Is there any evidence of a "July effect" in patients undergoing major cancer surgery?

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Background: The "July effect" refers to the phenomenon of adverse impacts on patient care arising from the changeover in medical staff that takes place during this month at academic medical centres in North America. There has been some evidence supporting the presence of the July effect, including data from surgical specialties. Uniformity of care, regardless of time of year, is required for patients undergoing major cancer surgery. We therefore sought to perform a population-level assessment for the presence of a July effect in this field.

Methods: We used the Nationwide Inpatient Sample to abstract data on patients undergoing 1 of 8 major cancer surgeries at academic medical centres between Jan. 1, 1999, and Dec. 30, 2009. The primary outcomes examined were postoperative complications and in-hospital mortality. Univariate analyses and subsequently multivariate analyses, controlling for patient and hospital characteristics, were performed to identify whether the time of surgery was an independent predictor of outcome after major cancer surgery.

Results: On univariate analysis, the overall postoperative complication rate, as well as genitourinary and hematologic complications specifically, was higher in July than the rest of the year. However, on multivariate analysis, only hematologic complications were significantly higher in July, with no difference in overall postoperative complication rate or in-hospital mortality for all 8 surgeries considered separately or together.

Conclusion: On the whole, the data confirm an absence of a July effect in patients undergoing major cancer surgery.

Contexte : L'effet « juillet » désigne les répercussions négatives que peut avoir sur les soins aux patients le roulement du personnel médical qui survient au cours de ce mois d'été dans les centres médicaux universitaires d'Amérique du Nord. Certaines preuves ont étayé l'existence de l'effet juillet, notamment des données provenant des spécialités chirurgicales. Peu importe le temps de l'année, l'uniformité des soins est indispensable pour les patients qui doivent subir des interventions chirurgicales majeures pour le cancer. Nous avons donc voulu effectuer une évaluation à l'échelle des populations au sujet de l'existence d'un effet juillet dans cette branche de la médecine.

Méthodes : Nous avons utilisé la base de données Nationwide Inpatient Sample pour extraire les données relatives aux patients soumis à l'une de 8 interventions chirurgicales majeures pour le cancer dans des centres médicaux universitaires entre le 1er janvier 1999 et le 30 décembre 2009. Les principaux paramètres examinés ont été les complications postopératoires et la mortalité perhospitalière. Nous avons effectué des analyses univariées et, par la suite, des analyses multivariées en tenant compte des caractéristiques des patients et des hôpitaux afin de vérifier si la date à laquelle la chirurgie a eu lieu était un prédicteur indépendant des résultats après une chirurgie majeure pour le cancer.

Résultats : L'analyse univariée a révélé que les taux de complications postopératoires globales et de complications des interventions urogénitales et hématologiques plus spécifiquement ont été plus élevés en juillet qu'à d'autres moments de l'année. Toutefois, à l'analyse multivariée, seules les complications des suites d'interventions pour un cancer hématologique ont été significativement plus élevées en juillet, sans différence au plan du taux de complications postopératoires globales ou du taux de mortalité perhospitalière pour les 8 interventions considérées séparément ou ensemble.

Conclusion : Globalement, les données confirment l'absence d'un effet juillet chez les patients soumis à une intervention chirurgicale majeure pour un cancer.

According to a landmark report by the Institute of Medicine in 1999, preventable medical errors lead to the deaths of up to 100 000 patients each year in the United States at a cost of $17–29 billion.[1] Every July, academic medical centres in North America experience a changeover in medical staff, with thousands of medical students assuming new roles as interns and other junior staff taking on extra responsibilities.[2] This has given rise to the hypothesis that a higher number of medical errors occurring in July may adversely impact patient care — the so-called "July effect" or "July phenomenon."

Although there is some evidence in favour of this hypothesis,[3–6] most studies, including those from medical,[7–9] surgical,[10–14] trauma[15–17] and obstetric fields,[18] have not demonstrated the presence of the July effect. However, several of these studies were limited by their single-centre nature and their focus on a single patient group.[11,16,17] While there have been a few population-based approaches to this question, they have largely been limited to a single specialty, such as neurosurgery[3,13,14] or obstetrics.[18]

Patients undergoing major cancer surgery require increased levels of multidisciplinary care, and given the complexity of their surgery, they are likely to receive care from a team that includes physicians in training. We therefore sought to perform a population-level assessment for the presence of a July effect in outcomes following commonly performed major cancer surgeries. Specifically, we examined complication rates and mortality after major cancer surgeries performed in July compared with the rest of the calendar year, and we attempted to identify whether the month of surgery was an independent predictor of poorer outcome. Our hypothesis was that patients undergoing major cancer surgery at a teaching hospital in the month of July may have been more likely to experience adverse events.

Methods

Data source

Relying on the Nationwide Inpatient Sample (NIS), hospital discharges in the United States between Jan. 1, 1999, and Dec. 30, 2009, were abstracted. The NIS is a set of hospital inpatient databases included in the Healthcare Cost and Utilization Project family created by the Agency for Healthcare Research and Quality through a federal–state partnership.[19] The database includes discharge abstracts from 8 million hospital stays and incorporates patient and hospital information, including patients covered by Medicare, Medicaid, private insurance and other types of insurance.

Each discharge includes up to 15 inpatient diagnoses and procedures per hospital admission. All procedures and diagnoses are coded using the International Classification of Diseases, 9th revision, Clinical Modification (ICD–9–CM). Included patient and sociodemographic characteristics are patient sex, race, age, expected source of payment, outcome (in-hospital mortality) and hospital information (unique hospital identifier, date of admission, hospital location, hospital volume). Patients' socioeconomic status was evaluated using a proxy income, defined by county-specific zip codes according to the U.S. Census.

Study population

We selected the following major surgical oncological procedures carried out at an academic medical centre given their complexity and high rates of surgical morbidity: colectomy, cystectomy, esophagectomy, gastrectomy, hysterectomy, pneumonectomy, pancreatectomy and prostatectomy. Analyses were restricted to cancer diagnoses only. Relying on specific ICD–9–CM procedure codes (available on request), we assessed each surgical procedure independently.

Primary outcome

The main outcomes were in-hospital mortality and the occurrence of a postoperative complication. They were defined using ICD-9 diagnoses, as described according to previously established methodology,[20] and updated using additional codes. For analytical purposes, we grouped postoperative complications into 12 categories (cardiac, neurologic, respiratory, digestive, genitourinary, vascular, iatrogenic, wound, hematologic, infection, septicemia and others). Coding of complications has been shown to be in agreement when ICD–9 diagnostic and/or procedure codes and medical records are compared.[21,22]

Patient and hospital characteristics

Independent variables for analyses included patient age at hospital admission, race, sex, insurance status, baseline comorbidities, median household income by zip code and hospital location. Information on race was categorized as white, black, Hispanic, other (i.e., Asian or Pacific Islander, Native American) or unknown. Insurance status was classified based on the expected primary payer and included Medicare, Medicaid, private insurance (i.e., Blue Cross, commercial carriers, private health maintenance organizations and preferred provider organizations) and other insurance types, including those who were not insured. Patient age was considered as a continuous variable. Baseline comorbidities were determined using a Charlson Comorbidity Index (CCI)–derived score[23] adapted by Deyo and colleagues.[24]

Income at the patient level was not available within NIS. Consequently, we relied on the median household income for the patient's zip code, which we derived from U.S. Census data. Four categories were available within the database: less than $25 000, $25 000–$34 999, $35 000–$44 999 and $45 000 or more.

Hospital characteristics, including region (Northeast, Midwest, South and West), location (rural v. urban) and teaching status were obtained from the American Hospital Association Annual Survey of Hospitals and defined by the United States Census Bureau. A hospital was considered a teaching institution if it had an American Medical Association–approved residency program, was a member of the Council of Teaching Hospitals or had a ratio of 0.25 or more full-time equivalent interns and residents to non–nursing home beds.[25] Annual hospital volume represents the number of procedures performed at each participating institution during each study calendar year; we calculated annual volume independently for each of the 8 procedures. Patients were divided according to 4 equal hospital volume quartiles: very low, low, high and very high.

Table 1. Baseline characteristics of patients undergoing major cancer surgery in teaching hospitals, Nationwide Inpatient Sample 1999–2009

	Month of admission; %*		
Characteristic	All months	July	August–June
Patients, no. (%)			
Male	845 220 (61.7)	65 730 (60.7)	779 490 (61.7)
Female	525 518 (38.3)	42 540 (39.3)	482 978 (38.3)
Total	1 370 738	108 270	1 262 468
Mean age, (median) yr [IQR]	64.8 (65.0) [16]	64.9 (65.0) [16]	64.8 (65.0) [16]
Race			
White	59.2	58.8	59.2
Black	8.2	8.1	8.2
Hispanic	3.9	3.2	4.0
Other	4.2	4.0	4.2
Unknown	24.5	25.9	24.4
CCI†			
0	64.3	63.4	64.4
1	24.0	24.8	23.9
2	4.8	4.8	4.8
≥ 3	6.9	7.0	6.9
Hospital location			
Rural	2.4	2.7	2.4
Urban	97.6	97.3	97.6
Hospital region‡			
Northeast	25.9	27.7	25.8
Midwest	27.3	28.7	27.2
South	29.8	25.3	30.2
West	17.0	18.3	16.9
Hospital volume per quartile			
Very low	9.4	9.4	9.4
Low	20.8	21.4	20.8
High	30.2	30.8	30.2
Very high	39.6	38.4	39.7
Insurance status			
Private	46.0	46.0	46.0
Medicaid	3.7	4.1	3.7
Medicare	45.9	45.7	45.9
Other	4.4	4.2	4.4
Median income by zip code			
≤ $24 999	14.3	14.3	14.3
$25 000–$34 999	20.8	20.8	20.8
$35 000–$44 999	25.4	25.0	25.4
≥ $45 000	37.5	38.0	37.4

CCI = Charlson Comorbidity Index; IQR = interquartile range.
*Unless otherwise indicated.
†Based on comorbidity developed by Charlson and colleagues[23] and adapted by Deyo and colleagues.[24]
‡Hospital region is defined by the United States Census Bureau.

Statistical analysis

Data distribution was adjusted according to the provided NIS population weights to render estimates more accurate nationally. We used the weighted population when conducting all our analyses.

First, we generated descriptive statistics on frequencies and proportions for categorical variables (sex, race, insurance status, median household income by zip code, CCI, annual hospital volume, hospital location, hospital region, hospital teaching status), stratified according to month of admission (July v. other months). Means, medians and interquartile ranges were reported for continuously coded variables (age). We performed χ^2 and Mann–Whitney tests to compare significant differences within categorical and continuous variables. Second, overall complication rates and mortality were extracted for each month throughout the study period. We performed a Pearson χ^2 test of independence to analyze variations throughout the year. Third, in-hospital mortality and occurrence of complications were stratified according to month of admission (July v. other months). We applied the same statistical analyses as we did with descriptive statistics. Fourth, multivariable logistic regression analyses were fitted to predict the

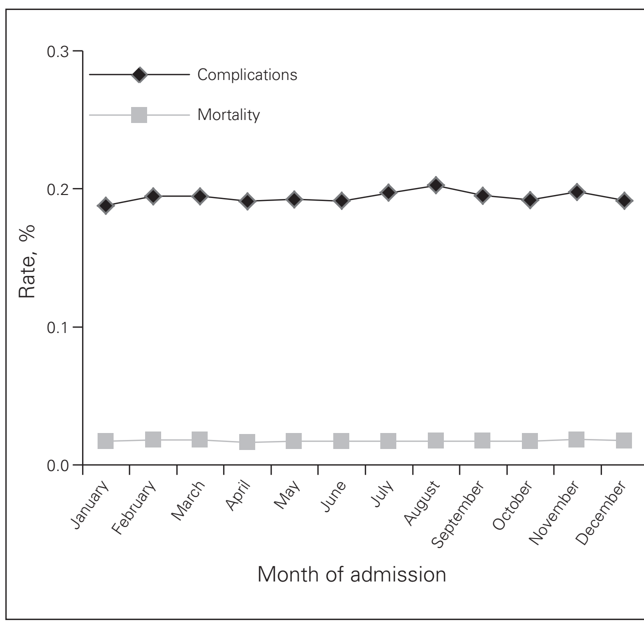

Fig. 1. Complication rate and mortality according to date of admission in teaching hospitals from the Nationwide Inpatient Sample, 1999–2009. Average yearly complication and mortality rates were 19.4% and 1.73%, respectively. Univariate χ^2 test of independence showed significant variations for overall complications ($p < 0.001$) and for mortality ($p = 0.003$).

occurrence of complications following major cancer surgery. July admission was observed as an independent variable. In addition, in patients who experienced 1 or more complications, we considered year of surgery, age, race, baseline CCI, median household income by zip code, hospital location, hospital region and hospital teaching status as covariates. When each complication was analyzed separately, the other complications were also included as covariates. Fifth, we fitted separate models to predict in-hospital mortality and complications as outcomes, stratified according to procedure type. July admission was observed as an independent variable in addition to the aforementioned covariates. To adjust for clustering within surgeons and hospitals, we fitted multivariable logistic regression models with generalized estimating equations.[26] Sixth, length of stay was analyzed using generalized linear modelling, corrected for age, sex, race, insurance status, comorbidities, hospital location, hospital region, hospital volume, median household income by zip code and year of admission.

We performed all statistical analyses using the R statistical package system (R Foundation for Statistical Computing). All tests were 2-sided, with statistical significance set at $p < 0.00625$ to adjust for multiple comparisons using the Bonferroni correction.

Results

Baseline characteristics

A weighted estimate of 1 370 738 patients underwent a major cancer surgery at an academic medical centre between 1999 and 2009. The baseline characteristics of this cohort are shown in Table 1.

Complications and mortality after surgery

Figure 1 shows overall complication rates and mortality by month of admission. Table 2 shows the results of univariate analyses of complications occurring after all major cancer surgeries, stratified by month of admission. The overall postoperative complication rate was higher in July than other months (19.7% v. 19.4%, $p = 0.003$). Specifically, there were higher rates of genitourinary (1.3% v. 1.2%, $p < 0.001$) and hematologic (2.2% v. 1.9%, $p < 0.001$) complications in July than other months. There were no significant differences in in-hospital mortality (1.7% v. 1.7%, $p = 0.31$). The median length of stay in hospital was significantly different when comparing July with other months ($p < 0.001$).

Multivariable models of the July effect on complications and mortality

The results of multivariate analyses showing the July effect on specific postoperative complications and mortality after all major cancer surgeries are shown in Table 3. After adjusting for age, sex, race, CCI, insurance status, hospital volume, household income by zip code, hospital location, hospital region and the year of admission, we found that admission in July was not associated with an increased odds of postoperative complications (OR 1.00, $p = 0.90$), length of stay (β 0.017, $p = 0.42$) or in-hospital

Table 2. Univariate analysis of complications, mean length of stay and in-hospital mortality for major cancer surgery in teaching hospitals*

	Month of admission; no. (%)†						
Variable	All months		July		August–June		*p* value
Postoperative complication							
Overall	250 219	(19.4)	21 390	(19.7)	228 829	(19.4)	0.003
Cardiac	37 561	(2.7)	2 909	(2.7)	34 652	(2.7)	0.26
Respiratory	35 852	(2.6)	2 824	(2.6)	33 028	(2.6)	0.88
Digestive	82 035	(6.0)	6 522	(6.0)	75 513	(6.0)	0.58
Neurologic	39 216	(2.9)	3 045	(2.8)	36 171	(2.9)	0.32
Genitourinary	16 369	(1.2)	1 446	(1.3)	14 922	(1.2)	< 0.001
Vascular	4 074	(0.3)	301	(0.3)	3 773	(0.3)	0.23
Wound	9 406	(0.7)	770	(0.7)	8 636	(0.7)	0.30
Infection	28 352	(2.1)	2 188	(2.0)	26 164	(2.1)	0.25
Hematologic	26 205	(1.9)	2 402	(2.2)	23 803	(1.9)	< 0.001
Septicemia	24 802	(1.8)	2 067	(1.9)	22 735	(1.8)	0.01
Iatrogenic	73 828	(5.4)	5 925	(5.5)	67 903	(5.4)	0.19
Other	584	(< 0.1)	46	(< 0.1)	538	(< 0.1)	0.98
Median length of stay (IQR)	5.00	(3–8)	5.00	(3–9)	5.00	(3–8)	< 0.001‡
In-hospital mortality	22 393	(1.7)	1840	(1.7)	20 553	(1.7)	0.31

IQR = interquartile range.
*Stratified by time of surgery, Nationwide Inpatient Sample, 1999–2009.
†Unless otherwise indicated.
‡Mann–Whitney *U* Test.

mortality (OR 0.94, p = 0.33), Conversely, admission in July was associated with a higher odds of hematologic complications (OR 1.17, $p < 0.001$). In subset multivariate analyses, admission in July was not associated with greater odds of any postoperative complication developing or of in-hospital mortality following any of the 8 major cancer surgeries analyzed individually (Table 4).

Discussion

Cancer is one of the major public health problems in the United States, with a predicted incidence of more than 1.6 million cases this year.[27] Although there are expected to be more than 325 000 deaths in 2014 from just the 8 major cancers we analyzed in this study, mortality from solid cancers has generally been declining for the past 15–20 years.[27] Surgery can offer a curative therapy for cancer, and improvements in surgical technique and technology are, in part, responsible for the downward trend in solid tumour–related mortality.[28–31]

While major cancer surgery is technically demanding, the physiologic demands of such surgery on patients necessitate very high standards of postoperative care, with involvement of all members of the multidisciplinary team, including interns, residents, the attending surgeon and nursing staff. Moreover, it is paramount to ensure that the quality of medical care provided remains at the same high level throughout the year, particularly at times of changeover in medical staff, such as that which occurs every July in the United States. Based on these considerations, we sought to examine, at a population level, the July effect on postoperative outcomes following major cancer surgery.

Our results, on the whole, refute the presence of a July effect with regards to major cancer surgery. While the overall rate of postoperative complications was higher in the month of July than the rest of the calendar year on univariate analysis, this association was not observed on multivariate analysis. To account for patients who underwent procedures in the month of June in whom complications may have developed as a result of care in the month of July, we performed separate sensitivity analyses excluding the month of June, and these analyses yielded similar results (see the Appendix, available at cma.ca/cjs). On multivariate analyses for all major cancer surgeries and when considering each procedure separately, the month of July was found to be an independent predictor only of a higher rate of hematologic complications following all major cancer surgeries. Importantly, there was no July effect observed for in-hospital mortality, replicating previous data from surgical fields.[10,12–14] Therefore, the overall data emphasize an absence of any July effect following major cancer surgery.

Table 3. Multivariate analyses showing the effect of month of admission (July v. others) on the likelihood of adverse events following major cancer surgery in teaching hospitals*

Factor	No. all mo	OR (95% CI)	*p* value
Postoperative complication			
Overall	250 219	1.00 (0.97 to 1.04)	0.90
Cardiac	37 561	0.95 (0.87 to 1.04)	0.25
Respiratory	35 852	1.19 (0.86 to 1.63)	0.30
Digestive	82 035	0.99 (0.94 to 1.05)	0.81
Neurologic	39 216	0.95 (0.87 to 1.03)	0.22
Genitourinary	16 369	1.11 (0.98 to 1.25)	0.11
Vascular	4 074	0.90 (0.70 to 1.18)	0.46
Wound	9 406	1.04 (0.87 to 1.23)	0.69
Infection	28 352	0.93 (0.84 to 1.04)	0.19
Hematologic	26 205	1.17 (1.07 to 1.29)	0.001
Septicemia	24 802	1.06 (0.96 to 1.18)	0.25
Iatrogenic	73 828	0.99 (0.93 to 1.06)	0.83
Other	584	0.99 (0.50 to 1.95)	0.97
Length of stay	—	0.017 (–0.024 to 0.058)†	0.42†
In-hospital mortality	22 393	0.94 (0.84 to 1.06)	0.33

CI = confidence interval; OR = odds ratio.
*Corrected for age, sex, race, comorbidities, insurance status, hospital location, hospital region, hospital volume and median household income by zip code, Nationwide Inpatient Sample, 1999–2009.
†β coefficient as reported from a generalized linear regression modelling for the "July effect," corrected for all other variables, including complications.

Table 4. Multivariate analyses showing the effect of month of admission (July v. others) on the likelihood of adverse events, according to surgical procedure*

	Mortality		Complications	
Procedure	OR (95% CI)	*p* value	OR (95% CI)	*p* value
All surgeries	0.94 (0.84 to 1.06)	0.33	1.00 (0.97 to 1.04)	0.90
Colectomy	0.93 (0.79 to 1.11)	0.42	0.99 (0.94 to 1.05)	0.83
Cystectomy	0.96 (0.55 to 1.65)	0.87	0.93 (0.79 to 1.08)	0.31
Esophagectomy	1.16 (0.67 to 1.99)	0.60	1.08 (0.83 to 1.42)	0.54
Gastrectomy	0.82 (0.54 to 1.23)	0.34	0.99 (0.84 to 1.17)	0.90
Hysterectomy	0.69 (0.32 to 1.47)	0.33	1.05 (0.94 to 1.18)	0.40
Lung	1.00 (0.79 to 1.28)	0.98	0.99 (0.92 to 1.07)	0.83
Pancreatectomy	0.67 (0.43 to 1.05)	0.08	0.98 (0.84 to 1.15)	0.81
Prostatectomy	1.19 (0.40 to 3.54)	0.76	0.98 (0.88 to 1.09)	0.68

CI = confidence interval; OR = odds ratio.
*Corrected for age, sex, race, comorbidities, insurance status, hospital location, hospital region, hospital volume and median household income by zip code, Nationwide Inpatient Sample, 1999–2009.

Despite the evidence that first-year residents make more errors at the start of training than later,[32] there are several factors that may explain the absence of a July effect for major cancer surgeries. First, and perhaps most importantly, there may have been greater supervision provided by more senior members of the medical team, including fellows and attending surgeons, as well as a greater level of support from the nursing staff.[33] Interns and new residents may have been more cautious at the start of the academic year and may have asked for help at times of difficulty rather than attempt to solve problems themselves.[11] Furthermore, much of postoperative surgical care is delivered according to standardized management protocols, which have been shown to improve postoperative surgical outcomes.[34,35] This relative uniformity of care may therefore have compensated for the relative inexperience of some members of the health care team at the start of the academic year. Moreover, given the technical expertise required to perform major cancer surgery, it is highly unlikely that newer members of the surgical team would have been heavily involved in these operations from the outset of their training. Thus, patient outcome may not have been compromised in July, given that intraoperative events are predictive of postoperative outcome.[36]

Some data in the literature support the presence of a July effect in the context of vascular and general surgery,[5] surgery for spinal metastases,[3] cerebrospinal fluid shunt surgery[4] and in a trauma setting.[6] Despite relying on a nationwide data set, the study by Dasenbrock and colleagues[3] focused on outcomes after a specific surgical procedure and was based on a sample size of fewer than 3000 patients over 4 years. In contrast, our data set was based on more than 1 million patients over a period of 11 years and included 8 different procedures. This is the major strength of our analyses and may explain why our results differ from those previously described in a surgical setting.

Limitations

There are important limitations to our study. Aside from the inherent drawbacks in using a retrospective data set, such as the Nationwide Inpatient Sample, we were unable to control for particular factors that may have influenced outcomes after major cancer surgery, specifically tumour stage and grade. Moreover, "near misses" (i.e., events that may have led to adverse outcomes but were somehow prevented, possibly owing to extra supervision, double-checking or simply good fortune) are not included, and it is possible that these may have been more frequent at the start of the academic year. The NIS includes information only on in-hospital events; therefore, longer-term postoperative course cannot be captured with this data set. Finally, although we were able to correct for hospital surgical volume in multivariate analyses, we were unable to specifically restrict analyses to hospitals with cancer surgery fellowships or those designated as cancer centres. Hence, while recognizing that caution must be exercised in interpreting our findings, to our knowledge, our study is the largest to date to report on the July effect, and we believe that the size and depth of our analysis provide reliability to our conclusions.

Conclusion

Our nationwide population-based analysis refutes the presence of a July effect with respect to major cancer surgery. Given the physical and emotional stresses, including potentially curative surgery, placed on patients with cancer, our finding that outcomes following major cancer surgery are equivalent at all times of the year are reassuring to patients and their families as well as to physicians and other members of the health care team. These findings emphasize that despite multiple changes occurring within house staff in academic hospitals, appropriate senior staff supervision and hospital protocols prevent the potential for increased complications.

Competing interests: None declared.

Contributors: P. Ravi, M. Sun and Q.-D. Trinh designed the study. V.Q. Trinh, M. Sun and Q.-D. Trinh acquired the data, which all authors analyzed. P. Ravi and Q.-D. Trinh wrote the article, which all authors reviewed and approved for publication.

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Corrections

Correction: Canadian Surgery Forum abstracts

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The Canadian Surgery Forum abstract supplement published in August 2013 contained errors in the table of abstract 76, entitled "Identification of inferior quality of surgical care of elderly patients in the emergent setting: a pilot study." In addition, the definition of "CCI" should have been "Charlson Comorbidity Index." We apologize for these errors.

Correction: Canadian Society for Vascular Surgery abstracts

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The Canadian Society for Vascular Surgery abstract supplement published in December 2013 contained an error in abstract 38, entitled "Retrospective and prospective review of abdominal EVAR cases at Sunnybrook Health Sciences Centre, type II endoleaks: a decade of experience and lessons learned." Only the first author's name was listed. The full author list includes K. Maggisano, D. Cannataro, B. Chan, L. Sandhu, A. Dueck, G. Papia, D. Kucey and R. Maggisano. We apologize for this error.