interventional radiology suite. The second patient had a gastrostomy tube that became dislodged 4 weeks after insertion. This child was brought to the emergency department, and a Foley catheter was placed in the gastrostomy site. A contrast study revealed a leak into the peritoneal cavity, so the patient was taken to the operating room and received repeat LAPEG with no further complications.

There was also 1 patient who experienced an intra-abdominal fluid collection and inflammatory response on postoperative day 2. The fluid was initially drained percutaneously but ultimately required a laparotomy and washout on day 7. The gastrostomy tube was in good position with no evidence of leakage and did not require a surgical revision. This patient was on acid suppression therapy before surgery and was not given preoperative antibiotics. As a result, the complex fluid collection was attributed to microscopic spillage of gastric contents during the initial LAPEG insertion. This was the only patient in this series (1.1%) who required a laparotomy.

Three (3.1%) patients had retained T-fastener material that was assessed endoscopically (n = 1) or removed via local excision (n = 2). The patient who underwent endoscopy presented with a deflated gastrostomy balloon approximately 1 month after LAPEG insertion. Upper endoscopy revealed an area of granulation tissue at the previous location of one of the T-fasteners but no visible suture material. This patient was ultimately switched to a nonballoon gastrostomy tube with a bolster and experienced no further complications. The 2 patients who underwent local excision for retained T-fastener material underwent surgery on an outpatient basis and did not require admission to hospital. These procedures occurred 8 months and 2 years, respectively, after initial LAPEG insertion.

**Discussion**

The first description of LAPEG in children was reported in 1995 in 2 adolescents in whom previous PEG insertion had failed. Many variations on this technique have been described since then. These include: the use of gastroproxy versus no gastroproxy, gastrostomy using a PEG tube versus a balloon-dependent device and “pull” versus “push” techniques to insert the gastrostomy tube. The LAPEG approach described here is similar to the Georgeson technique, which involves large, transabdominal U-stitches to affix the stomach to the abdominal wall. Gastrostomy tube insertion is then performed via sequential dilatation over a guidewire rather than insertion using a tear-away sheath. The main drawback of the Georgeson technique is that the U-stitches can slip, resulting in gastrostomy tract dehiscence and the need for reoperation.

In our experience, LAPEG using a tear-away sheath is a safe and minimally invasive procedure for gastrostomy tube insertion in patients of all ages, ranging from infants to young adults. The rate of major complications appears to be lower than published rates for PEG tube insertion in children (%–19%) and similar to those reported for the laparoscopic (2%–8% ) and percutaneous radiologic techniques (4%–11%). Furthermore, LAPEG with a tear-away sheath allows for the placement of a skin-level device in a single procedure. As a result, additional visits to hospital for tube exchanges are not required. In children with complex conditions and multiple medical comorbidities, this represents an important benefit to patients and their families. The skin-level gastrostomy tube can be used immediately, and early feeding has not resulted in any complications. This results in a short hospital stay, with a median length of 4 days.

In addition, LAPEG with a tear-away sheath is associated with acceptable duration of surgery, which improves with increased experience. We found the dilator and tear-away sheath to be somewhat awkward at first, but the learning curve is short and handling improves after a few cases. Other drawbacks include the need for endoscopic and laparoscopic equipment in the operating room and 3 personnel to perform the procedure. Other techniques, such as laparoscopic gastrostomy, can be performed with a primary surgeon and single assistant.

Important safety benefits are gained from being able to simultaneously visualize the peritoneal cavity (via laparoscopy) and lumen of the stomach (via upper endoscopy). These include preventing injury to intra-abdominal structures, preventing the omentum from becoming interposed between the stomach and abdominal wall, accurate placement of the gastrostomy tube along the greater curve of the stomach, endoscopic confirmation of T-fastener placement and endoscopic confirmation of balloon inflation and position. This has resulted in no intraoperative complications or need for conversion to an open procedure.

All postoperative complications observed in our series occurred within the first 50 cases at our centre and within the first 40 cases for each surgeon. We have made small modifications to this technique, and there have been no further complications. The most important change was the decision to remove all T-fasteners on postoperative day 5 (we previously removed them in clinic 3 weeks to 1 month after surgery). Removal on day 5 prevents the suture material from becoming embedded in the subcutaneous tissue and causing chronic infection and granulation. The 2 patients with early dislodged tubes experienced these complications before making this change in practice, and we have not experienced any additional gastrostomy tract dehiscence following early T-fastener removal.
CONCLUSION

We believe LAPEG with a tear-away sheath is an excellent option for gastrostomy tube insertion. This approach is safe, fast and minimally invasive; provides adequate visualization; uses a skin-level device; allows for early feeding; and does not require tube exchanges postoperatively. This technique is associated with acceptable duration and rate of complications, and these outcomes appear to improve with increased experience.

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Affiliations: From the Division of General Surgery, Schulich School of Medicine & Dentistry, Western University (Livingston, Pepe, Jones, Butter, Merritt); and the Division of Paediatric Surgery, Schulich School of Medicine & Dentistry, Western University (Jones, Butter, Merritt), London, Ont.

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Competing interests: None declared.

Contributors: M. Livingston, S. Jones, A. Bütter and N. Merritt designed the study. M. Livingston and D. Pepe acquired and analyzed the data. M. Livingston and D. Pepe wrote the article, which all authors reviewed and approved for publication.

References

Initial assessment of patient handoff in accredited general surgery residency programs in the United States and Canada: a cross-sectional survey

Abdulaziz M. Saleem, MD
Jessica K. Paulus, ScD
Melina C. Vassiliou, MD
Susan K. Parsons, MD

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Correspondence to:
A.M. Saleem
Department of General Surgery
McGill University Health Centre
Montreal QC H3G 1A4
abdulaziz.m.saleem@gmail.com

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Background: Communication errors are considered one of the major causes of sentinel events. Our aim was to assess the process of patient handoff among junior surgical residents and to determine ways in which to improve the handoff process.

Methods: We conducted nationwide surveys that included all accredited general surgery residency programs in the United States and Canada.

Results: Of the 244 American and 17 Canadian accredited surgical residency programs contacted, 65 (27%) and 12 (71%), respectively, participated in the survey. Of the American and Canadian respondents, 66% and 69%, respectively, were from postgraduate year (PGY) 1, and 32% and 29%, respectively, were from PGY 2; 85 (77%) and 50 (96%), respectively, had not received any training about patient handoff before their surgical residency, and 27% and 64%, respectively, reported that the existing handoff system at their institutions did not adequately protect patient safety. Moreover, 29% of American respondents and 37% of Canadian respondents thought that the existing handoffs did not support continuity of patient care. Of the American residents, 67% and 6% reported receiving an incomplete handoff that resulted in minor and major patient harm, respectively. These results mirrored those from Canadian residents (63% minor and 7% major harm). The most frequent factor reported to improve the patient handoff process was standardization of the verbal handoff.

Conclusion: Our survey results indicate that the current patient handoff system contributes to patient harm. More efforts are needed to establish standardized forms of verbal and written handoff to ensure patient safety and continuity of care.

Contexte : Les erreurs de communication sont considérées comme l’une des causes majeures des événements sentinelles. Notre but était d’évaluer le processus de transfert des patients chez les résidents junior en chirurgie et de trouver des façons de l’améliorer.

Méthodes : Nous avons procédé à des sondages nationaux qui ont inclus tous les programmes agréés de résidence en chirurgie générale aux États-Unis et au Canada.

Résultats : Sur les 244 programmes agréés de résidence en chirurgie américains et les 17 canadiens, 65 (27%) et 12 (71%), respectivement, ont participé au sondage. Parmi les participants américains et canadiens, 66 % et 69 %, respectivement, étaient en première année de résidence (PGY 1) et 32 % et 29 %, respectivement, étaient en deuxième année de résidence (PGY 2); 85 (77 %) et 50 (96 %), respectivement, n’avaient reçu aucune formation sur le transfert des patients avant leur résidence en chirurgie et 27 % et 64 %, respectivement, ont déclaré que le système actuel de transfert de leur établissement n’assurait pas adéquatement la sécurité des patients. De plus, 29 % des participants américains et 37 % des participants canadiens ont dit estimer que le mode actuel de transfert ne favorisait pas la continuité des soins. Chez les résidents américains, 67 % et 6 % ont déclaré recevoir un rapport de transfert incomplet susceptible d’entraîner un préjudice mineur et majeur, respectivement, pour le patient. Ces réponses correspondaient à celles des résidents canadiens (63 % et 7 %, respectivement, en ce qui concerne les préjudices mineurs et majeurs). Le facteur mentionné comme le plus propice à une amélioration du processus de transfert des patients était la standardisation du rapport verbal.

Conclusion : Les résultats de nos sondages indiquent que le système actuel de transfert des patients serait préjudiciable à ces derniers. Il faudra travailler à standardiser les processus de transfert et de rapports verbaux et écrits pour assurer la sécurité des patients et la continuité des soins.
Patient handoff is an important method to transfer patient care from one health care provider to another to ensure patient safety and continuity of care. Patient handoff takes place multiple times during the day among health care providers, including residents, nurses and staff surgeons. After the Accreditation Council for Graduate Medical Education’s (ACGME) new rules to limit resident working hours came into effect in January 2003, more frequent handoffs were required between health care providers to comply with the new rules and to ensure continuity of care for patients.

Despite the importance of patient handoff, incomplete patient handoff and communication failure are still considered to be the most common causes of a sentinel event. The Joint Commission defines sentinel events as an unexpected occurrence involving death or serious physical or psychological injury, which includes loss of limb or function. In an analysis of root causes of sentinel events by the Joint Commission conducted from 2012 through 2014, communication errors were found to be one of the leading causes. Furthermore, the analysis showed that communication errors contributed to all types of sentinel events. In response to these results, the Joint Commission instituted a National Patient Safety Goal in 2006 to implement a standardized approach to patient handoffs in all hospitals.

In a survey of 161 medical and surgical residents at the Massachusetts General Hospital conducted by Kitch and colleagues, 58% of residents reported that at least 1 patient had experienced minor harm, and 12.3% reported that at least 1 patient had experienced major harm related to handoffs. However, information about patient handoff among junior surgical residents and how they perceive the current process of patient handoff is lacking despite the importance of this skill.

The aim of the present study was three-fold: to gain a better understanding of how verbal and written patient handoff is conducted between junior surgical residents at the time of the handoff in accredited general surgery residency programs in the United States and Canada, to identify the common reasons leading to incomplete handoff and to determine the factors perceived by the residents as necessary to improve the existing handoff process at their institutions.

**Methods**

**Selection criteria**

We identified 246 ACGME-accredited general surgery residency programs in the United States using the ACGME website (www.acgme.org). Two general surgery residency programs were excluded because they were not active at the time of the survey. Further, we identified 17 accredited general surgery residency programs in Canada using the Royal College of Physicians and Surgeons of Canada website (www.royalcollege.ca). All of the accredited general surgery programs were contacted initially by phone and then by email to the program director to explain the background and aims of the study. All programs that agreed to participate in the study were sent another email containing an electronic link to the survey to be sent to all junior general surgery residents. All junior general surgery residents (postgraduate year [PGY] 1 and PGY 2) who rotated at least 1 month in general surgery were eligible to participate in the study. All participants were assured that the survey was completely anonymous. As remuneration for study participation, all residents who successfully completed the survey received 1 week of free access to the American Board of Surgery In-Training Examination online question bank (www.clinicalreview.com). They did not have any contribution to the study methods or results. The institutional review boards of Tufts University and McGill University approved our study protocol.

**Survey content**

The survey, which we developed to assess each step of the patient handoff process, was composed of 6 sections with a total of 47 questions. The first section contained questions about demographics and general questions about patient handoff, the second section focused on verbal handoff and how it was conducted and the third section focused on the written handoff. The fourth and fifth sections contained questions about minor and major harm, respectively. The sixth section contained items eliciting participants’ perspectives on how to improve the existing handoff at their institutions. The survey instrument was first pilot tested by the junior and senior surgical residents at Tufts Medical Center and the Lahey Hospital and Medical Center to ensure clarity of items and flow.

**Survey administration**

The survey was administered online using SurveyMonkey as a one-time data collection effort. We sent the link to the online survey to program directors with an accompanying request to forward it to eligible residents. Owing to the confidentiality of residents’ emails, we were not be able to send reminders to nonresponders.

**Definitions of patient handoff and patient harm**

Patient handoff is defined as “the transfer of information (along with authority and responsibility) during transitions in care across the continuum; to include an opportunity to ask questions, clarify, and confirm.” Minor harm was defined as an event with a limited clinical consequence (e.g., a missed or delayed follow up on a radiological test or laboratory result, a delay in assessing a new patient owing to communication error or incomplete handoff) without any harm occurring to the patient as a result. Major harm was defined as an event with a clinically important consequence.
of communication failure or incomplete handoff, including the examples mentioned for minor harm, resulting in the patient experiencing a complication, being injured or dying.

Statistical analysis

Data are presented as counts and proportions. We downloaded summary statistics from the SurveyMonkey website (www.surveymonkey.com).

RESULTS

Respondent characteristics

Of the 244 American and 17 Canadian accredited surgical residency programs contacted, 65 (27%) and 12 (71%), respectively, participated in the survey. Reasons for non-participation were not collected. The demographics of the American and Canadian participants from these programs are shown in Table 1.

General questions about patient handoff

Of the 127 US and 73 Canadian junior surgical residents who participated, 79% and 71%, respectively, reported that the time they spent receiving the handoff was adequate, whereas 18% and 29%, respectively, found that not enough time was spent receiving the handoff. Fifty percent of American and 13.5% of the Canadian surgical residents reported that the handoff was always conducted in an interactive fashion, with opportunity for questions and answers. Only 3% of American and 2% of Canadian surgical residents reported that senior residents always supervised the handoff process; no residents from either country reported that a staff member always supervised the handoff process. Twenty percent of American and 15% of Canadian surgical residents reported that the handoff process always occurred at a designated time; similarly, 20% of American and 14% of Canadian surgical residents reported that it always occurred at a designated place. Among the American surgical residents, 54% reported that they were always interrupted during the handoff process in contrast to 14% of the Canadian surgical residents. The most common reasons for handoff interruptions for American and Canadian surgical residents, respectively, were nurses paging (79% and 69%), medical personnel paging (12 and 21%), trauma alert or patient coding (5% and 2%), and new consults or admissions (4% and 4%).

American and Canadian surgical residents, respectively, reported that interruptions during patient handoff led to the following consequences: loss of some information related to patients (75% and 82%), decreased quality of effective communication (69% and 53%), decreased quality of patient care (23% and 28%) and patient harm (11% and 16%). According to American and Canadian respondents, respectively, handoff was most problematic when the resident was the cross-coverage resident (72% and 51%), followed by the night float resident (11% and 20%), the primary team resident (10% and 14%) and the moonlighting resident (8% and 14%). Forty percent of American residents reported that they typically cover 20–39 patients, including service patients and consults, when they are on call, while 25% reported that they cover 40–60 patients. However, 39% of the Canadian residents covered 40–60 patients during their on-call time, 35% covered more than 60 patients and 25% covered 20–39 patients. About 77% of American and 96% of Canadian residents reported that they did not receive patient handoff training of any kind during their surgical training. The 2 groups also reported that the existing handoff systems at their institutions do not adequately protect patient safety (27% American v. 64% Canadian). Moreover, 29% of American and 37% of Canadian surgical residents received no patient handoff training of any kind during their surgical training. The 2 groups also reported that the existing handoff systems at their institutions do not adequately protect patient safety (27% American v. 64% Canadian).

Table 1. Characteristics of the survey participants by country

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>United States</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country; no. (%)*</td>
<td>244</td>
<td>17</td>
</tr>
<tr>
<td>Total no. programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participated</td>
<td>65 (27)</td>
<td>12 (71)</td>
</tr>
<tr>
<td>Refused</td>
<td>20 (8)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>No response</td>
<td>159 (65)</td>
<td>5 (29)</td>
</tr>
<tr>
<td>Male sex</td>
<td>65 (55)</td>
<td>33 (46)</td>
</tr>
<tr>
<td>Age, mean, yr</td>
<td>28.9</td>
<td>29.0</td>
</tr>
<tr>
<td>Level of training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGY–1</td>
<td>78 (66)</td>
<td>45 (69)</td>
</tr>
<tr>
<td>PGY–2</td>
<td>38 (32)</td>
<td>19 (29)</td>
</tr>
<tr>
<td>Hospital type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University hospital</td>
<td>78 (66)</td>
<td></td>
</tr>
<tr>
<td>Community hospital affiliated with a university</td>
<td>28 (24)</td>
<td></td>
</tr>
<tr>
<td>Community hospital not affiliated with a university</td>
<td>8 (7)</td>
<td></td>
</tr>
<tr>
<td>VA hospital</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Military hospital</td>
<td>3 (3)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1 (0.8)</td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>15 (13)</td>
<td></td>
</tr>
<tr>
<td>Middle Atlantic</td>
<td>30 (25)</td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>38 (32)</td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>25 (21)</td>
<td></td>
</tr>
<tr>
<td>Southwest</td>
<td>5 (4)</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>5 (4)</td>
<td></td>
</tr>
<tr>
<td>Type of resident</td>
<td></td>
<td></td>
</tr>
<tr>
<td>International medical graduate</td>
<td>23 (20)</td>
<td>10 (14)</td>
</tr>
<tr>
<td>American or Canadian medical graduate</td>
<td>94 (80)</td>
<td>62 (86)</td>
</tr>
<tr>
<td>Specialty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General surgery</td>
<td>104 (91)</td>
<td>58 (98)</td>
</tr>
<tr>
<td>Other</td>
<td>17 (9)</td>
<td>4 (2)</td>
</tr>
</tbody>
</table>

*Unless otherwise indicated.

PGY = postgraduate year; VA = Veterans Affairs.
thought that the existing handoffs do not allow continuity of care for patients.

Overall, 9% of the American surgical residents were very satisfied with the patient handoff process at their institutions, 63% were moderately satisfied, 25% were moderately dissatisfied and 3% were very dissatisfied; in comparison, 6% of the Canadian surgical residents were very satisfied about the current patient handoff at their institutions, 52% were moderately satisfied, 35% were moderately dissatisfied and 8% were very dissatisfied.

**Assessment of the verbal handoff**

At their institutions, 87% of American surgical residents and 96% of Canadian surgical residents reported that they did not have a standardized protocol for verbal handoff. Fifty-one (49.5%) of the American surgical residents compared with 10 (20.8%) of the Canadian residents spent on average 15–29 minutes receiving handoffs when they were the incoming (starting) residents. Further assessment of the verbal handoff and how it was conducted is shown in Table 2.

**Assessment of the written handoff**

Among the American and Canadian participants, 77% and 89%, respectively, reported that they did not have a standardized protocol for the written handoff at their institutions. Of the American residents, 94% used a written handoff created electronically, 57% reported that the handoff program is linked electronically to the hospital computer system so that elements such as a patient’s room number can be updated automatically, and 67% reported that they could access the patient list from any computer in the hospital. Only 14% were very satisfied with the existing computer program for the written handoff, and 49% were moderately satisfied. Outgoing residents reported spending 15–29 minutes preparing for the written handoff (i.e., adding new patients to the list, updating the list). Table 3 shows further assessment of the written handoff and how it was conducted.

Among the Canadian residents, 70% reported that they used an electronically generated patient handoff, 58% stated that the computer program they used to create the patient handoff is linked to the hospital computer system, and 62% reported that the patient list is accessible from any computer in the hospital. Of the Canadian respondents, 16.7% were very satisfied and 42% were moderately satisfied with the current patient handoff computer system. As outgoing residents, 62.2% reported spending less than 15 minutes updating the patient handoff list before leaving the hospital. Further details about the content of both verbal and written handoffs are shown in Table 4.

<table>
<thead>
<tr>
<th>Question; How often...</th>
<th>American surgical residents; no. (%)</th>
<th>Canadian surgical residents; no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Always</td>
<td>Most of the time</td>
</tr>
<tr>
<td>Do you receive a verbal handoff about all patients whom you need to take care of during the on call?</td>
<td>36 (35)</td>
<td>48 (47)</td>
</tr>
<tr>
<td>Do you receive complete verbal handoff, which makes you well prepared for the shift change?</td>
<td>12 (12)</td>
<td>55 (54)</td>
</tr>
<tr>
<td>Is the verbal handoff conducted face to face?</td>
<td>23 (23)</td>
<td>73 (71)</td>
</tr>
<tr>
<td>Is the verbal handoff conducted over the phone?</td>
<td>0 (0)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Do you use the read-back technique (repeating back critical information to ensure that it is accurately received)?</td>
<td>7 (7)</td>
<td>23 (23)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question; How often...</th>
<th>American surgical residents; no. (%)</th>
<th>Canadian surgical residents; no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Always</td>
<td>Most of the time</td>
</tr>
<tr>
<td>Do you receive a complete written handoff about all the patients whom you need to take care of during the on call?</td>
<td>44 (43)</td>
<td>29 (28)</td>
</tr>
<tr>
<td>Do you receive complete written handoff, which makes you well prepared for the shift change?</td>
<td>30 (29)</td>
<td>37 (36)</td>
</tr>
<tr>
<td>Is the written handoff handed to you physically?</td>
<td>31 (31)</td>
<td>40 (40)</td>
</tr>
<tr>
<td>Is the written handoff left for you so that you can pick it up?</td>
<td>6 (6)</td>
<td>11 (11)</td>
</tr>
</tbody>
</table>
Minor patient harm

Sixty-seven percent of the American surgical residents and 63% of the Canadian surgical residents reported receiving an incomplete patient handoff that resulted in minor harm. Both the American (70%) and the Canadian (59%) surgical residents reported that the most common reason for incomplete patient handoff that resulted in minor patient harm was lack of the most current information about the patient during the verbal handoff. Other reasons are listed in Table 5.

### Table 4. Components of verbal and written handoff, by country

<table>
<thead>
<tr>
<th>Component</th>
<th>Verbal handoff, no. (%)</th>
<th>Written handoff, no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>United States</td>
<td>Canada</td>
</tr>
<tr>
<td>Name of each patient</td>
<td>87 (85)</td>
<td>32 (67)</td>
</tr>
<tr>
<td>Age of each patient</td>
<td>67 (65)</td>
<td>19 (40)</td>
</tr>
<tr>
<td>Room number of each patient</td>
<td>42 (41)</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Medical record number of each patient</td>
<td>27 (26)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Date of admission for each patient</td>
<td>33 (32)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Primary diagnosis for each patient</td>
<td>85 (83)</td>
<td>29 (60)</td>
</tr>
<tr>
<td>Primary physician for each patient</td>
<td>36 (35)</td>
<td>8 (17)</td>
</tr>
<tr>
<td>Type of surgical procedure(s) in the current admission for each patient</td>
<td>94 (91)</td>
<td>33 (69)</td>
</tr>
<tr>
<td>Date of procedure(s) for each patient</td>
<td>69 (67)</td>
<td>15 (31)</td>
</tr>
<tr>
<td>Relevant prior surgical procedure(s) for each patient</td>
<td>55 (53)</td>
<td>13 (27)</td>
</tr>
<tr>
<td>Clinical course in the current admission for each patient</td>
<td>73 (71)</td>
<td>24 (50)</td>
</tr>
<tr>
<td>Complications experienced by each patient</td>
<td>83 (81)</td>
<td>27 (56)</td>
</tr>
<tr>
<td>Comorbidities</td>
<td>61 (60)</td>
<td>15 (31)</td>
</tr>
<tr>
<td>Medications for each patient</td>
<td>24 (23)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Diet information for each patient</td>
<td>54 (52)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Code status for each patient (if any recent change)</td>
<td>29 (28)</td>
<td>14 (29)</td>
</tr>
<tr>
<td>Identification of the sickest patient on the list</td>
<td>79 (77)</td>
<td>35 (73)</td>
</tr>
<tr>
<td>Pending laboratory results to follow</td>
<td>98 (95)</td>
<td>39 (81)</td>
</tr>
<tr>
<td>Pending consults to evaluate</td>
<td>75 (73)</td>
<td>37 (77)</td>
</tr>
<tr>
<td>Pending radiological tests to follow</td>
<td>99 (96)</td>
<td>40 (83)</td>
</tr>
<tr>
<td>Anticipated issues or problems</td>
<td>88 (85)</td>
<td>39 (81)</td>
</tr>
<tr>
<td>New consults/admissions</td>
<td>68 (66)</td>
<td>30 (63)</td>
</tr>
</tbody>
</table>

### Table 5. Reasons for incomplete patient handoff resulting in minor or major harm

<table>
<thead>
<tr>
<th>Reason</th>
<th>American; no. (%)</th>
<th>Canadian; no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minor</td>
<td>Major</td>
</tr>
<tr>
<td>The verbal handoff did not contain the most current information</td>
<td>45 (70)</td>
<td>6 (100)</td>
</tr>
<tr>
<td>The written/electronic handoff did not contain the most current information</td>
<td>30 (47)</td>
<td>3 (50)</td>
</tr>
<tr>
<td>Interruption during the handoff process</td>
<td>25 (39)</td>
<td>2 (33)</td>
</tr>
<tr>
<td>Language barrier between the residents</td>
<td>1 (2)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Knowledge base problem from either one of the residents</td>
<td>24 (38)</td>
<td>5 (83)</td>
</tr>
<tr>
<td>Time constraint affecting the outgoing resident</td>
<td>15 (23)</td>
<td>2 (33)</td>
</tr>
<tr>
<td>Time constraint affecting the incoming resident (you)</td>
<td>12 (19)</td>
<td>1 (17)</td>
</tr>
<tr>
<td>Interpersonal conflict between you and the outgoing resident</td>
<td>2 (3)</td>
<td>1 (17)</td>
</tr>
<tr>
<td>Lack of interactive handoff process (handoff given without opportunity for questions and answers)</td>
<td>15 (23)</td>
<td>2 (33)</td>
</tr>
<tr>
<td>The handoff was conducted in a distracting environment (eg, hospital hallway or emergency department)</td>
<td>17 (27)</td>
<td>2 (33)</td>
</tr>
</tbody>
</table>
Of note, 26% of the American and 39% of the Canadian surgical residents who received an incomplete patient handoff that led to minor harm did not report back to the residents providing them with the handoff to discuss what was missing from the handoff in order to prevent such an incident from happening again. In the case of American surgical residents, the reasons cited were no major harm having happened to the patient (35%), having forgotten it (18%), or not wanting to confront the colleague who gave the incomplete handoff (12%). Other less common reasons were that the resident who received the incomplete handoff did not have time to discuss it with the other resident (6%), or that the resident received the handoff from a senior resident (6%). Reasons for not reporting back about the incomplete handoff among Canadian participants was somewhat different, with lack of time (33%) being the most common, followed by having received the handoff from a senior resident (25%), having forgotten about it (25%) and no major harm having happened to the patient (8%).

**Major patient harm**

Only 6% of American and 7% of Canadian surgical residents reported that major harm occurred as a consequence of problematic patient handoff. The most common reason reported by both groups was that receiving a verbal patient handoff did not contain the most current information. Other reasons are reported in Table 5. All of the American and 67% of the Canadian surgical residents discussed the incident with their senior resident; however, while 50% of the American surgical residents reported that the incident had been discussed in the morbidity and mortality conference, none of the Canadians discussed the incident there. Among the American surgical residents, 83% discussed the incident with the resident who had given them the incomplete handoff, whereas 17% instead discussed it with the senior resident, who consequently addressed it with the resident who was responsible. Of the Canadian surgical residents who had an incomplete handoff that led to major harm, 33% did not discuss the incident with the resident who had given them the handoff owing to lack of time. Fifty percent of the American surgical residents reported that there was a change in the patient handoff process as a result of the patient’s major harm; changes included performing the handoff under supervision, asking more questions and making the handoff a more interactive process. None of the Canadian surgical residents reported any change as a result of major events.

**Improving patient handoff**

Among American respondents, the most frequently endorsed suggestion to improve the patient handoff process was standardizing the verbal handoff so that all residents follow the same technique every time they sign out. In contrast, taking extra measures to decrease the interruptions during patient handoff and devoting a specific and protected time of day for the handoff process were the most frequent factors reported by the Canadian surgical residents to improve the handoff process (Table 6 and Table 7).

**Discussion**

Patient handoff is the method used to transfer patient-related information among health care providers at the time of shift change to ensure patient safety and continuity of care. Handoff is not restricted to the medical field. Many other high-impact organizations, including the National Aeronautics and Space Administration (NASA), nuclear power plants, and railroad dispatch centres, depend on handoff between workers on a daily basis to ensure the safety of the community and the employee at the same time, with an excellent safety profile. However, the health care system is still plagued with medical errors. The landmark report from the US Institute of Medicine in 1999 showed that between 44,000 and 98,000 patients die each year in hospitals secondary to medical errors. A recent study conducted over 5 years that included 10 hospitals from North Carolina found that 25.1 harms occurred per 100 admissions, furthermore, no improvement was found during the 5 years of the study. Medical errors have a huge impact on the economy as well. In 2008, it was estimated that the total costs of measurable medical errors was $171 billion. One of the main causes of patient harm is communication failure among health care providers. Through root cause analysis, the Joint Commission found that communication failure was the third most common cause of sentinel events in 2009 through 2011. Inadequate and incomplete patient handoff had major consequences that led to patient harm.

In our study, we surveyed junior surgical residents in the United States and Canada to assess their perceptions of patient handoff and to determine how to improve it. The participating residents reported that the most common cause leading to both major and minor harm was incomplete verbal handoff. This could be the result of many factors, including lack of training of the junior surgical residents, lack of standardization of verbal and written handoff, failure to include all patients in the verbal handoff, lack of face-to-face interaction, passive transfer of information without opportunity for questions and answers, interruptions, time constraints and failure to identify the sickest patients on the list. Mnemonics have been used to standardize the handoff process and to ensure the completeness and consistency of the handoff. However, a systematic review conducted between 1987 and 2008 identified 24 mnemonics reported in the literature and found that more than half of the studies used “SBAR” (situation, background, assessment, recommendations). This clearly indicates that there is no single mnemonic that can fit each situation and specialty. Moreover, these mnemonics...
were not validated on a larger scale. An example of a comprehensive list of items to follow during the verbal handoff is shown in Table 8, which can be modified according to each rotation. A recent study by Starmer and colleagues showed that an implementation of I-PASS handoff bundle was associated with a significant decrease in medical errors.

Patient handoff is often conducted by the most junior part of the team at the time of shift change to allow continuity of care and, at the same time, to respect the rules of working hours. Although patient handoff is a critical component of patient safety, we found that most junior surgical residents did not receive any patient handoff training in

<table>
<thead>
<tr>
<th>Table 6. Ways to improve existing handoff from the residents’ perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suggested improvement</strong></td>
</tr>
<tr>
<td>Implement an education course about patient handoff to all the residents</td>
</tr>
<tr>
<td>Perform the handoff under supervision of the senior resident</td>
</tr>
<tr>
<td>Perform the handoff under supervision of the attending surgeon</td>
</tr>
<tr>
<td>Take extra measures to decrease the nonurgent interruptions during the handoff process</td>
</tr>
<tr>
<td>Standardize the written/electronic handoff so that all the residents will follow the same technique to sign out every time</td>
</tr>
<tr>
<td>Standardize the verbal handoff so that all the residents will follow the same technique to sign out every time</td>
</tr>
<tr>
<td>Devote a specific and protected time of the day for the handoff process</td>
</tr>
<tr>
<td>Devote a specific place for the handoff process to take place</td>
</tr>
<tr>
<td>Improve the electronic/written handoff computer program</td>
</tr>
<tr>
<td>Use an electronic tablet (such as iPad) for the handoff</td>
</tr>
<tr>
<td>Use a smartphone application for the handoff</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 7. Program- and resident-related recommendations to improve patient handoff from the residents’ perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program-related</strong></td>
</tr>
<tr>
<td>Training: implement a training course for the new residents about how to perform patient handoff</td>
</tr>
<tr>
<td>Improve consistency: designate a specific place and time for patient handoff to take place every day at the same place and time</td>
</tr>
<tr>
<td>Improve consistency: designate a specific place and time for patient handoff to take place every day at the same place and time</td>
</tr>
<tr>
<td>“Sterile medical rule”: develop a new protocol to minimize interruptions and pages during the time of patient handoff except for emergencies</td>
</tr>
<tr>
<td>Feedback: adopt a policy to report and discuss any problem in communication or patient handoff that resulted or could have led to patient harm</td>
</tr>
<tr>
<td>Improve electronic format of the written handoff</td>
</tr>
<tr>
<td>Provide feedback at the time of receiving the handoff and after the shift change during the next handoff, and discuss what was missing and how to avoid such a problem in the future</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8. Proposed list of items to be covered during verbal patient handoff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient name, age and sex</strong></td>
</tr>
<tr>
<td><strong>Diagnosis</strong></td>
</tr>
<tr>
<td><strong>Type of surgery(es)</strong></td>
</tr>
<tr>
<td><strong>Number of postoperative days</strong></td>
</tr>
<tr>
<td><strong>Surgical/medical history</strong></td>
</tr>
<tr>
<td><strong>Brief hospital course during this current admission</strong></td>
</tr>
<tr>
<td><strong>Issues during the day and what has been done to address them</strong></td>
</tr>
<tr>
<td><strong>Potential problems during the on call and what’s the plan to address those problems</strong></td>
</tr>
<tr>
<td><strong>Things to follow up on (e.g., laboratory results, imaging results)</strong></td>
</tr>
<tr>
<td><strong>Code status, level of care</strong></td>
</tr>
</tbody>
</table>
their programs, and approximately one-third of the residents recommended implementing courses at the start of residency. This recommendation has been supported in the literature; it was found that brief training on patient handoff might improve the handoff process.14,15

Surgical residents reported that receiving handoff from cross-covering or moonlighting residents was most problematic. This could be explained by the fact that the cross-covering residents do not receive a complete handoff about all the patients they are covering, which can lead to poor cross-coverage of the inpatient service by the moonlighter and, consequently, a poor signoff to the primary team when the shift ends. This situation is exacerbated if the moonlighter signs off to a new team. Furthermore, this problem could be due to lack of patient ownership since the cross-covering resident is covering only a shift and will not follow this patient later on.

Surgical residents reported that interruptions during the patient handoff process led to minor and major harm. More than half of these residents reported that they were interrupted during the handoff process some of the time, leading to loss of information that should have been transferred to the other resident, in turn leading to incomplete patient handoff. Paging of surgical residents by nurses during the handoff process was the most common reason for interruptions reported in our study. It has been shown that reducing the number of unnecessary pages decreases disruption of patient care and leads to more rest for the interns.16 In aviation, many accidents were reported before 1981 owing to distraction of the flight crew with nonessential tasks. As a result, the Federal Aviation Administration enacted “The Sterile Cockpit Rule,” which entails that pilots and crew members are prohibited from doing nonessential activities during critical moments of the flight, including the taxi, landing and takeoff. Nonessential activities include eating meals, engaging in nonessential conversations within the cockpit and nonessential communications between the cabin and cockpit crews.17 In health care, there are critical situations, such as patient handoff, surgical timeout and a patient code or trauma resuscitation, where a “sterile medical rule” should be applied, avoiding all nonessential tasks, discussions and distractions to ensure patient safety and the best possible care for the patient. Each health care institution should implement their own new protocols to minimize those interruptions during those times.

One method for improving the learning process and performance is the use of feedback. However, certain rules must be followed to maximize the benefits of feedback.18 We found that approximately 40% of the Canadian surgical residents didn’t discuss the problematic patient handoff that led to minor harm with the residents who gave the handoff. Although the reasons differ between the American and Canadian surgical residents, feedback should be part of the daily patient handoff to improve the process.19

We asked the surgical residents about how to improve the patient handoff at their institutions. We divided their responses into 2 categories: program-related and resident-related (Table 7). More effort from the residency programs is required to optimize the patient handoff. All the factors that are resident-related could be taught in a course or workshop about patient handoff.

**Limitations**

We acknowledge the study’s limitations. First, we had a very low response rate from the surgical residency programs, particularly in the United States, and responses were from junior surgical residents only, which limits the generalizability of our findings. The survey was anonymous and lacked any identifiers. Thus we could not compare responders to nonresponders in this study. Second, the measurement of patients’ harm was subjective and broadly divided to either minor or major harm based on junior residents’ impressions. Given the anonymity of the survey, these perceptions were not correlated with more standardized objective assessment of complications. Third, our study was restricted to junior surgical residents and did not include senior-level residents, which may overstate the lack the training and/or inexperience with handoffs.

**CONCLUSION**

Despite these limitations, surgical residents self-report that the current patient handoff system still contributes to patient harm. More efforts are needed to establish standardized forms of verbal and written handoff to ensure patient safety and continuity of care.

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**Competing interests**: None declared.

**Contributors**: All authors designed the study. A. Saleem acquired and analyzed the data, which S. Parsons also analyzed. A. Saleem wrote the article, which all authors reviewed and approved for publication.

**References**


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Rehabilitation after lower limb injury: development of a predictive score (RALLI score)

Dominique M. Rouleau, MD, MSc
Alexandre Place, MD
Mélanie Bérubé, Inf, MSc
Yves G. Laflamme, MD
Debbie Feldman, PhD, PT

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Correspondence to:
D. Rouleau
Department of Orthopaedic Surgery
Hôpital du Sacré-Cœur de Montréal
5400 Gouin Ouest, C-2095
Montreal QC H4J 1C6
dominique.rouleau@umontreal.ca

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**Background:** The purpose of our study was to identify the risk factors associated with the need for inpatient rehabilitation after lower limb injury to develop a predictive scoring tool for early identification of such patients.

**Methods:** We followed a prospective cohort of patients admitted to a level 1 trauma centre. Data were collected through chart review and a self-administered questionnaire on sociodemographics, patient living environment, pretrauma status, injury and treatment received. We compared patients who were discharged home with those going to rehabilitation after acute care. Analysis consisted of bivariate comparisons and logistic regression.

**Results:** Our study included 160 patients with a mean age of 56 years. A total of 40% were discharged to an inpatient rehabilitation centre. Factors associated with inpatient rehabilitation were low preinjury physical health status, concomitant injury of the upper limbs, bilateral lower limb injury, the use of a walking aid before injury, head injury and femur or pelvic fractures. We created a predictive score using the top 3 risk factors: upper limb injury, bilateral lower limb injury and presence of femoral or pelvic fractures. The chance of needing inpatient rehabilitation rose from 14% with 0 factors to 47% with 1 factor and 96% with 2 factors.

**Conclusion:** Rehabilitation planning should begin for patients exhibiting at least of 3 risk factors at the time of admission to acute care. Prospective validation of the tool is needed, but it has the potential to orient the multidisciplinary team’s decision on rehabilitation needs postdischarge.
Lower limb injuries account for up to 38% of all serious injuries. Ambulatory limitation following these injuries prevents a large number of patients from returning home rapidly. Furthermore, a substantial proportion of patients continue to have disabilities, and after 1 year 50% of patients with lower limb trauma have not regained their pre-injury level of function. Ponsford and colleagues showed that only 54% of patients admitted for orthopedic trauma were back at work 1 year post-trauma. Rehabilitation needs remain a crucial element of recovery that could be improved. Often, to determine what kind of rehabilitation is needed for patients after acute care, a multidisciplinary team composed of a physiotherapist, occupational therapist, social worker, nurse and physician is needed. This team analyzes a multitude of factors, including patient characteristics, trauma severity, home description and social support. The final decision of whether a patient can be discharged home is made after a concerted professional health care evaluation, which can take several days, extends length of stay in hospital (LOS) and consumes important health care resources. Poulos and colleagues reported that 45% of inappropriate days in acute care were due to delays in this decision process. As cost containment and evidence-based orthopedics are becoming increasingly important, reliable tools and valid measures are required to optimize rehabilitation and to reduce costs.

Optimally, the need for rehabilitation should be predicted as soon as possible after the patient is admitted in order to avoid undesirable delays in discharge planning. Similar challenges have been encountered with the joint replacement surgical population leading to the development of the “fast track” philosophy with an increased rate of discharge home rather than to the rehabilitation centre. Significant decreases in length of stay were obtained in multiple studies based on this type of approach. Clay and colleagues highlighted the need for more prospective studies with methodologies that have larger sample sizes and that consider a comprehensive range of factors to predict autonomy after injury.

Factors that typically predict rehabilitation needs include age, premorbid level of activity, obesity, injury severity and certain comorbid medical conditions. Despite the complexities involved with a heterogeneous trauma population, we believe it is possible to develop a systematic tool to help determine the patient’s need for rehabilitation after lower limb injury. Therefore, the aim of our study was to develop a predictive score of inpatient rehabilitation needs after lower limb injury, and the secondary objective was to explore factors associated with acute care LOS.

**Methods**

We conducted a prospective cohort study that included all patients older than 18 years who were admitted to a level 1 trauma centre for lower limb injury between August 2011 and September 2012. Patients had to stay a minimum of 1 night in the orthopedics ward to be considered hospitalized. We defined lower limb injury as a fracture or clinically important soft tissue injury affecting structures from the pelvis to the toes. Patients who had simple lower limb trauma without hospitalization (e.g., an ankle fracture, including those treated by open reduction and internal fixation on an ambulatory basis) were excluded. We also excluded patients with pathologic fractures, those who were unable to communicate and those with previous lower limb surgery. The hospital research ethics board approved the study, and all participants signed an informed consent form.

Based on the determinants that affect rehabilitation needs after surgery that have been previously identified in the literature, we hypothesized that the following factors could potentially determine the need for inpatient rehabilitation: preinjury functional status, injury severity, surgical treatment, age, sex, distance between home and hospital and socioeconomic status. We also collected the following data from the patient’s file: patient and injury characteristics, time of injury, admission, hospital discharge and destination after acute care hospitalization. Patients completed questionnaires that described function preinjury (Lower Extremity Measure [LEM]), health status (SF-12 version 2 [SF12V2]) and sociodemographic information. Preinjury functional status was assessed with medical history and included the number of stairs inside and outside the home, the type of residence (home, apartment, nursing home, prison) and the use of walking aids. We also collected information on body mass index (BMI) — calculated from height and weight as reported by the patient — and smoking status, which may be correlated with a longer hospitalization as it is associated with medical complications. Injury severity characteristics included isolated trauma or poly-trauma, upper limb involvement, open or closed fracture, trauma associated with head injury, surgical versus conservative treatment, trauma above or below the knee, time between injury and hospital admission and time between admission and surgery. Socioeconomic status was characterized by employment status (unemployed, employed, retired, autonomous worker, student, other), marital status (married, divorced, single, widower) and patient insurance (none, provincial automobile insurance plan, workers compensation, private insurance). The distance between the home and hospital was calculated using Google Maps and the patient’s postal code. The LEM, a questionnaire for which a normal functional score is 85 or higher and that has been validated in the orthopedic population, was used to assess preinjury lower limb functional status. For assessment of their general health status, patients completed the SF12V2, which has also been validated in trauma patients. We estimated that we would need a sample size of 160 patients to create a regression model with 5–7 factors using the rule of thumb of 20 patients per predictor.
Statistical analysis

Primary analysis: rehabilitation needs
We classified patients in 2 groups: patients going directly home after acute care and patients who were discharged to inpatient rehabilitation in another centre. We compared these groups in terms of age, number of stairs at home, LOS, LEM and SF12V2 scores using \( t \) tests. We used \( \chi^2 \) tests to compare them with respect to sex, employment status, marital status, smoking status, use of walking aids, fracture versus soft tissue injury, number of injuries (> 1 v. 1), presence of head injury, unilateral versus bilateral lower limb injury, presence of upper limb injury, surgical treatment, pelvis versus other lower limb injury, femur injury versus other injury and open versus closed fracture. We considered results to be significant at \( p < 0.05 \).

We constructed a step-wise logistic regression model, entering age, sex and any factor \( (p < 0.05) \) associated with discharge to inpatient rehabilitation in the bivariate analysis. A prospective score of 3 items was built using the factors whose odds ratios (ORs) remained significant in the regression analysis.25 The score was tested on the database to determine a threshold for prediction of rehabilitation needs using the PASW version 18.0 software for statistical analyses.

Secondary analysis
In order to achieve our second objective, we analyzed the factors related to LOS in acute care. We conducted a bivariate analysis between potential risk factors (the same as those for the rehabilitation needs analysis described previously) and increased LOS (in days) using Pearson correlations for continuous data and Student \( t \) tests for dichotomous variables. We considered results to be significant at \( p < 0.05 \).

RESULTS

During our study period, 301 potential patients were identified: 160 agreed to participate and 141 were not included (Fig. 1). Reasons for nonparticipation or exclusion were missed patients \( (n = 69) \), refusal \( (n = 41) \), cognitive impairment \( (n = 12) \), severe head injury \( (n = 6) \), language barrier \( (n = 5) \), isolation for resistant germs \( (n = 3) \), pathologic fracture \( (n = 2) \), previous lower limb surgery \( (n = 2) \) and rheumatoid arthritis \( (n = 1) \). Participants were younger than nonparticipants \( (56 v. 64 \text{ yr}, p = 0.002) \), but did not otherwise differ. The sample included 84 men (53%). The mean age of patients was 56 years, and 26% were 70 years or older. A description of the cohort is provided in Table 1, Table 2 and Table 3.

Bivariate analysis revealed that the following factors were associated with inpatient rehabilitation: polytrauma, bilateral lower limb injury, pelvic injury, femoral injury, upper limb and head injury and use of a walking aid before injury (Table 4); these factors increased the risk of inpatient rehabilitation from OR 2.4 to OR 7.3. Patients who underwent
rehabilitation also had a lower preinjury SF12 physical score (47 ± 15 v. 52 ± 10, p = 0.051).

The stepwise logistic regression model was built using 0.05 or lower as an entry value and 0.1 as an exit value. As described in the analysis section, we forced age and sex into the model and then used step-wise methodology. In the final logistic regression model, the following factors were retained: bilateral lower limb injury, upper limb injury and femur or pelvis fracture (Table 5).

The 3 factors that predicted inpatient rehabilitation were assessed. If none were present, the risk of inpatient rehabilitation was only 14%. When 1 factor was present, depending on which one, the risk increased between 41% and 53%, and with 2 factors present it increased between 79% and 86% (Table 6). Based on this data, we constructed a simple decision tool; the presence of at least 2 factors (score of 2) would indicate referral to inpatient rehabilitation.

With respect to our secondary objective, patients needing rehabilitation stayed longer in hospital (16 v. 11 d, p = 0.011). Factors affecting LOS in acute care were decreased preinjury LEM score, bilateral lower limb injury, upper limb injury and use of a walking aid before injury (Table 7).

**DISCUSSION**

We determined that bilateral injury, upper limb injury and femur or pelvic fractures were strong predictors for inpatient rehabilitation following hospital admission for lower limb injury, and we developed a simple tool to predict the need for inpatient rehabilitation after lower limb injury. Although this tool will need to be validated, it has the potential to help the medical team determine early during the hospital admission the required postdischarge care. Our bivariate analysis findings agree, for the most part, with the literature. Oldmeadow and colleagues determined that for patients undergoing hip or knee arthroplasty, older age and use of a walking aid were predictive of extended inpatient rehabilitation. Our results indicated that bilateral limb injuries and concomitant injury of the upper limbs were associated with inpatient rehabilitation; both these factors led to greater challenges for renewed mobility and thus the potential need for rehabilitation strategies. Polytrauma patients, owing to the more severe nature of their injuries, are more likely to have greater functional limitations and therefore greater rehabilitation needs. Clearly, ambulatory capacities play a decisive role regarding the need for inpatient rehabilitation. Similarly, the use of a walking aid before injury suggests a more fragile premorbid state and reduced adaptive capabilities postoperatively. Severity of injury, preinjury disability and pelvic or femur fractures were also identified as factors affecting inpatient rehabilitation needs and disability after trauma.

This study marks, to our knowledge, the first step toward the development of a scoring system that could guide discharge of lower limb trauma patients as early as possible. Strengths of the study include its prospective

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**Table 1. Cohort description**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of patients or mean ± SD (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking aid preinjury</td>
<td>20 (16)</td>
</tr>
<tr>
<td>Tobacco</td>
<td>41 (26)</td>
</tr>
<tr>
<td>Retired</td>
<td>51 (32)</td>
</tr>
<tr>
<td>Polytrauma</td>
<td>50 (32)</td>
</tr>
<tr>
<td>Upper limb injury</td>
<td>24 (15)</td>
</tr>
<tr>
<td>Bilateral lower limb injury</td>
<td>26 (16)</td>
</tr>
<tr>
<td>Head injury</td>
<td>19 (12)</td>
</tr>
<tr>
<td>Conservative treatment</td>
<td>19 (12)</td>
</tr>
<tr>
<td>Femur fracture</td>
<td>41 (26)</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>32 (20)</td>
</tr>
<tr>
<td>Age, yr</td>
<td>56 ± 20 (18–89)</td>
</tr>
<tr>
<td>Male sex</td>
<td>84 (53)</td>
</tr>
<tr>
<td>Distance from the hospital, km</td>
<td>43 ± 101 (0–615)</td>
</tr>
<tr>
<td>LEM score preinjury</td>
<td>92 ± 16 (22–100)</td>
</tr>
<tr>
<td>SF12 physical score preinjury</td>
<td>50 ± 12 (0–66)</td>
</tr>
<tr>
<td>SF12 mental score preinjury</td>
<td>54 ± 10 (0–70)</td>
</tr>
</tbody>
</table>

LEM = Lower Extremity Measure; SD = standard deviation; SF12 = Short-Form 12 version 2.

---

**Table 2. Comparison of patients included and excluded**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Included, n = 160</th>
<th>Missed/excluded, n = 141</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr*</td>
<td>56 ± 20 (18–89)</td>
<td>64 ± 24 (18–101)</td>
<td>0.002</td>
</tr>
<tr>
<td>Male sex†</td>
<td>84 (53)</td>
<td>60 (43)</td>
<td>0.08</td>
</tr>
<tr>
<td>Polytrauma†</td>
<td>50 (31)</td>
<td>36 (26)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

SD = standard deviation.  
*Student t test.  
†c² test.

---

**Table 3. Description of fractures**

<table>
<thead>
<tr>
<th>Location of the fractures</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic</td>
<td>32 (17)</td>
</tr>
<tr>
<td>Hip</td>
<td>18 (10)</td>
</tr>
<tr>
<td>Femur diaphysis</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Distal femur</td>
<td>9 (5)</td>
</tr>
<tr>
<td>Patella</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Proximal tibia</td>
<td>13 (7)</td>
</tr>
<tr>
<td>Tibia diaphysis</td>
<td>35 (18)</td>
</tr>
<tr>
<td>Ankle</td>
<td>52 (27)</td>
</tr>
<tr>
<td>Foot</td>
<td>21 (11)</td>
</tr>
</tbody>
</table>

*Twenty-seven patients had multiple fractures.

---

**Table 4. Predictors of inpatient rehabilitation need (bivariate analysis)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>OR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polytrauma</td>
<td>4.9 (2.4–10.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Bilateral lower limb injury</td>
<td>7.3 (2.8–19.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Pelvis injury</td>
<td>4.5 (2.5–10.4)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Femur injury</td>
<td>2.4 (1.2–5.0)</td>
<td>0.015</td>
</tr>
<tr>
<td>Upper limb injury</td>
<td>5.4 (2.1–13.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Head injury</td>
<td>3.8 (1.4–10.7)</td>
<td>0.007</td>
</tr>
<tr>
<td>Walking aid preinjury</td>
<td>3.3 (1.3–8.3)</td>
<td>0.009</td>
</tr>
</tbody>
</table>

CI = confidence interval; OR = odds ratio.
nature, use of both patient questionnaire and medical file data and a stable multidisciplinary team for the entire data collection period. Furthermore, the scoring system is simple and can be used at an early stage of the hospitalization process.

**Limitations**

Challenges of the study included avoiding recruitment bias. Nonparticipants were older than participants but were not otherwise significantly different; however, this may have led to an underestimation of the association between age and inpatient rehabilitation needs. Validation of this tool is also needed before suggesting its use elsewhere, as the results are most pertinent to the centre where the research was performed. Finally, there may be a problem with generalizability to other acute care. Further research using the tool in other health centres is needed.

Through a prospective study using a cohort of patients hospitalized for lower limb injuries, we found that having bilateral lower limb injury, a concomitant upper limb injury, or polytrauma increases the risk of requiring inpatient rehabilitation by 3–7 times. The tool that we created can be used to screen patients who are likely to require inpatient rehabilitation after acute care and consists of 3 factors: bilateral injury, upper limb injury and femur or pelvic fractures. This information can be used to accelerate discharge planning to the appropriate resource. Additional study is required to determine if this new scoring system results in a reduction of LOS and in improved care efficiency. Application of the tool in another centre could be an interesting way to further the investigation.

**Table 5. Predictors of need for inpatient rehabilitation after lower limb injury**

<table>
<thead>
<tr>
<th>Factor</th>
<th>OR (95% CI)</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral lower limb injury</td>
<td>7.2 (2.2–23.1)</td>
<td>0.001</td>
</tr>
<tr>
<td>Concomitant upper limb injury</td>
<td>4.4 (1.3–14.3)</td>
<td>0.015</td>
</tr>
<tr>
<td>Femur or pelvic fracture</td>
<td>5.6 (2.4–13.0)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

CI = Confidence interval; OR = odds ratio.

**Table 6. RALLI score**

<table>
<thead>
<tr>
<th>No. of factors</th>
<th>Concomitant upper limb injury</th>
<th>Femur or pelvic fracture</th>
<th>Bilateral lower limb injury</th>
<th>Risk of inpatient rehabilitation</th>
<th>Mean risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>1/3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>41%</td>
<td>47%</td>
</tr>
<tr>
<td>2/3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>79%</td>
<td>83%</td>
</tr>
<tr>
<td>3/3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>96%</td>
<td>96%</td>
</tr>
</tbody>
</table>

RALLI = rehabilitation after lower limb injury.

**Table 7. Factors increasing length of stay**

<table>
<thead>
<tr>
<th>Factor</th>
<th>LOS; mean ± SD, ( d )*1</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral injury</td>
<td>18 ± 9</td>
<td>12 ± 12</td>
</tr>
<tr>
<td>Upper limb injury</td>
<td>18 ± 9</td>
<td>12 ± 12</td>
</tr>
<tr>
<td>Walking aid preinjury</td>
<td>18 ± 22</td>
<td>12 ± 9</td>
</tr>
<tr>
<td>LEM preinjury, Pearson correlation coefficient</td>
<td>( r = -0.274 )</td>
<td>0.001</td>
</tr>
</tbody>
</table>

LEM = Lower Extremity Measure; LOS = length of stay in hospital; SD = standard deviation.

*Unless indicated otherwise.

**References**

Penetrating nontorso trauma: the head and the neck

Chad G. Ball MD, MSc
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Correspondence to:
C.G. Ball
Foothills Medical Centre
University of Calgary
1403 – 29 St. NW
Calgary AB T2N 2T9
ball.chad@gmail.com

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Summary

Acute penetrating injuries to the head and neck cause considerable anxiety for most clinicians owing to concern for airway control and neurologic injury and to limited clinician experience in most centres. This article discusses an organized approach to the evaluation and initial treatment of penetrating injuries to the head and neck based on regional anatomy and clinical examination. The approach is particularly helpful in the context of ongoing hemorrhage and/or airway compromise.

Acute penetrating injuries to the head and neck continue to induce considerable anxiety for most clinicians. This reality is founded in an appropriate concern for both airway control and neurologic injury, as well as in limited clinician experience in most centres. The focus of this article is to deliver a concise and efficient diagnostic and initial management plan for patients with penetrating injuries to the head and neck.

Brain and face injuries

Penetrating brain injuries can be particularly lethal. As with torso and extremity penetrating trauma, high-fidelity cross-sectional imaging with computed tomography (CT) represents the gold standard diagnostic investigation for penetrating brain injuries. This method allows a rapid and detailed evaluation of the skull, face, sinuses, intracranial blood vessels and brain parenchyma. Although these wounds can be dramatic in appearance and presentation, the trajectory is particularly important in the case of gunshot wounds (GSWs). Transcranial wounds (i.e., wounds that cross the midline) are almost uniformly fatal. Notable exceptions include isolated frontal lobe transcranial wounds as well as a minority of occipital transcranial trajectories. Gunshot injuries that remain ipsilateral, however, generally have a much better prognosis. In this setting, immediate guidance from a neurosurgeon is mandatory, as full neurologic rescue manoeuvres are common. It is interesting to note that many GSWs to the skull provide pressure decompression via the wounds themselves.

Given the vascular nature of the head and face, ongoing massive hemorrhage is not infrequent. As noted elsewhere, balloon tamponade can be particularly helpful in the initial arrest of hemorrhage, as can simple intraoral finger pressure or packing pressure.1 Similarly, capturing an airway is typically the most urgent matter in patients who present with massive destruction of their mandible and midface following coronal GSWs. Obtaining an airway is often simple in these patients, using the exposed tongue as a guide; obtaining an airway must precede the diagnostic workup for concurrent brain and/or other injuries. A surgical cricothyroidotomy remains the resident rescue airway.

It should also be noted that foreign bodies (missiles, shrapnel, dirt, glass) within the orbits, eyes and scalp lacerations must be ruled out via imaging or clinical examination. Retained debris in these areas is particularly problematic with regard to both function and sepsis.

Neck injuries

Penetrating neck injuries are variable with respect to the occurrence of injury (GSWs 50%, stab wounds 10%–20%). As with torso trauma, the approach to
penetrating trauma of the neck is based on regional anatomy. The modern division of the anterior neck comprises 3 zones: zone 3 above the angle of the mandible, zone 2 between the angle of the jaw and the cricothyroid membrane and zone 1 between the cricothyroid membrane and the clavicles/manubrium (Box 1). Penetrating injuries to zones 1 and 3 parallel notorious difficulty in obtaining emergent surgical access and therefore require an urgent CT screening examination to rule out injury in the presence of any abnormality detected on physical examination or chest radiograph. Vascular injury in particular can be studied with CT angiography, percutaneous exploration for detecting clinically relevant penetrating vascular injuries (false-negative rate 1%), angiography should be considered mandatory in cases of injury that traverse 2 neck zones, cross the midline, have concurrent head injury and resulted from shotgun blasts and/or multiple missile tracts. Because of the ease of surgical access, zone 2 has undergone a series of liberal versus conservative approaches over the past decades. Current evidence clearly supports a selective nonoperative algorithm in cases where hemodynamic and airway stability are evident. Nontherapeutic neck explorations in this scenario approach 67% in some series. When patients require investigations to rule out vascular (carotid and vertebral arteries), digestive (esophagus) and/or airway (trachea) injuries, some authors advocate multidetector CT as an isolated test to rule out all 3 systems. Additive bronchoscopy, esophagoscopy and contrast fluoroscopy examinations can also be extremely helpful. The combination of endoscopic and radiologic examination of the esophagus in particular is known to improve the sensitivity of each test in isolation. As always, hard signs of cervical arterial and/or vascular injury mandate immediate operative or percutaneous exploration. These include ongoing hemorrhage, enlarging/pulsatile hematoma, bruit (carotid-jugular arteriovenous fistula), pulse deficit, pending airway compromise, bubbling from the wound, acute focal neurologic deficits (including hemiparesis), large-volume hemoptysis or hematemesis, or concern for complete airway transection (i.e., respiratory distress/stridor). Approximately 3% of patients with soft signs of injury (subcutaneous emphysema, hoarseness, odynophagia) will require a therapeutic operative intervention. As with extremity trauma, injuries with shotgun or explosive mechanisms should undergo a complete angiographic evaluation of regional vasculature to rule out the presence of multiple injuries. Unlike extremity trauma, however, there remains no reliable equivalent of an ankle-brachial index for the brain. As a result, massive bleeding at the scene, proximity to trajectory and a nonpulsatile hematoma are considered to be soft signs of potential vascular injury that should illicit further investigations. It must be emphasized that there remains no role for probing neck wounds. If the wound has penetrated the platysma, there is a 45% chance of an underlying injury. Balloon tamponade can be particularly expedient at arresting hemorrhage in the neck and has been advocated as a definitive treatment for venous injuries in some centres. Clinically significant cervical spine injuries caused as a result of penetrating trauma are rare. If a patient arrives with an intact neurologic examination despite GSW or stab wounds to the neck, the incidence of a cervical spine injury that requires a therapeutic intervention is minute. As a result, in a neurologically intact and examinable patient, a cervical collar should be immediately removed to facilitate the remaining components of the diagnostic evaluation.

Box 1. Organs of potential concern within the anterior cervical zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>Anatomical structures involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>Great vessels, Esophagus, Trachea, Phrenic nerve, Vagus nerve</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Carotid and vertebral arteries, Esophagus, Airway</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Base of skull, Carotid and vertebral arteries, Oropharynx</td>
</tr>
</tbody>
</table>

References

Penetrating nontorso trauma: the extremities

Similar to penetrating torso trauma, nontorso injuries have undergone a fascinating oscillation between invasive and noninvasive approaches. This article discusses an organized approach to the evaluation and initial treatment of penetrating extremity injuries based on regional anatomy and clinical examination. The approach is reliable, efficient and minimizes both delays in diagnosis and missed injuries. Outpatient follow-up is particularly important for patients with extremity injuries who are discharged home from the emergency department.

Penetrating nontorso trauma: the extremities

Summary

Similar to penetrating torso trauma, nontorso injuries have undergone a fascinating oscillation between invasive and noninvasive approaches. The history of managing penetrating peripheral extremity vascular wounds includes some of the most notable surgeons within the history of surgery. The aim of this discussion is to outline a logical and systematic approach to the diagnosis and initial management of penetrating extremity trauma.

Peripheral extremity trauma remains the most common source of vascular injury (51%), with the femoral artery continuing to be the most frequently injured vessel (35%). More specifically, 6% of all patients with penetrating extremity trauma sustain a vascular injury compared with less than 1% of patients with blunt injuries. Associated regional trauma is also common in the context of an extremity arterial injury and includes major veins (31%), nerves (27%) and bones (26%). It is interesting to note that the treatment of extremity vascular injuries has evolved substantially over the past 100 years. This improvement is best indicated by a progressive decrease in amputation rates owing to specific advances within military conflicts (World War I 16% [exsanguination], World War II 50% [prolonged tourniquet use and vessel ligation], Korean War 13% [primary vessel repair], Vietnam War 12% [rapid transport and primary vessel repair], Middle Eastern conflicts 3%–20% [early temporary intravascular shunts]).

The ability to temporize ongoing hemorrhage via proximal occlusion (i.e., compression or tourniquet) offers a distinct advantage for the rapid management of extremity injuries over torso wounds of similar magnitude (i.e., “no vessel outside the human trunk is larger than the human thumb”). The work-up of penetrating extremity injuries also emphasizes physical examination as the mainstay of the diagnostic algorithm. Although the specific operative management of these injuries is beyond the scope of this discussion, the ability of the clinician to obtain proximal vascular control with ease in addition to the absence of concern over gastrointestinal contamination makes the diagnosis and initial management of extremity trauma extremely rapid.

It should be re-emphasized that an immediate evaluation of the entire body (including the torso) is essential as a first manoeuvre upon the arrival of any patients with a penetrating injury (Fig. 1). Ruling out additional life-threatening overt or occult hemorrhage clearly precedes the salvage of limbs. A rapid primary survey of the extremities is then warranted. This should include evaluation for bony, nervous, vascular and soft-tissue injuries. Beyond initial palpation of the limbs, radiographs with wound markers (e.g., paper clips) are mandatory to rule out fractures. Similarly, if the patient is interactive, evaluating the neural integrity (motor and sensory) of the limbs is crucial. All active
bleeding must be stopped by digital occlusion/direct pressure, balloon tamponade, or proximal tourniquet before proceeding with any diagnostic or therapeutic endeavours. All long, bony fractures should be reduced before assessing for alterations in or a return of distal pulses.

Although the indications for immediate transfer to the operating theatre (Box 1) and/or “hard” signs that should trigger interventions (Box 2) are not debated, it is becoming increasingly evident that shortening the time interval to reperfusion of the extremity is essential. More specifically, reperfusion before the traditional 6-hour ischemia cutoff clearly results in improved long-term function of the extremity. It must also be remembered that arteries with a complete transection tend to spasm and stop bleeding below systolic blood pressures of 80 mm Hg, whereas partial thickness arterial lacerations are not able to contract and therefore continue to hemorrhage (regardless of systemic hypotension).

Evaluating the vascular status of a limb requires multiple steps. Although pulse status is important, it must also be remembered that distal pulses will continue to be present in many limbs with confirmed significant arterial injuries via propagation of the pulse through a column of blood clot. Similarly, although bruits secondary to acute arteriovenous fistulas (AVF) occur immediately following the injury itself, auscultation is very challenging within a noisy trauma bay environment. The subsequent step in the diagnosis of extremity vascular injuries is obtaining an ankle-brachial (ABI) and/or brachial-brachial index measurement. This technique requires a sphygmomanometer and audible Doppler machine or stethoscope. The pressure at which the audible pulse is detected in the injured limb (numerator) is compared (ratio) to that within the noninjured limb (denominator). If this ratio is greater than 0.9, the incidence of a clinically relevant vascular extremity injury is negligible. If the ratio is less than 0.8, the chances of the patient possessing a true vascular injury is very high (sensitivity 95%). In this scenario, many surgeons proceed directly to the operating theatre on an urgent basis. If the ratio is between 0.9 and 0.8, however, further investigations (angiography) are typically warranted. It should be noted that these ratios can be affected by severe limb hypothermia, so ensuring a warm trauma bay environment is crucial. Additional “soft” signs of extremity vascular injury that may necessitate further diagnostic evaluation include a neurologic deficit adjacent to a named vessel, bony dislocation/fracture adjacent to a named vessel and small nonpulsatile hematomas. Any of these soft signs in isolation will yield a vascular injury rate of approximately 10%. Variant combinations will yield injury rates between 3% and 25%. It should be noted that despite the very high sensitivity inherent within ABIs, clinically less significant nonocclusive vascular injuries remain possible with an ABI > 0.9 (i.e., intimal flap, spasm, subintimal or intramural hematoma, tiny pseudoaneurysm). These are rarely treated with intervention.

There have been several trends regarding the role of angiography in extremity trauma over the past decades. More specifically, routine bedside emergency department (ED) angiography by the trauma service for all extremity wounds (i.e., using indications such as wound proximity) has long since been shown to be unnecessary. Although the specific angiographic modality of choice is debatable, patients with an ABI less than 0.9 require a definitive diagnostic arteriogram. Options include ED angiography using either multiple “single-shot” radiographs (30 mL injectable contrast), C-arm fluoroscopy, or Lodox continuous gantry technology. In most developed centres, however, more formal angiography with either computed tomography (CTA) or percutaneous techniques is preferred. Given recent improvements in the fidelity of CTA (i.e., 3-dimensional reconstruction), CTA is the first choice of many clinicians. If, however, the surgeon’s pretest probability of a vascular injury is high (concerning clinical exam and ABI < 0.9), angiography at the time
of operative exploration may be more expedient. Although patency of most lower-extremity vascular repairs should be confirmed with an angiogram before leaving the operating suite, the return of distal pulses, capillary refill and warmth to the injured upper limb is usually sufficient to avoid a formal study. It should also be noted that in patients who sustain shotgun or blast/shrapnel injuries, angiography should be performed immediately after hemorrhage control but before reconstruction to rule out the common occurrence of multiple sites of vascular injury. Similarly, temporary intravascular shunts should be placed liberally and clearly before the limb fracture is reduced and fixed (e.g., in a Gustilo III C injury). Decisions about limb salvage should not be made within the trauma bay. These patients require a detailed operative examination under optimal conditions with the input of experienced colleagues (orthopedic, vascular, plastic surgery teams). In the work-up of a potential lower-extremity vascular injury, it must be remembered that a limb is rarely compromised in the context of an arteriogram showing patency of at least 1 of the 3 major arteries below the knee. Given that the peroneal artery has no anatomically palpable pulse, it is not surprising that 50% of missed vascular injuries occur below the knee joint. In addition, posterior dislocations of the knee in the context of diminished or absent pedal pulses (after reduction) mandate immediate arteriography.

Evaluation for extremity compartment syndrome must be considered early in the work-up or intervention for cases of prolonged ischemia, long prehospital intervals, crush injury, and/or tourniquet usage. Compartment pressures are easily measured with a long catheter, tubing and pressure transducer. The deep compartment is at particular risk owing to location and dual arterial residency. Pressures greater than 30 mm Hg generally compromise capillary flow and warrant immediate decompression (2-incision [4 compartment] approach for lower extremity and 1-incision [3 compartment] approach for upper extremity). It must also be considered that even in the extremity with frank compartment syndrome, the arterial systemic pressure is higher than the limb compartment pressure, therefore ensuring a continuing and dangerously misleading pulse on examination.

If the patient does not appear to have a bony, neurologic, or arterial injury of concern, a venous laceration remains possible. In cases where ongoing dark hemorrhage is not draining from the leg, the patient must be mobilized before discharge. More specifically, they must pressurize their lower extremity venous system by walking a reasonable distance within the ED. If this does not induce new hemorrhage, the patient can be safely discharged. Although there remains no practical role for venograms, prehospital reports of massive bleeding at the scene with no appreciable hemorrhage in the trauma bay are often consistent with venous injury. Patients must be followed in an outpatient setting within 1–2 weeks. During this visit, a physical examination to rule out the development/progression of AVF or arterial pseudoaneurysms is essential.

Percutaneous techniques are rapidly evolving in the treatment of extremity penetrating wounds with either proximally controlled hemorrhage or minimal ongoing bleeding. Therapeutic embolization is a reasonable approach for isolated traumatic aneurysms of branches of the subclavian, axillary, brachial, common femoral, superficial femoral, popliteal and shank arteries as well as pseudoaneurysms/AVFs of the distal profunda femoris. Similarly, endovascular stents/grafts are possible for subclavian artery pseudoaneurysms without ongoing hemorrhage into the pleural space. Finally, although there are multiple limb injury scoring systems available to the clinician, they cannot reliably predict the need for amputation among the majority of patients.

Affiliations: From the Department of Surgery, University of Calgary, and the Foothills Medical Centre, Calgary, Alta.

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References

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