ORIGINAL INVESTIGATION

A Population-Based Study of Anesthesia Consultation Before Major Noncardiac Surgery

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Background: In single-center studies, consultation by an anesthesiologist days to weeks before surgery was associated with reduced patient anxiety, case cancellations on the day of surgery, and duration of hospitalization. Nonetheless, the impact of anesthesia consultation on outcomes in the population remains unclear.

Methods: We used population-based, linked, administrative databases to conduct a cohort study of patients, aged 40 years and older, who underwent selected elective intermediate- to high-risk noncardiac surgical procedures in Ontario, Canada, between April 1, 1994, and March 31, 2004. Propensity-score methods were used to construct a matched-pairs cohort that resolved important differences between patients who underwent consultation and those who did not. We then determined the association of consultation (within 60 days before surgery) with hospital length of stay and postoperative mortality (30-day and 1-year) rates within the matched pairs.

Results: Of the 271 082 patients in the entire cohort, 39% (n=104 716) underwent anesthesia consultation. The proportion of patients who underwent consultation increased from 19% in 1994 to 53% in 2003. Within the matched-pairs (n=180 254), consultation was associated with reduced mean hospital length of stay (8.17 days vs 8.52 days; difference, −0.35 days; 95% confidence interval [CI], −0.27 to −0.43; $P<.001$). Consultation was not associated with reduced mortality at 30 days (relative risk, 1.04; 95% CI, 0.96 to 1.13; $P=.36$) or 1 year (relative risk, 0.98; 95% CI, 0.95 to 1.02; $P=.20$).

Conclusions: Preoperative anesthesia consultation is associated with reduced length of stay but not with reduced mortality. Future research should evaluate the cost-effectiveness of the increasing use of anesthesia consultation.

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PATIENTS UNDERGOING INTERmediate- to high-risk noncardiac surgical procedures often have considerable comorbid disease. For example, approximately 25% of patients either have, or are at risk for, ischemic heart disease,[1] while at least 14% have chronic obstructive pulmonary disease.[2] Preoperative anesthesia consultation may help improve the outcomes of these patients. Preoperative anesthesia consultation differs from a routine in-hospital evaluation by the responsible anesthesiologist on the day before or the morning of surgery. Instead, patients undergo a formal consultation by an anesthesiologist days to weeks before surgery, typically in an outpatient preassessment clinic. This consultation provides an opportunity to better document comorbid disease, to selectively order investigations, to optimize preexisting medical conditions, to discuss aspects of perioperative care (eg, postoperative analgesia), and to defer or cancel surgery, if necessary. Consequently, preoperative anesthesia consultation clinics showed measurable benefits in several single-center studies. They were associated with reduced patient anxiety,[3] case cancellations on the day of surgery,[4,5] duration of hospitalization,[5,6] and hospital costs.[6]

Despite this promising preliminary evidence, the wider impact of anesthesia consultation in the population remains unclear. We therefore performed a population-based cohort study to determine whether anesthesia consultation before elective intermediate- to high-risk noncardiac surgery is associated with reduced hospital length of stay and mortality (30-day and 1-year) rates. These procedures included major vascular (abdominal aortic aneurysm repair, carotid endarterectomy, and peripheral vascular bypass), intra-abdominal (large-bowel surgery, liver resection, Whipple procedure, gastrectomy, and esophagectomy), urologic (nephrectomy and cystectomy), thoracic (pneumonectomy and pulmonary lobectomy), and orthopedic (total hip replacement and total knee replacement) operations.

METHODS

STUDY DESIGN

After research ethics approval from Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, we used linked population-based administrative health care databases in Ontario to undertake a cohort study. These databases were the Canadian Institute for Health Information (CIHI) Discharge Abstract database, which describes all hospital admissions; the Ontario Health Insurance Plan (OHIP) database, which describes physician billing for inpatient and outpatient services; the Registered Persons Database (RPDB), which describes demographics and vital statistics; the Corporate Providers Database (CPDB), which describes physicians' specialties; the Ontario Drug Benefit (ODB) database, which describes prescription medications dispensed to all individuals 65 years and older; and the 2001 Canadian census. While these databases lack physiologic and laboratory measures (eg, blood pressure and hemoglobin), they have been validated for many other variables, including a range of outcomes, exposure, and comorbidities.[7-12] During the study period, Ontario was Canada's most populous province, with a population of approximately 12 million. Residents had access to physician services and hospital services through a universal health care program.

STUDY COHORT

We retrospectively identified all residents of Ontario 40 years and older who underwent specific elective surgical procedures during fiscal years 1994 to 2003 (April 1, 1994, to March 31, 2004): 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 were intermediate to high risk,[13] applicable to either sex, and previously described in research studies that used the CIHI database.[14-18] Procedure codes in the CIHI database have excellent accuracy.[12]

The principal exposure was preoperative anesthesia consultation, as defined by a physician billing for outpatient anesthesia consultation within 60 days before surgery. This definition has previously been used for research purposes.[19] The outcomes of interest were all-cause mortality rates (30 days and 1 year after surgery) and hospital length of stay. Mortality was determined using the CIHI (in-hospital deaths) and RPDB (out-of-hospital deaths) databases. We used the CIHI database to determine hospital length of stay.

Demographic information was obtained from the RPDB. We used validated administrative data algorithms to identify patients with diabetes or hypertension.[8,11] The OHIP database was used to identify patients who had previously required dialysis. We used previously described methods to identify other comorbidities based on the *International Classification of Diseases, Ninth Revision, Clinical Modification*, or the *International Classification of Diseases, 10th Revision*, within the CIHI database. These other comorbid conditions were ischemic heart disease, congestive heart failure, cerebrovascular disease, pulmonary disease, chronic renal insufficiency, malignancy, liver disease, and dementia.[20,21] To improve sensitivity for identifying comorbidities, we used information from hospitalizations within 2 years before surgery.[10] The OHIP database and CPDB were used to identify outpatient medical consultations (general internal medicine and cardiology) within 60 days before surgery and intraoperative invasive monitoring. Procedure codes in the OHIP database have a high accuracy rate.[12] We imputed patients' incomes based on their neighborhood (Forward Sortation Area) median income in the 2001 Canadian census.

To better understand how consultation might influence outcomes, we used the OHIP database and ODB to identify several related processes of care: outpatient testing (cardiac investigations and pulmonary function tests), perioperative epidural anesthesia or analgesia (which, for convenience, is hereafter referred to as *anesthesia*), and outpatient prescriptions for β-blockers within 100 days before surgery. It is conceivable that patients attending a preassessment clinic are systematically more compliant with health care recommendations. We therefore used the OHIP database to identify testing that might indicate adherence to screening guidelines: mammography, colonoscopy, and fecal occult blood testing.

STATISTICAL ANALYSES

Bivariate tests were initially used to compare the characteristics of patients who did or did not undergo anesthesia consultation (*t* test, Mann-Whitney *U* test, χ^2 test, and Fisher exact test). We used propensity-score matched-pairs analyses to determine the adjusted association of anesthesia consultation with the outcomes of interest. The rationale and methods underlying the use of propensity scores for proposed causal exposure variables have been previously described.[22] We developed a nonparsimonious multivariable logistic regression model to estimate a propensity score for preoperative anesthesia consultation, without regard for outcome. Clinical significance guided the initial choice of covariates in this model: age, sex, year, surgical procedure, hospital type (teaching, low-volume nonteaching, mid-volume nonteaching, and high-volume nonteaching), comorbid disease, other specialist consultations (general internal medicine and cardiology), intraoperative invasive monitoring, and income. Previously described methods were used to categorize nonteaching hospitals into terciles[23] based on the annual volume of included procedures.

We considered comorbid conditions that were present in 1% or more of the study cohort: ischemic heart disease, congestive heart failure, cerebrovascular disease, hypertension, diabetes, pulmonary disease, renal disease, and malignancy. As suggested by recent statistical research on propensity score development, we used a structured iterative approach to refine this model, with the goal of achieving covariate balance within the matched pairs.[24,25] Covariate balance was measured using the standardized difference, by which an absolute standardized difference above 10% is suggested to represent meaningful covariate imbalance.[25,26] We matched consultation patients to no-consultation patients using a greedy-matching algorithm with a caliper width of 0.2 SD of the log odds of the estimated propensity score. This method involved sampling without replacement and has been shown to remove 98% of the bias from measured covariates.[27] Within the matched pairs, we used the paired *t* test to compare hospital length of stay and the methods of Agresti and Min[28] to compare mortality rates.

Prespecified subgroup analyses were also performed within the following categories: hospital type (teaching or high-volume hospital vs mid- or low-volume hospital), period (fiscal years 1994 to 1999 vs fiscal years 2000 to 2003), cardiac disease (presence vs absence of ischemic heart disease or congestive heart failure), and surgical procedure (vascular, orthopedic, intraperitoneal, or intrathoracic). A subgroup analysis based on period was performed because preoperative consul-

Table 1. Characteristics of the Entire Cohort[a]

Variable	Anesthesia Consultation (n=104 716)	No Consultation (n=166 366)
Demographics		
Female sex	52 700 (50)	86 607 (52)
Age, mean (SD), y	69 (10)	68 (10)
Socioeconomic status		
Annual income, mean (SD), $[b]	24 773 (5125)	24 665 (5036)
Procedure		
AAA repair	4606 (4.4)	3325 (2.0)
Carotid endarterectomy	6354 (6.1)	5691 (3.4)
Peripheral vascular bypass	7561 (7.2)	8485 (5.1)
Total hip replacement	24 801 (24)	39 890 (24)
Total knee replacement	32 717 (31)	53 748 (32)
Large bowel surgery	15 006 (14)	38 854 (23)
Liver resection	611 (0.6)	1323 (0.8)
Whipple procedure	463 (0.4)	643 (0.4)
Pneumonectomy or lobectomy	5933 (5.7)	4336 (2.6)
Gastrectomy or esophagectomy	2282 (2.2)	3345 (2.0)
Nephrectomy	3338 (3.2)	5519 (3.3)
Cystectomy	1044 (1.0)	1207 (0.7)
Hospital type		
Teaching	39 752 (38)	52 793 (32)
High-volume nonteaching	22 955 (22)	34 578 (21)
Mid-volume nonteaching	22 830 (22)	37 335 (22)
Low-volume nonteaching	19 179 (18)	41 666 (25)
Comorbid disease		
Ischemic heart disease	12 747 (12)	13 815 (8.3)
Congestive heart failure	3377 (3.2)	3650 (2.2)
Cerebrovascular disease	5692 (5.4)	6198 (3.7)
Hypertension	61 879 (59)	83 958 (50)
Diabetes mellitus	21 896 (21)	27 427 (16)
Pulmonary disease	6671 (6.4)	7336 (4.4)
Dialysis or renal disease	1599 (1.5)	1789 (1.1)
Malignancy	9146 (8.7)	14 766 (8.9)
Medical consultation[c]		
General internal medicine	22 056 (21)	41 118 (25)
Cardiology	10 265 (9.8)	10 272 (6.2)
Intraoperative monitoring		
Arterial line	42 503 (41)	38 805 (23)
Central venous line	11 323 (11)	10 848 (6.5)
Pulmonary artery catheter	4805 (4.6)	4208 (2.5)

Abbreviation: AAA, abdominal aortic aneurysm.
[a] Values other than age and annual income are expressed as number (percentage).
[b] Income is expressed as Canadian dollars.
[c] Within 60 days before surgery.

tation practice may have changed substantially after major randomized trials of perioperative β-blockade were published in 1996 and 1999.[29,30] We performed subgroup analyses based on cardiac disease and procedure type because the evidence supporting perioperative interventions is strongest for preventing cardiac events,[13] especially during vascular surgery.[30,31] For these subgroup analyses, we repeated the same propensity-score matching process, while forcing an exact match on the subgroup characteristics. The 30-day and 1-year mortality rates were then compared within the subgroup-specific matched pairs. We used conditional logistic regression to determine whether there was an interaction between the exposure (anesthesia consultation) and specific subgroups.[32] An additional subgroup analysis was performed among patients 66 years and older specifically to describe preoperative β-blocker use. We performed this analysis because data on outpatient prescriptions are only available for individuals 65 years and older in Ontario.

In a sensitivity analysis, we used multivariable logistic regression to determine the adjusted association of anesthesia consultation with 30-day mortality in the entire sample (N=271 082). These results were very similar to the propensity-score analysis and are therefore not reported. Analyses were performed using SAS version 9.1 (SAS Inc, Cary, North Carolina) and R 2.4.1.[33] A 2-tailed $P<.05$ was used to define statistical significance.

RESULTS

The study cohort comprised 271 082 patients, 39% (n=104 716) of whom underwent anesthesia consultation within 60 days before surgery (**Table 1**). The median time between consultation and surgery was 8 days (interquartile range, 5-14 days). Consultation rates increased through the study period from 19% of cases in fiscal year 1994 to 53% of cases in fiscal year 2003 (**Figure**). Approximately 93% (n=97 458) of these consultations were ordered by surgeons, 6.0% (n=6259) by family physicians, 0.8% (n=813) by internists, and 0.2% (n=186) by other specialists.

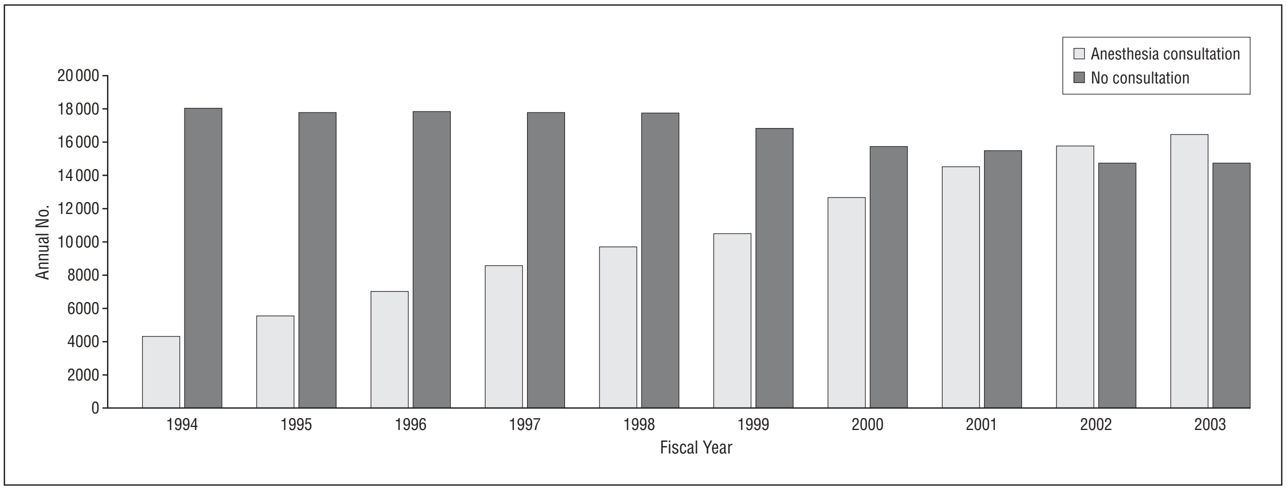

Figure. Annual numbers of anesthesia consultations and no consultations.

Patients who did or did not undergo preoperative consultation differed significantly ($P < .001$) for all measured characteristics, except malignancy ($P = .21$). The patients who underwent consultation were typically older men who underwent surgery at teaching hospitals and who had more comorbid disease (Table 1). They were also more likely to undergo cardiology consultation before surgery and require intraoperative invasive monitoring; conversely, they were less likely to be evaluated by general internists. The different surgical procedures demonstrated considerable variation with regard to anesthesia consultation (Table 1).

Of the patients who underwent anesthesia consultation, 86% (n = 90 127) were successfully matched to a similar patient who did not. The covariate balance between the 2 arms improved considerably through propensity-score matching (**Table 2**). Within this matched cohort, mean hospital length of stay was significantly shorter among patients who underwent preoperative consultation (8.17 days vs 8.52 days; difference, −0.35 days; 95% confidence interval [CI], −0.27 to −0.43; $P < .001$). This reduction in overall hospital length of stay was due to reduced length of stay before surgery (difference, −0.23 days; 95% CI, −0.20 to −0.26; $P < .001$) and after surgery (difference, −0.12 days; 95% CI, −0.04 to −0.12; $P = .003$). Consultation was not associated with reduced mortality at either 30 days (relative risk [RR], 1.04; 95% CI, 0.96 to 1.13; $P = .36$) or 1 year (RR, 0.98; 95% CI, 0.95 to 1.02; $P = .20$) after surgery.

Consultation was associated with generally higher rates of specific testing (echocardiograms, myocardial perfusion tests, and pulmonary function tests) and epidural anesthesia (**Table 3**). The rates of mammography, colonoscopy, and fecal occult blood testing were similar among patients who did or did not undergo preoperative consultation, suggesting that the matching process produced cohorts that had similar compliance with nonsurgery-related screening recommendations (Table 3).

The subgroup of patients 66 years and older comprised 59 481 patients who underwent consultation and 59 481 patients who did not. In this subgroup, the proportion receiving preoperative β-blockers was 20% (n = 11 859) among patients who underwent consultation and 18% (n = 10 457) among those who did not. This difference corresponded to an RR of 1.13 (95% CI, 1.10 to 1.16; $P < .001$) or a number needed to treat of 56 (95% CI, 45 to 73).

The association of consultation with mortality was unchanged when the analyses were repeated in subgroups based on hospital type or period (**Table 4**). In contrast, the effects of anesthesia consultation appeared to vary with the surgical procedure and perhaps with the presence of cardiac disease (ischemic heart disease or congestive heart failure) (Table 4). Specifically, the observed benefits appeared to be greater in patients with cardiac disease or those undergoing vascular surgery.

COMMENT

In this population-based cohort study, we found that rates of anesthesia consultation before elective intermediate- to high-risk noncardiac surgery had increased over time and that patients who underwent consultation generally had more comorbid disease. Anesthesia consultation was associated with reduced hospital length of stay; however, after adjustment for important baseline differences, it was not associated with improved survival.

IMPLICATIONS

Our results confirm that preoperative anesthesia consultation is associated with reduced hospital length of stay[4-6] and that the magnitude of this reduction is consistent with similar interventions (eg, outpatient internal medicine consultation and postoperative hospitalist care).[34,35] Although an average reduction of 0.35 days may seem modest, it is best interpreted at the population level. Based on the approximately 32 000 Ontario patients who underwent eligible procedures in 2003, routine anesthesia consultation might have prevented the equivalent of 11 200 days of inpatient hospitalization. This reduction in patient-days of hospitalization could permit hospitals to reduce costs for inpatient care, to schedule more surgical procedures, or to use the hospital beds for other nonsurgical patients.

Table 2. Characteristics of the Propensity-Matched Pairs

Variable	Anesthesia Consultation[a] (n=90 127)	No Consultation[a] (n=90 127)	Absolute Standardized Difference, % Before Matching	Absolute Standardized Difference, % After Matching
Demographics				
Female sex	46 509 (52)	46 567 (52)	3.5	0.1
Age, mean (SD), y	69 (10)	69 (10)	15.8	0.09
Socioeconomic status				
Annual income, mean (SD), $[b]	24 777 (5124)	24 776 (5117)	2.1	0.02
Fiscal year				
1994	4271 (4.7)	4349 (4.8)	25.9	0.4
1995	5507 (6.1)	5735 (6.4)	20.0	1.0
1996	6856 (7.6)	6902 (7.7)	14.4	0.2
1997	8194 (9.1)	8030 (8.9)	8.6	0.6
1998	8985 (10)	8884 (9.9)	4.8	0.4
1999	9548 (11)	9394 (10)	0.3	0.6
2000	10 612 (12)	10 518 (12)	8.5	0.3
2001	11 541 (13)	11 632 (13)	14.2	0.3
2002	12 125 (13)	12 164 (13)	19.2	0.1
2003	12 488 (14)	12 519 (14)	21.0	0.1
Procedure				
AAA repair	2749 (3.1)	2751 (3.1)	13.7	0.01
Carotid endarterectomy	4609 (5.1)	4545 (5.0)	12.5	0.3
Peripheral vascular bypass	5909 (6.6)	5729 (6.4)	8.8	0.8
Total hip replacement	22 606 (25)	22 558 (25)	0.7	0.1
Total knee replacement	30 385 (34)	30 633 (34)	2.3	0.6
Large bowel surgery	13 748 (15)	13 677 (15)	23.2	0.2
Liver resection	586 (0.7)	587 (0.7)	2.6	0.01
Whipple procedure	393 (0.4)	402 (0.4)	0.9	0.2
Pneumonectomy or lobectomy	3563 (4.0)	3659 (4.1)	15.4	0.5
Gastrectomy or esophagectomy	1774 (2.0)	1754 (1.9)	1.2	0.2
Nephrectomy	2985 (3.3)	3032 (3.4)	0.7	0.3
Cystectomy	820 (0.9)	800 (0.9)	2.9	0.2
Hospital type				
Teaching	32 872 (36)	33 552 (37)	13.1	1.6
High-volume nonteaching	19 374 (22)	19 052 (21)	2.8	0.9
Mid-volume nonteaching	19 859 (22)	19 613 (22)	1.5	0.7
Low-volume nonteaching	18 022 (20)	17 910 (20)	16.4	0.3
Comorbid disease				
Ischemic heart disease	9591 (11)	9433 (10)	12.8	0.6
Congestive heart failure	2516 (2.8)	2519 (2.8)	6.4	0.02
Cerebrovascular disease	4307 (4.8)	4225 (4.7)	8.2	0.4
Hypertension	51 761 (57)	51 662 (57)	17.4	0.2
Diabetes mellitus	17 751 (20)	17 642 (20)	11.4	0.3
Pulmonary disease	5016 (5.6)	5027 (5.6)	8.7	0.05
Dialysis or renal disease	1262 (1.4)	1245 (1.4)	4.0	0.2
Malignancy	7589 (8.4)	7604 (8.4)	0.5	0.06
Medical consultation[c]				
General internal medicine	19 711 (22)	19 841 (22)	8.7	0.3
Cardiology	7744 (8.6)	7676 (8.5)	13.4	0.3
Intraoperative monitoring				
Arterial line	30 171 (33)	29 896 (33)	37.7	0.6
Central venous line	7880 (8.7)	7805 (8.7)	15.3	0.3
Pulmonary artery catheter	3283 (3.6)	3252 (3.6)	11.1	0.2

Abbreviations: AAA, abdominal aortic aneurysm; NA, not applicable.
[a]Values other than age and annual income are expressed as number (percentage).
[b]Income is expressed in Canadian dollars.
[c]Within 60 days before surgery.

Several plausible mechanisms explain how consultation might reduce length of stay. Patients who are evaluated at anesthesia preassessment clinics are generally better prepared for surgery.[36] The consulting anesthesiologists can optimize the management of chronic medical conditions, facilitate referral to appropriate subspecialists, better document patients' baseline medical status, and order further investigations to diagnose occult conditions (eg, aortic stenosis) or to establish the severity of previous diagnoses (eg, ischemic heart disease).[37] This improved preoperative preparation would help prevent last-minute case cancellations or delays, thereby reducing

Table 3. Processes-of-Care and Outcomes in the Propensity-Matched Pairs

Variable	No. (%)	
	Anesthesia Consultation (n=90 127)	No Consultation (n=90 127)
Preoperative testing		
Within 180 d before surgery		
Echocardiogram	16 373 (18)	11 246 (12)
Noninvasive myocardial perfusion test	15 651 (17)	12 805 (14)
Coronary angiogram	1365 (1.5)	1191 (1.3)
Pulmonary function test	13 921 (15)	12 233 (14)
Within 60 d before surgery		
Echocardiogram	10 730 (12)	6548 (7.3)
Noninvasive myocardial perfusion test	8840 (9.8)	6667 (7.4)
Coronary angiogram	496 (0.6)	485 (0.5)
Pulmonary function test	10 711 (12)	9340 (10)
Perioperative procedures		
Epidural anesthesia	25 603 (28)	16 382 (18)
Recommended screening tests[a]		
Mammography	6066 (6.7)	6255 (6.9)
Colonoscopy	15 642 (17)	15 011 (17)
Fecal occult blood testing	8517 (9.5)	8870 (9.8)
Postoperative mortality		
30 d	1183 (1.3)	1139 (1.3)
1 y	5131 (5.7)	5215 (5.8)

[a] Within 2 years before hospital admission for surgery.

hospital length of stay before surgery. Also, a shift in preoperative testing from the inpatient to the outpatient setting would further reduce length of stay before surgery. Finally, improved preoperative preparation might help reduce some postoperative complications,[38] which could thereby shorten postoperative hospital length of stay.[39]

Preoperative consultation was not associated with improved survival. Several factors may, in combination, explain this finding. First, comparisons between consultation and no-consultation patients are biased by confounding by indication. Specifically, patients who are referred for consultation have greater burdens of comorbid illness. Despite the use of statistical methods to adjust for these differences, our administrative data sources might lack sufficient clinical detail for adequate risk adjustment. Second, consultation may improve survival only within the context of high-risk patients or specific types of surgery. The evidence supporting the benefit of perioperative interventions (eg, β-blockers and α_2-adrenergic agonists) is often strongest in patients who have cardiac disease or are undergoing vascular surgery[30,31,40]; hence, consulting anesthesiologists may have greater opportunities for improving the outcomes of these specific patients. Third, preoperative consultation may have led to interventions, such as perioperative β-blockade, which, although previously recommended,[13] might actually be associated with harm.[41] Finally, low compliance with anesthesiologists' recommendations may limit the overall effectiveness of preoperative consultation. As reported by a previous single-center study, although adherence to anesthesiologists' recommendations was associated with reduced postoperative complications, these recommendations were ignored in 45% of cases.[38]

Our results also showed a 4-fold increase in rates of anesthesia consultation over the study period. To our knowledge, this substantial increase has not been previously reported at the population-level. Potential institutional reasons for this increase include the establishment of preassessment clinics by hospitals after promising single-center reports[4-6] and a gradual shift to same-day admission for many surgical procedures. Furthermore, we found that preoperative consultation was associated with an increased use of epidural anesthesia. Many patients are reluctant to accept epidural anesthesia,[42] despite evidence for improved pain relief[43] and decreased respiratory complications.[44] The physician-patient dialogue during the consultation visit might help address some of their concerns and thereby increase the overall use of epidural anesthesia. Since epidural anesthesia is associated with, at best, a small reduction in mortality,[45] it is not surprising that its increased use did not necessarily translate into decreased mortality after consultation.

Further research is needed to evaluate the overall economic impact of anesthesia consultation. Consultations, and their associated preassessment clinics, entail additional costs to the health care system. As suggested by our study, costs may be further increased through greater use of specialized preoperative tests. Conversely, consultation decreases other health care costs through reduced hospital length of stay and case cancellations on the day of surgery. In light of the increasing rates of preoperative consultation over the past decade, future research should evaluate its overall economic impact on the health care system.

STRENGTHS

This study has several strengths. To our knowledge, it is the only population-based multicenter study to evaluate the association of preoperative anesthesia consultation with hospital length of stay and mortality rates. The population-based sample also enhances the generalizability of our findings to other health care systems that are reasonably similar to that in Ontario. Also, our study included only elective intermediate- to high-risk surgical procedures. Urgent or emergent procedures are unlikely to be delayed to facilitate anesthesia consultation. Furthermore, the benefits of preoperative consultation, investigation, and optimization are likely diminished in low-risk procedures such as cataract surgery.[46] Therefore, our study focused on patients who had the opportunity to receive, and potentially benefit from, anesthesia consultation.

LIMITATIONS

Our study has also several recognized limitations. First, given that it is an observational study, our results demonstrate an association between consultations and reduced length of stay but do not prove causality. Nonetheless, it is very plausible that this association represents a cause-effect relationship. Alternative study designs also

Table 4. Association of Consultation With Outcomes Within Specific Matched Subgroups

Variable	30-d Mortality RR (95% CI)	30-d Mortality Interaction[a]	1-y Mortality RR (95% CI)	1-y Mortality Interaction[a]
Entire matched cohort	1.04 (0.96-1.13)	NA	0.98 (0.95-1.02)	NA
Subgroups				
Hospital type				
Teaching or high-volume	1.03 (0.93-1.15)	*P*=.44	0.98 (0.94-1.03)	*P*=.87
Mid- or low-volume	1.10 (0.97-1.25)		0.99 (0.93-1.05)	
Period				
1994-1999	1.06 (0.95-1.19)	*P*=.38	1.00 (0.95-1.05)	*P*=.25
2000-2003	0.99 (0.89-1.12)		0.95 (0.90-1.00)	
Cardiac disease[b]				
Present	0.94 (0.79-1.13)	*P*=.30	0.89 (0.82-0.97)	*P*=.03
Absent	1.05 (0.96-1.15)		0.99 (0.95-1.03)	
Procedure				
Vascular	0.86 (0.73-1.01)	*P*=.009	0.83 (0.76-0.91)	*P*<.001
Abdominal or thoracic	1.09 (0.97-1.22)		0.99 (0.95-1.04)	
Orthopedic	1.13 (1.05-1.55)		1.13 (1.04-1.24)	

Abbreviations: CI, confidence interval; NA, not applicable; RR, relative risk.
[a]Tests in which treatment effects differed significantly between subgroups.
[b]History of ischemic heart disease or congestive heart failure.

have limitations. A randomized controlled trial, although better suited to proving causality, is likely unfeasible and unethical. Many surgeons would not permit older patients with comorbid disease to be randomized to the no-consultation arm. Furthermore, participation in such a trial might alter usual clinical practice in the no-consultation arm, thereby artificially diminishing differences between the study arms. Second, our study did not account for patients who had their operations cancelled after being deemed unfit for surgery by the consulting anesthesiologist. Although these cancellations may bias our results, they are rare,[37,38] and they are the potential benefits of anesthesia consultation. Specifically, unnecessary deaths may be prevented in these highest-risk patients by resulting in more limited surgery or by the avoidance of surgery altogether. Third, administrative data sources do not adequately capture postoperative complications (eg, pneumonia)[47] or causes of death. Such information may have helped to better describe how consultation might alter outcomes. Specifically, a consultation is more likely to prevent cardiac- or pulmonary-related complications as opposed to primarily surgical complications. Fourth, the subgroup analyses should be interpreted cautiously and viewed only as hypothesis generating. Further research is needed to determine whether our overall and subgroup-specific results can be replicated in other similar populations. Finally, these administrative data were limited with respect to detailed clinical information and some processes of care (eg, inpatient medication use). We addressed this limitation, in part, by using comorbidity definitions with generally high specificity and moderate-to-good sensitivity.[7-11,48] We further improved their sensitivity by using hospitalization information from the 2 years before surgery.[10]

In conclusion, anesthesia consultation before elective intermediate- to high-risk noncardiac surgery is associated with reduced hospital length of stay but not with improved overall survival. In light of these potential benefits, further research is needed to evaluate the cost-effectiveness of the increasing use of preoperative anesthesia consultation.

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