

Variation in the Practice of Preoperative Medical Consultation for Major Elective Noncardiac Surgery

A Population-based Study

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ABSTRACT

Background: Patients scheduled for major elective noncardiac surgery frequently undergo preoperative medical consultations. However, the factors that determine whether individuals undergo consultation and the extent of interhospital variation remain unclear.

Methods: The authors used population-based administrative databases to conduct a cohort study of patients, aged 40 yr or older, who underwent major elective noncardiac surgery in Ontario, Canada, between April 2004 and February

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What We Already Know about This Topic

- Preoperative consultation by internal medicine specialists occurs in 10–40% of patients, but whether this can be explained solely by surgical or patient factors is not known

What This Article Tells Us That Is New

- More than one third of more than 200,000 patients in Ontario undergoing surgery received preoperative medical consultation
- Although patient and surgical factors were weakly associated with medical consultation, there was a large variability among hospitals, suggesting local factors play a large role in this practice

2009. Multilevel logistic regression models were used to identify patient- and hospital-level predictors of consultation.

Results: Within the cohort of 204,819 patients who underwent surgery at 79 hospitals, 38% (n = 77,965) underwent preoperative medical consultation. Although patient- and surgery-level factors did predict consultation use, they explained only 5.9% of variation in consultation rates. Differences in rates across hospitals were large (range, 10–897 per 1,000 procedures), were not explained by surgical procedure volume or hospital teaching status, and persisted after adjustment for patient- and surgery-level factors. The median odds of undergoing consultation were 3.51 times higher if the same patient had surgery at one randomly selected hospital as opposed to another.

Conclusions: One-third of surgical patients undergo preoperative medical consultation. Although patient- and surgery-level factors are weak predictors of consultation use, the individual hospital is the major determinant of whether patients undergo consultation. Additional research is needed to better understand the basis for this substantial interhospital variation and to determine which patients benefit most from preoperative consultation.

◇ This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 9A.

◆ This article is accompanied by an Editorial View. Please see: Kheterpal S: Random clinical decisions: Identifying variation in perioperative care. ANESTHESIOLOGY 2012; 116:3–5.

⊕ Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are available in both the HTML and PDF versions of this article. Links to the digital files are provided in the HTML text of this article on the Journal's Web site (www.anesthesiology.org).

PREOPERATIVE consultations by internal medicine specialists (hereafter referred to as “preoperative medical consultations”) play an important role in the care of patients undergoing major surgery. They may be especially helpful for the many surgical patients who have medical comorbidities. For example, approximately 20% have diabetes mellitus,¹ whereas 14% have chronic obstructive pulmonary disease.² For such patients, the preoperative consultation is an opportunity to better document comorbid disease, undertake risk stratification, optimize factors associated with pre-existing medical conditions, initiate interventions intended to decrease perioperative risk, and defer or cancel surgery.

Despite these presumed benefits for intermediate-to-high-risk patients, the factors that determine whether an individual does or does not undergo preoperative medical consultation remain unclear. Current data addressing this issue are limited. Previous studies generally were single-center in design and reported consultation rates ranging from 10% to 40%,^{3–8} thus suggesting important practice variation between hospitals. Similarly, consultation rates may differ substantially across surgical services, even after adjustment for patients’ medical comorbidities.⁴ In addition, previous research has suggested that medical comorbidities are not the most important determinant of preoperative consultation. For example, more than half of patients who underwent consultation in two previous North American studies were considered low-risk patients.^{9,10}

Given the overall paucity of relevant data and the limited generalizability of previous single-center studies, we conducted a population-based cohort study in Ontario, Canada. Our objectives were to (1) identify the patient- and hospital-level determinants of preoperative medical consultation; (2) describe the extent of any interhospital variation; and (3) describe the association of hospital-specific consultation rates with related processes of care and outcomes.

Materials and Methods

After research ethics approval was received from Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, we used population-based administrative healthcare databases to undertake a retrospective cohort study in Ontario, Canada. These databases were the Discharge Abstract Database (DAD) of the Canadian Institute for Health Information (hospital admissions), the Ontario Health Insurance Plan (OHIP) database (physician service claims), the Registered Persons Database (demographics and vital statistics), the Institute for Clinical Evaluative Sciences Physician Database (physicians’ specialties), the Ontario Drug Benefit database (prescription medications for individuals 65 yr and older), and the Canadian census. Although the databases lack physiologic and laboratory measures, such as blood pressure or hemoglobin, they have been validated for many outcomes, exposures, and comorbidities.^{11–15} Unique anonymous

identifiers were used to link healthcare information on the same individuals across these data sets. During the study period, Ontario was Canada’s most populous province, with more than 13 million residents, all of whom have universal access to physician and hospital services through a publicly funded healthcare program.

Overview of Preoperative Processes of Care in Ontario

Any patient scheduled to undergo elective surgery at an Ontario hospital must undergo a documented preoperative history and physical, which is typically performed by the patient’s primary care physician or surgeon. In Canada, adult primary care is almost exclusively provided by family physicians, whereas general internists and specialists principally perform a consultative role.^{16,17} As opposed to the mandatory preoperative history and physical, referrals for preoperative consultations by internal medicine specialists are left to the discretion of the responsible surgeon or anesthesiologist. The responsible surgeon may also refer a patient for preoperative anesthesia consultation, which is *distinct* from the routine in-hospital evaluation by the responsible anesthesiologist on the day before or the morning of surgery.¹⁸ Instead, the patient undergoes a formal consultation with an anesthesiologist several days to weeks before surgery, typically in an outpatient preassessment clinic. These preoperative anesthesia consultations are identified by distinct physician billing codes in the OHIP database.

Assembly of Study Cohort

We retrospectively identified all Ontario residents, aged 40 yr or older, who underwent the following elective noncardiac surgeries between April 1, 2004 and February 28, 2009: abdominal aortic aneurysm repair, carotid endarterectomy, peripheral vascular bypass, total hip replacement, total knee replacement, large bowel surgery, liver resection, Whipple procedure, pneumonectomy, pulmonary lobectomy, gastrectomy, esophagectomy, nephrectomy, or cystectomy. These procedures were selected because they are associated with intermediate to high risk,¹⁹ are applicable to either sex, and can be identified using the DAD.^{20–22} Procedural information in the DAD is very accurate.¹⁵ To reduce variability caused by low procedure volumes, we excluded data from hospitals that did not perform at least 10 eligible procedures during *each* year of the study period (*i.e.*, 50 or more procedures during the study period).

Because there is no specific OHIP fee code to identify medical consultations for preoperative evaluation, as opposed to nonoperative indications, we used a validated claims-based definition: an OHIP claim for a consultation by a cardiologist, general internist, endocrinologist, geriatrician, or nephrologist within 4 months (120 days) before the index surgery. Although this 4-month interval may not be typical of some other jurisdictions, it is consistent with typical preoperative wait times in Ontario. Specifically, once patients have been deemed to require surgery, the time required for

90% of them to undergo their scheduled procedure is 58 days for cancer surgery, 104 days for vascular surgery, and 192 days for orthopedic surgery.[#] In addition, compared with reabstraction of primary medical records in a multi-center validation study, this algorithm had a sensitivity of 90%, specificity of 92%, positive predictive value of 93%, and negative predictive value of 90%.²³

Demographic information (age, sex) was obtained from the Registered Persons database. We used validated algorithms to identify patients with diabetes mellitus or hypertension.^{12,14} The OHIP database was used to identify patients who required dialysis before their index surgery. Using the DAD, we used previously described methods to identify other comorbidities based on *International Classification of Diseases* codes (ninth or tenth revisions) from hospitalizations within 3 yr before surgery: coronary artery disease, congestive heart failure, atrial fibrillation, cerebrovascular disease, peripheral vascular disease, pulmonary disease, chronic renal insufficiency, previous venous thromboembolism, liver disease, peptic ulcer disease, rheumatologic disease, hemiplegia or paraplegia, malignancy, and dementia.^{24–26} The OHIP database was used to identify outpatient anesthesiologist consultations within 60 days before surgery,¹⁸ outpatient specialized testing (noninvasive cardiac stress tests, echocardiograms, pulmonary function tests),^{27,28} epidural anesthesia or analgesia (hereafter referred to as “anesthesia”),¹ and intraoperative invasive monitoring. The Ontario Drug Benefit database was used to identify outpatient prescriptions for related medications (β -blockers, statins) in individuals 65 yr and older. Patients’ socioeconomic status was estimated based on their neighborhood median income in the Canadian census, and their residence (rural *vs.* urban) was determined using Statistics Canada definitions.²⁹ In addition, we ascertained all-cause mortality at 30 days after surgery, which is accurately captured by the DAD (in-hospital events) and Registered Persons Database (out-of-hospital events).³⁰

Statistical Analysis

We initially used standardized differences to compare the characteristics of patients who did or did not undergo preoperative medical consultation.³¹ A multilevel logistic regression model was then used to determine the adjusted association of patient- (demographics, neighborhood income quintile, rural residence, comorbid disease, surgery) and hospital-level (teaching status, surgical procedure volume) factors with preoperative medical consultation, while accounting for clustering of patients within individual hospitals. This multilevel model, also termed a “random intercept model,” is a standard multivariable logistic regression model that includes an extra term to characterize random differences in

consultation rates between hospitals. We used methods previously described to categorize hospitals into quartiles³² based on the total volume of included procedures. The final model included all patient- and hospital-level factors, as well as any clinically sensible interaction terms that had *P* values <0.20 and improved model fit. For the final model, discrimination was measured using the c index, calibration was evaluated using observed-*versus*-predicted plots, and proportion of explained variation was measured by the squared Pearson correlation between observed and predicted outcomes.³³ We used the variance inflation factor to assess for any multicollinearity within the model.

Given the interpretational difficulties of the intraclass correlation coefficient with multilevel modeling of binary outcomes, we used the median odds ratio to measure variability between hospitals.³⁴ The median odds ratio is the median value obtained comparing the adjusted odds of undergoing consultation if the same individual underwent surgery at two different randomly selected hospitals. Because it always involves comparisons of higher-ranked *versus* lower-ranked hospitals, the median odds ratio has a value greater than or equal to one. It characterizes heterogeneity across hospitals, is adjusted for patient-level covariates, and may be directly compared against odds ratios of patient-level characteristics.³⁴ For example, a value of 1.50 suggests 50% higher odds of receiving preoperative medical consultation if the same patient had surgery at one randomly selected hospital as opposed to another.

Several analytical approaches were used to further evaluate interhospital variation in preoperative medical consultation. First, we measured the overall interhospital variation in rates of consultation. Second, descriptive statistics were used to compare the patient-level characteristics, hospital-level characteristics, and perioperative processes of care at hospitals with differing rates of preoperative medical consultation. Hospitals initially were ranked based on their unadjusted rates of preoperative medical consultation. The ranked hospitals were then categorized into quartiles with approximately equal numbers of patients. Finally, we used a Cox proportional hazards model to determine the association of hospital-specific consultation rates (categorized into quartiles) with 30-day postoperative mortality. This model adjusted for patient-level factors (demographics, neighborhood income quintile, rural residence, comorbid disease, surgery), hospital characteristics (teaching status, procedure volume quartile), and perioperative processes of care that may vary across hospitals (anesthesia consultation, epidural anesthesia, invasive monitoring). For these analyses, hospital-specific rates of anesthesia consultation, epidural anesthesia, and invasive monitoring were categorized into quartiles with approximately equal patient numbers. We used appropriate statistical methods to account for clustering of patients within hospitals³⁵ and verified the proportional hazards assumption by visual inspection of estimated logarithm-minus-logarithm survival curves.

[#] Ontario Ministry of Health and Long-Term Care: Ontario Wait Times: Wait Time for Surgery, MRIs and CTs. Toronto, Ontario, Queen’s Printer for Ontario, 2011. Available at: <http://waittimes.hco.on.ca/en/search/surgery/adult>. Accessed June 29, 2011.

All analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC), and a two-tailed P value <0.05 was used to define statistical significance.

Results

The study cohort consisted of individuals who underwent surgery at 79 hospitals. Within this cohort, 38.1% ($n = 77,965$) underwent preoperative medical consultation. Patients who underwent consultation typically were older individuals who had surgery at teaching or very high-volume hospitals and had increased burdens of most comorbid diseases (table 1).

The adjusted associations of patient-level factors with consultation are presented as odds ratios from a multilevel logistic regression model in table 1 of Supplemental Digital Content 1, <http://links.lww.com/ALN/A791>. Consultation was associated closely with increased age and comorbid disease. In addition, considerable variation existed across surgical procedures and hospitals with regard to consultation use. The median odds ratio across institutions was 3.51, meaning that the odds of receiving preoperative medical consultation was 3.5 times greater if the same patient had surgery at one randomly selected hospital as opposed to another. However, this interhospital variation was not explained by either hospital teaching status ($P = 0.81$) or procedure volume ($P = 0.22$). The regression model had good discrimination (c index 0.82), good calibration (based on an observed-*vs.*-predicted plot), and explained 30.5% of the observed variation in consultation rates. By comparison, a logistic regression model that did not account for any hospital-level variation and included only the patient-level factors listed in table 1 of Supplemental Digital Content 1, <http://links.lww.com/ALN/A791>, showed poor discrimination (c index 0.64) and explained only 5.9% of the observed variation in consultation rates.

When the 79 hospitals were ranked with respect to rates of medical consultation, there was considerable interinstitutional variation (fig. 1). The median hospital-specific consultation rate was 266 per 1,000 procedures (range, 10–897). Although there was also considerable interinstitutional variation in preoperative anesthesia consultation (median 542 per 1,000 procedures, range 6–967), there was no significant correlation (see fig. 1 of Supplemental Digital Content 2, <http://links.lww.com/ALN/A792>) between rates of anesthesia and medical consultation rates within the same institution (Pearson R , 0.13; $P = 0.13$). Interhospital variation was also evident within subgroups defined by surgical procedure, such as major orthopedic (see fig. 2 of Supplemental Digital Content 2, <http://links.lww.com/ALN/A792>) or large bowel resection (see fig. 3 of Supplemental Digital Content 2, <http://links.lww.com/ALN/A792>) procedures. There was a moderate positive correlation of medical consultation rates between orthopedic and large bowel resection procedures within the same institution (Pearson R , 0.41; $P = 0.003$).

When hospitals were ranked into quartiles based on unadjusted consultation rates, the mean consultation rate

ranged from 120 per 1,000 procedures in the lowest quartile to 702 per 1,000 procedures in the highest quartile. This large gradient in consultation rates was accompanied by some differences in patient characteristics, hospital characteristics, preoperative testing, perioperative processes of care, and new preoperative medication prescriptions (tables 2 and 3). After adjustment for patient and hospital characteristics (see table 2 of Supplemental Digital Content 1, <http://links.lww.com/ALN/A791>, which shows the characteristics of the multivariable regression model used for risk adjustment), the differences in 30-day postoperative mortality across quartiles (table 4) were statistically significant ($P < 0.001$). Compared with the quartile with the lowest adjusted mortality rate, namely quartile 2 (mean consultation rate, 219 per 1,000 procedures), the adjusted hazard ratio for 30-day mortality was 1.13 (95% CI, 0.95–1.34; $P = 0.16$) in quartile 1 (consultation rate, 120 per 1,000 procedures), 1.07 (CI, 0.91–1.25; $P = 0.42$) in quartile 3 (consultation rate, 432 per 1,000 procedures), and 1.33 (CI, 1.14–1.55; $P < 0.001$) in quartile 4 (consultation rate, 702 per 1,000 procedures).

Discussion

In this population-based cohort study, preoperative medical consultations for major elective noncardiac surgery were relatively common, having been performed in approximately one third of patients. Referrals for consultation were associated with several patient-level characteristics, including older age, comorbid disease, and type of surgery. However, differences in consultation rates across surgeries did not reflect their inherent operative risks. Even after adjustment for patient-level factors, there remained substantial variation in consultation rates across hospitals, which was not explained by either teaching status or procedure volume.

Implications

Rates of medical consultation demonstrated substantial interhospital variation that was not explained by differences in medical comorbidities, operative risk, hospital teaching status, or surgical procedure volume. Compared with the median odds ratio of 3.51 across hospitals, the highest odds ratio associated with any single patient comorbidity was 1.85 (see table 1 of Supplemental Digital Content 1, <http://links.lww.com/ALN/A791>), namely for coronary artery disease. This degree of interinstitutional variation, which is consistent with the wide range of consultation rates reported by previous single-center studies,^{3–8} is not completely unexpected. Practice variation is likely highest for any service for which there is little consensus about its appropriateness.³⁶ Although there are consensus-based guidelines for managing perioperative cardiac and pulmonary risk,^{19,37,38} they make no clear recommendations regarding which patients require medical consultation before surgery. Consequently, preoperative medical consultation can be considered a service for which there is little consensus and thus would be expected to have a high degree of variation.³⁶

Table 1. Preoperative Characteristics of the Entire Cohort

	Consultation (n = 77,965)	No Consultation (n = 126,854)	Absolute Standardized Difference
Demographics			
Female sex	41,456 (53.2%)	67,088 (52.9%)	0.6%
Age in yr, mean (SD)	69.4 (10.1)	66.6 (10.8)	26.5%
Income quintile			
First (lowest)	14,641 (18.8%)	22,205 (17.5%)	3.4%
Second	16,249 (20.8%)	25,036 (19.7%)	2.7%
Third	15,228 (19.5%)	24,915 (19.6%)	0.3%
Fourth	15,571 (20.0%)	26,266 (20.7%)	1.7%
Fifth (highest)	16,076 (20.6%)	28,097 (22.1%)	3.7%
Missing	200 (0.3%)	335 (0.3%)	<0.1%
Rural residence	10,678 (13.7%)	19,379 (15.3%)	4.5%
Comorbid disease			
Coronary artery disease	10,690 (13.7%)	8,754 (6.9%)	22.5%
Congestive heart failure	2,450 (3.1%)	1,637 (1.3%)	12.3%
Atrial fibrillation	3,397 (4.4%)	2,491 (2.0%)	13.7%
Cerebrovascular disease	2,472 (3.2%)	2,536 (2.0%)	7.5%
Peripheral vascular disease	6,582 (8.4%)	8,129 (6.4%)	7.6%
Hypertension	59,398 (76.2%)	81,239 (64%)	26.9%
Diabetes mellitus	21,545 (27.6%)	25,560 (20.1%)	17.7%
Thromboembolic disease	475 (0.6%)	429 (0.3%)	4.5%
Pulmonary disease	5,814 (7.5%)	6,756 (5.3%)	9.0%
Renal disease	2,731 (3.5%)	2,216 (1.7%)	11.3%
Liver disease	673 (0.9%)	928 (0.7%)	2.2%
Rheumatologic disease	1,714 (2.2%)	2,193 (1.7%)	3.6%
Peptic ulcer disease	880 (1.1%)	970 (0.8%)	3.1%
Hemiplegia or paraplegia	385 (0.5%)	440 (0.3%)	3.2%
Dementia	614 (0.8%)	676 (0.5%)	3.7%
Malignancy			
Primary	10,191 (13.1%)	23,211 (18.3%)	14.3%
Metastatic	3,187 (4.1%)	8,141 (6.4%)	10.3%
Hospital type			
Teaching hospital	29,305 (37.6%)	37,919 (29.9%)	16.3%
Procedure volume quartile*			
First (lowest)	16,317 (20.9%)	32,268 (25.4%)	10.7%
Second	20,817 (26.7%)	31,343 (24.7%)	4.6%
Third	12,432 (16.0%)	35,386 (27.9%)	29.2%
Fourth (highest)	28,399 (36.4%)	27,857 (22.0%)	32.2%
Procedure			
AAA repair	2,904 (3.7%)	3,191 (2.5%)	6.9%
Carotid endarterectomy	1,812 (2.3%)	3,323 (2.6%)	1.9%
Peripheral vascular bypass	2,733 (3.5%)	4,286 (3.4%)	0.5%
Total hip replacement	19,701 (25.3%)	27,698 (21.8%)	8.3%
Total knee replacement	36,770 (47.2%)	49,041 (38.7%)	17.2%
Large bowel surgery	8,132 (10.4%)	24,048 (19%)	24.5%
Liver resection	436 (0.6%)	1,501 (1.2%)	6.4%
Whipple procedure	387 (0.5%)	712 (0.6%)	1.4%
Pneumonectomy or lobectomy	1,362 (1.7%)	4,398 (3.5%)	11.3%
Gastrectomy or esophagectomy	977 (1.3%)	2,567 (2%)	5.5%
Nephrectomy	2,076 (2.7%)	4,877 (3.8%)	6.2%
Cystectomy	675 (0.9%)	1,212 (1%)	1.0%

Values are expressed as number (percentage) unless otherwise indicated.

* Divided into quartiles of approximately equal patient numbers based on total volume of eligible procedures performed during the study period (2004–2009).

AAA = abdominal aortic aneurysm.

Although this variation is not surprising, it may have implications for patients and the healthcare system. When performed in patients who are unlikely to benefit from them, these consultations can increase healthcare costs while exposing

some individuals to unnecessary, and potentially harmful, tests or interventions.^{27,28} Notably, there is no clear evidence that preoperative medical consultations improve outcomes. Indeed, previous observational studies have sug-

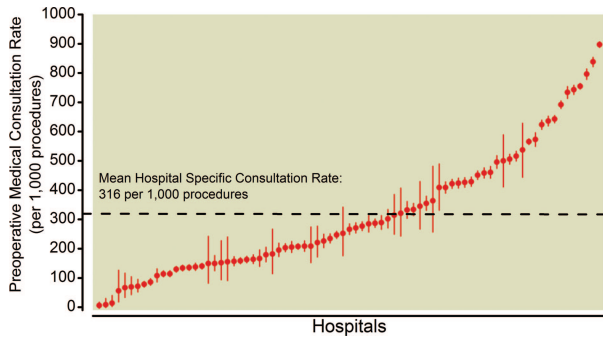


Fig. 1. Hospital-specific rates of preoperative medical consultation for major elective noncardiac surgery. Rates of preoperative medical consultation (per 1,000 procedures) for major elective noncardiac surgery at 79 individual Ontario hospitals in Ontario between April 1, 2004, and February 28, 2009. The circles are point estimates, whereas the lines are exact binomial 95% CIs. The dashed horizontal line is the mean hospital-specific consultation rate.

gested that consultations may worsen outcomes. Specifically, perioperative medical consultations were associated with increased hospital stay and a trend toward increased complications in a single-center American study,³ whereas a population-based evaluation of preoperative medication consultations performed in Ontario from 1999 to 2004 showed that consultations were associated with slightly increased postoperative mortality.³⁹ The current study also lends some support to these previous findings, as evidenced by the higher rates of postoperative mortality at hospitals with high consultation rates (table 4). However, our comparison of outcomes across hospitals with differing consultation rates should be viewed cautiously, especially because this analysis adjusted for relatively few hospital-specific confounders. Nonetheless, these observational studies, although not proving that preoperative medical consultations cause increased postoperative morbidity and mortality, do cast doubts on the appropriateness of the high consultation rates at many Ontario hospitals.

The basis for the substantial interhospital variation in preoperative medical consultation remains unclear. Differences in individual surgeons' preferences may explain it in some part. However, we did not evaluate the impact of individual surgeons on consultation rates in the current study because of the analytical difficulties of comparing multiple surgeons nested within many different surgical specialties and hospitals. Thus, future studies should evaluate the influence of surgeons on consultation rates within a more homogeneous group of surgical procedures (e.g., major joint replacement). Nonetheless, there is likely an important effect of the individual hospital on consultation rates, as evidenced by the moderate positive correlation between hospital-specific consultation rates for dissimilar surgeries, namely major joint replacement versus colon resection procedures. It is unlikely that hospital-specific financial incentives to physicians were a major influence on hospital-level variation because physicians at these Ontario hospitals were all compensated in a

similar manner through service claims to the publicly funded healthcare program. Consequently, the financial incentive to perform more consultations would have been similar across hospitals. In addition, institution-specific preferences for anesthesia consultation were not major influences on whether patients underwent medical consultation because there was little correlation between medical and anesthesia consultation rates. The hospital factors that may explain this substantial practice variation include facilities that aid preoperative consultations (e.g., dedicated preoperative assessment clinics), policies for the preoperative preparation of surgical patients, or institutional preference for the involvement of internists in perioperative care.

In the absence of previous data clearly defining which individuals most likely benefit from preoperative medical consultation, it is reasonable to assume that consultations should focus on patients who are at increased risk for perioperative complications because of medical and surgical risk factors. On that basis, our current study suggests that the unnecessary use of consultation in low-risk individuals is a real concern. The presence of medical comorbidities, although associated with preoperative consultation, explained only a small proportion of the substantial interhospital variation in consultation rates. In addition, although consultation rates varied across surgical procedures, thereby confirming a previous single-center study,⁴ the variation was not consistent with the inherent operative risks of different procedures. For example, patients undergoing orthopedic surgery were at least as likely to undergo consultation as those undergoing abdominal aortic aneurysm repair, despite the latter being a much higher-risk procedure.⁴⁰

Future Directions for Research

Given that preoperative medical consultation was relatively common and its use varied considerably across hospitals, our results highlight several broad areas that warrant additional research. First, more high-quality studies are needed to identify efficacious interventions for reducing perioperative risk. Without such research, consulting internists will have few evidence-based approaches for improving the outcomes of intermediate-to-high-risk surgical patients. Second, the characteristics of patients who are most likely to benefit from preoperative consultation must be better established. Such information will help define "appropriateness" criteria that could guide surgeons' decisions about which patients to refer for preoperative consultation and thereby reduce interinstitutional variation in consultation rates. Third, our analyses should be replicated using data sources from other geographic regions. It would be of interest to know whether such studies identify considerable interinstitutional variation in consultation rates, as well as the same "J-shaped" correlation between consultation rates and mortality.

Finally, more research is required on factors that may explain the substantial interhospital variation in consultation rates. These studies should combine qualitative and quanti-

Table 2. Patient-level Characteristics within Strata Based on Hospital-specific Rates of Preoperative Medical Consultation

	Quartile 1 (n = 47,324)	Quartile 2 (n = 54,147)	Quartile 3 (n = 44,862)	Quartile 4 (n = 58,486)
Medical consultation	5,683 (12.0%)	11,856 (21.9%)	19,374 (43.2%)	41,052 (70.2%)
Demographics				
Age in yr, mean (SD)	67.8 (10.6)	66.9 (10.8)	68.3 (10.4)	67.7 (10.5)
Female	25,125 (53.1%)	27,771 (51.3%)	24,228 (54.0%)	31,420 (53.7%)
Income quintile				
1 (lowest)	8,292 (17.5%)	9,803 (18.1%)	7,602 (17.0%)	11,149 (19.1%)
2	9,139 (19.3%)	10,755 (19.9%)	9,218 (20.6%)	12,173 (20.8%)
3	8,837 (18.7%)	10,714 (19.8%)	9,336 (20.8%)	11,256 (19.3%)
4	9,958 (21.0%)	11,095 (20.5%)	9,323 (20.8%)	11,461 (19.6%)
5 (highest)	10,971 (23.2%)	10,714 (19.8%)	9,336 (20.8%)	11,256 (19.3%)
Missing	127 (0.3%)	142 (0.3%)	92 (0.2%)	174 (0.3%)
Rural residence	8,842 (18.7%)	6,072 (11.2%)	7,538 (16.8%)	7,605 (13.0%)
Comorbid disease				
Coronary artery disease	4,025 (8.5%)	5,537 (10.2%)	4,090 (9.1%)	5,792 (9.9%)
Congestive heart failure	911 (1.9%)	1,250 (2.3%)	43,990 (1.9%)	1,054 (1.8%)
Atrial fibrillation	1,328 (2.8%)	1,626 (3.0%)	1,300 (2.9%)	1,634 (2.8%)
Cerebrovascular disease	1,073 (2.3%)	1,592 (2.9%)	1,023 (2.3%)	1,320 (2.3%)
Peripheral vascular disease	2,827 (6.0%)	5,540 (10.2%)	2,120 (4.7%)	4,224 (7.2%)
Hypertension	31,554 (66.7%)	36,549 (67.5%)	31,732 (70.7%)	40,802 (69.8%)
Diabetes mellitus	10,262 (21.7%)	12,742 (23.5%)	10,505 (23.4%)	13,596 (23.3%)
Thromboembolic disease	186 (0.4%)	253 (0.5%)	185 (0.4%)	280 (0.5%)
Pulmonary disease	2,560 (5.4%)	3,605 (6.7%)	2,569 (5.7%)	3,836 (6.6%)
Renal disease	1,032 (2.2%)	1,674 (3.1%)	905 (2.0%)	1,336 (2.3%)
Liver disease	228 (0.5%)	614 (1.1%)	277 (0.6%)	482 (0.8%)
Rheumatologic disease	833 (1.8%)	1,129 (2.1%)	753 (1.7%)	1,192 (2.0%)
Peptic ulcer disease	372 (0.8%)	541 (1.0%)	401 (0.9%)	536 (0.9%)
Hemiplegia or paraplegia	160 (0.3%)	280 (0.5%)	151 (0.3%)	234 (0.4%)
Dementia	333 (0.7%)	373 (0.7%)	241 (0.5%)	343 (0.6%)
Malignancy				
Primary	7,807 (16.5%)	10,013 (18.5%)	6,927 (15.4%)	8,655 (14.8%)
Metastatic	2,314 (4.9%)	3,634 (6.7%)	2,034 (4.5%)	3,346 (5.7%)
Procedure				
AAA repair	1,158 (2.5%)	2,511 (4.6%)	583 (1.3%)	1,843 (3.2%)
Carotid endarterectomy	1,181 (2.5%)	1,968 (3.6%)	693 (1.5%)	1,293 (2.2%)
Peripheral vascular bypass	1,452 (3.1%)	2,604 (4.8%)	1,033 (2.3%)	1,930 (3.3%)
Total hip replacement	11,533 (24.4%)	11,508 (21.3%)	10,628 (23.7%)	13,730 (23.5%)
Total knee replacement	19,949 (42.2%)	18,990 (35.1%)	20,777 (46.3%)	26,095 (44.6%)
Large bowel surgery	7,591 (16.0%)	9,256 (17.1%)	7,885 (17.6%)	7,448 (12.7%)
Liver resection	162 (0.3%)	906 (1.7%)	170 (0.4%)	699 (1.2%)
Whipple procedure	110 (0.2%)	417 (0.8%)	231 (0.5%)	341 (0.6%)
Pneumonectomy or lobectomy	1,683 (3.6%)	1,822 (3.4%)	712 (1.6%)	1,543 (2.6%)
Gastrectomy or esophagectomy	825 (1.7%)	1,189 (2.2%)	544 (1.2%)	986 (1.7%)
Nephrectomy	1,400 (3.0%)	2,383 (4.4%)	1,323 (3.0%)	1,847 (3.2%)
Cystectomy	280 (0.6%)	593 (1.1%)	283 (0.6%)	731 (1.3%)
Postoperative outcomes				
30-Day mortality	395 (0.8%)	468 (0.9%)	336 (0.7%)	536 (0.9%)

The strata range from the lowest consultation rate (quartile 1) to highest (quartile 4).

AAA = abdominal aortic aneurysm.

rative analytic strategies. Specifically, qualitative studies could use structured interviews of surgeons and internists at hospitals with differing consultation rates to identify factors that may explain the interinstitutional variation. In addition, future quantitative studies could enhance the detail of multivariable statistical analyses by incorporating information not available from the data sources in our current study. Potentially useful information could include the presence of dedicated

preoperative assessment clinic facilities and the use of medical-surgical comanagement models for postoperative care.⁴¹

Limitations

Several limitations should be considered when interpreting the results of our study. First, although it characterized the predictors of preoperative consultation and its practice variation within Ontario, similar types of studies should be repeated in

Table 3. Hospital-level Characteristics and Perioperative Processes of Care within Strata Based on Hospital-specific Rates of Preoperative Medical Consultation

	Quartile 1 (n = 47,324)	Quartile 2 (n = 54,147)	Quartile 3 (n = 44,862)	Quartile 4 (n = 58,486)
Preoperative medical consultation	5,683 (12.0%)	11,856 (21.9%)	19,374 (43.2%)	41,052 (70.2%)
Hospitals	22	22	23	12
Hospital-specific consultation rate (per 1,000 procedures, range)	10–155	159–287	289–537	566–897
Hospital type	—	—	—	—
Teaching	6,840 (14.5%)	28,202 (52.1%)	2,637 (5.9%)	29,545 (50.5%)
Procedure quartile*	—	—	—	—
First (lowest)	8,598 (18.2%)	17,144 (31.7%)	15,061 (33.6%)	7,782 (13.3%)
Second	6,922 (14.6%)	14,079 (26.0%)	11,011 (24.5%)	11,077 (18.9%)
Third	13,851 (29.3%)	13,186 (24.4%)	8,344 (18.6%)	19,859 (34.0%)
Fourth (highest)	5,704 (12.1%)	19,898 (36.8%)	11,363 (25.3%)	14,675 (25.1%)
Preoperative testing†	—	—	—	—
Noninvasive cardiac stress test	4,597 (9.7%)	7,457 (13.8%)	4,720 (10.5%)	7,967 (13.6%)
Resting echocardiogram	7,037 (14.9%)	8,895 (16.4%)	6,403 (14.3%)	10,682 (18.3%)
Pulmonary function test	4,013 (8.5%)	4,974 (9.2%)	3,829 (8.5%)	6,646 (11.4%)
Other consultations	—	—	—	—
Anesthesiology‡	30,891 (65.3%)	36,626 (67.6%)	27,470 (61.2%)	38,303 (65.5%)
Perioperative care	—	—	—	—
Epidural anesthesia	9,415 (19.9%)	11,056 (20.4%)	6,883 (15.3%)	9,939 (17.0%)
Invasive monitoring§	9,022 (19.1%)	17,116 (31.6%)	10,335 (23.0%)	15,392 (26.3%)
	Quartile 1 (n = 28,600)	Quartile 2 (n = 30,854)	Quartile 3 (n = 27,809)	Quartile 4 (n = 35,206)
Preoperative medications				
New β -blocker prescription#	616 (2.2%)	960 (3.1%)	949 (3.4%)	1,417 (4.0%)
New statin prescription#	370 (1.3%)	522 (1.7%)	386 (1.4%)	515 (1.5%)

The strata range from the lowest consultation rate (quartile 1) to highest (quartile 4).

* Divided into quartiles of approximately equal patient numbers, based on total volume of eligible procedures performed over study period. † Performed within 6 months before surgery. ‡ Outpatient consultation by an anesthesiologist within 60 days before surgery. § Intra-operative use of arterial line, central venous line, or pulmonary artery catheter monitoring. || Measured among individuals aged 66 yr and older. # Prescription within 60 days before surgery, but no prescription during the period from 61 days to 365 days before surgery.

other settings to determine the reproducibility of our findings. Several aspects of perioperative care in Ontario, such as the average preoperative wait time, the absence of internist involvement in primary care,^{16,17} and the degree of overall consensus regarding the need for preoperative medical consultation, may not be generalizable to other healthcare jurisdictions. For example, in jurisdictions where preoperative consultation is deemed

“appropriate” for a higher proportion of surgical patients, there is likely to be a lower degree of interinstitutional practice variation.³⁶ Second, as with any area-level analysis,⁴² the observed differences in postoperative mortality based on hospital-specific medical consultation rates do not imply that varying consultation rates were entirely responsible for the differences in perioperative outcomes.

Table 4. Association of Hospital Rate of Preoperative Medical Consultation with 30-day Mortality

	Unadjusted Mortality Rate	Adjusted Mortality Rate*	Adjusted Hazard Ratio†	95% CI	P Value
Quartile 1 (lowest)	0.83%	0.87%	1.13	0.95–1.34	0.16
Quartile 2	0.86%	0.76%	Reference	NA	NA
Quartile 3	0.75%	0.82%	1.07	0.91–1.25	0.42
Quartile 4 (highest)	0.92%	0.95%	1.33	1.14–1.55	<0.001

Hospital-specific rates are categorized into lowest (quartile 1) to highest (quartile 4) quartiles based on the overall hospital consultation rate during the study period.

* Indirectly standardized using a logistic regression model that included patient-level factors. † Adjusted for patient-level factors, hospital teaching status, hospital procedure volume (categorized into quartiles), hospital rate of preoperative anesthesia consultation (categorized into quartiles), hospital-specific rate of epidural anesthesia (categorized into quartiles), and hospital-specific rate of invasive monitoring (categorized into quartiles).

NA = not applicable.

Third, our administrative databases cannot account for patients who had their surgery canceled after being deemed unfit for surgery by the consulting internist. Nonetheless, such cancellations are rare, occurring after approximately 1–2% of preoperative consultations.^{43,44} Finally, these data sources lacked some important relevant information, such as specific hospital characteristics, most postoperative complications,⁴⁵ and measures of disease severity or surgical complexity. For example, unmeasured differences in disease severity, surgical complexity, and availability of preoperative assessment clinic facilities may have explained some of the residual interinstitutional variation in consultation rates. In addition, the availability of information on postoperative complications (*e.g.*, myocardial infarction) might help further assess whether hospital-specific consultation rates affect clinical outcomes. Specifically, because surgical mortality rates are not always reliable indicators of hospital quality⁴⁶ and the observed 30-day mortality rates in our current study were less than 1%, mortality may not be the ideal outcome measure for assessing the value or harm associated with preoperative medical consultation.

Conclusions

Preoperative medical consultation for major elective noncardiac surgery was relatively common in Ontario, occurring in approximately one third of patients. Referral for medical consultation was associated with increased patient age and comorbid disease. Consultation use also varied across surgeries but in a manner that did not reflect the inherent operative risks of the surgical procedures. Although these patient-level factors (age, comorbid disease, surgery) were associated with medical consultation, the individual hospital site, independent of its teaching status or surgical procedure volume, was the major determinant of whether patients underwent consultation before surgery. Additional research is needed to better determine the basis for this substantial interhospital variation and which patients would benefit most from preoperative consultation.

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