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REPORTS OF ORIGINAL INVESTIGATIONS

Knowledge and perceptions about perioperative stroke: a cross-sectional survey of patients scheduled for non-neurologic and non-cardiac surgery

Les connaissances et perceptions sur l'accident vasculaire cérébral périopératoire : un sondage transversal de patients devant subir une chirurgie non neurologique et non cardiaque

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Abstract

Purpose *Perioperative stroke is associated with significant morbidity and mortality yet patients may not be aware of their risk or receive appropriate counselling. Our objectives were to 1) compare patient's perceived vs calculated risk of stroke; 2) determine level of worry; and 3) assess prior discussion about perioperative stroke risk amongst elective patients undergoing non-cardiac, non-neurologic surgery.*

Methods *Over a consecutive four-week period, surveys were distributed at two pre-anesthetic clinics to adult patients scheduled for non-cardiac, non-neurologic surgery. The survey included questions about demographics, perioperative stroke risk factors, patient perception of their quantitative and qualitative stroke risk, level of worry about stroke, and risk discussions. We identified independent predictors of risk underestimation amongst medium- and high-risk patients.*

Results *Six hundred patients completed the survey (response rate 78%). Of these, 479, 104, and 15 patients were classified as low-, medium-, and high-risk, respectively (with two patients missing this data point). Most medium- (86%) and high-risk (80%) patients did not identify their elevated risk. Amongst medium- and high-risk patients, independent predictors of risk underestimation were lower education and absence of kidney disease. Medium- and high-risk patients were more worried than low-risk patients about perioperative stroke (median [interquartile range] visual analogue scale score 2 [0.5–4] vs 1 [0–2], P = 0.001). Fewer than half of patients had discussed perioperative stroke previously (40%, 23%, and*

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12% of high-, medium-, and low-risk patients, respectively).

Conclusions *Patients at higher risk of stroke frequently underestimate their risk of perioperative stroke. The majority of patients had not discussed perioperative stroke prior to anesthetic consultation.*

Résumé

Objectif *L'accident vasculaire cérébral (AVC) périopératoire est associé à une morbidité et à une mortalité importantes, et les patients pourraient ne pas être conscients du risque qu'ils courent ou ne pas recevoir des conseils adaptés. Nos objectifs étaient de 1) comparer le risque perçu vs calculé d'AVC des patients; 2) déterminer leur degré d'inquiétude; et 3) évaluer les discussions préalables concernant le risque d'AVC périopératoire chez les patients devant subir une chirurgie non cardiaque et non neurologique non urgente.*

Méthode *Sur une période de quatre semaines consécutives, des sondages ont été distribués dans deux cliniques pré-anesthésiques aux patients adultes devant subir une chirurgie non cardiaque et non neurologique. Le sondage comportait des questions concernant les données démographiques, les facteurs de risque d'AVC périopératoire, la perception des patients de leur risque quantitatif et qualitatif d'AVC, leur degré d'inquiétude concernant un AVC, et les discussions des risques. Nous avons identifié des prédicteurs indépendants de sous-estimation du risque parmi les patients à risque intermédiaire et élevé.*

Résultats *Six cents patients ont complété le sondage (taux de réponse de 78 %). Parmi ces réponses, 479, 104 et 15 patients ont été catégorisés comme courant un risque faible, intermédiaire et élevé, respectivement (données manquantes pour deux patients à ce point de mesure). La plupart des patients de risque intermédiaire (86 %) et élevé (80 %) n'ont pas identifié leur risque élevé. Parmi les patients à risque intermédiaire et élevé, les prédicteurs indépendants de sous-estimation du risque étaient un niveau d'éducation moins élevé et l'absence de maladie rénale. Les patients à risque intermédiaire et élevé étaient plus inquiets que les patients à risque faible quant au risque d'AVC périopératoire (score médian [écart interquartile] sur une échelle visuelle analogique de 2 [0,5–4] vs 1 [0–2], P = 0,001). Moins de la moitié des patients avaient discuté du risque d'AVC périopératoire au préalable (40 %, 23 %, et 12 % des patients à risque élevé, intermédiaire et faible, respectivement).*

Conclusion *Les patients courant un risque plus élevé d'AVC sous-estiment souvent leur risque d'AVC périopératoire. La majorité des patients n'avaient pas discuté du risque d'AVC périopératoire avant leur consultation anesthésique.*

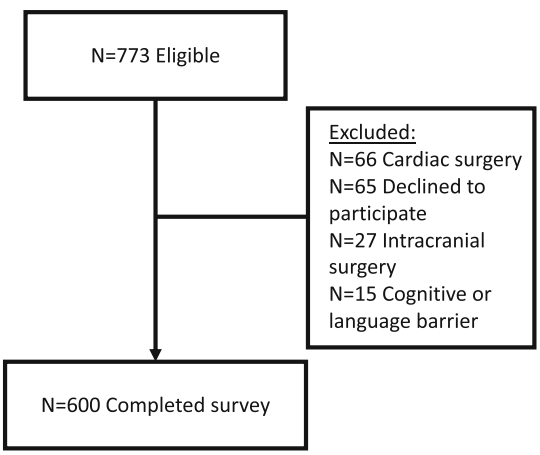

Figure Study participant flow diagram

Introduction

Stroke is a potentially disabling or deadly event that is defined as "a focal or global neurologic deficit of cerebrovascular cause that persists beyond 24 hr or is interrupted by death within 24 hr."[1] A perioperative stroke is considered to occur within 30 days after surgery.[2] The incidence of perioperative stroke has been reported as 0.1% in non-cardiac and non-neurologic surgery, but the incidence varies depending on surgical and patient risk factors.[3,4] In contrast, the incidence of covert perioperative stroke (acute cerebral ischemic event that is not clinically apparent)[5] may be higher. A recent pilot study in non-cardiac, non-carotid surgery patients over 65 yr of age found a rate of 10%,[5] but the importance of covert perioperative stroke requires additional study. Although relatively rare, perioperative stroke has potentially devastating consequences with an eight-fold increase in perioperative mortality, which is double that of patients in the non-surgical setting.[3] Mortality after perioperative stroke ranges from 26% after general surgery to 87% for patients with history of stroke.[6]

Patients often perceive risk inaccurately and little is known about patient perception of perioperative stroke risk. Understandably, patients may wish to discuss rare complications that have serious consequences, such as perioperative stroke, especially since fear of stroke was second only to fear of death in a previous study of surgical patients.[7] The Society of Neuroscience in Anesthesiology and Critical Care, supported by the American Society of Anesthesiologists, published a consensus statement on perioperative stroke and recommended that healthcare

providers should screen for perioperative stroke risk factors and communicate the risk to patients.[2]

For elective surgery, patient education and counselling regarding the risk of perioperative stroke may influence preoperative decision-making, yet patient perceptions of this risk have not been evaluated. In this study of patients undergoing elective non-cardiac, non-neurologic surgery, our objectives were to: 1) compare patient's perceived versus calculated risk of perioperative stroke; 2) assess the level of patient worry about perioperative stroke; and 3) determine the proportion of patients who discussed perioperative stroke with a physician prior to seeing the anesthesiologist.

Methods

Study population

With approval from our institutional research ethic boards (University of British Columbia H15-00320; Western University Research Ethics Board 109673), we performed a cross-sectional paper survey using purposeful sampling.[8] Over a consecutive four-week period (between March 1 and April 30, 2018) we surveyed all adult (> 18 yr old) patients screened at two major Canadian preoperative consult clinics (Vancouver General Hospital, Vancouver, British Columbia, and University Hospital, London, Ontario) who were scheduled for elective non-cardiac and non-neurologic surgery. The study population reflected two geographic catchment areas from two different provinces. Patients were excluded if they were having cardiac, intracranial, or carotid surgery, were unable to read or speak English, or had significant cognitive impairment (e.g., dementia). Paper surveys were distributed to patients on arrival to the clinic, either in the waiting room or the examination room, prior to their consultation with the anesthesiologist.

Survey development

Survey questions were developed to address five domains with all authors participating in item generation and reduction (eAppendix, available as Electronic Supplementary Material ESM]).[8,9] Domains included: 1) demographic information; 2) perioperative stroke risk factors used to calculate perioperative stroke risk; 3) patient's subjective perception of their quantitative and qualitative stroke risk; 4) knowledge and prior counselling about perioperative stroke; and 5) level of worry about perioperative stroke. Survey items were generated after an initial review of the literature, including identification of perioperative stroke risk factors and associated mortality,[3,10,11] as well as a review of previous publications concerned with questioning of patients about risk estimation about stroke.[12–17] Survey questions were revised several times and reduced by study investigators who are experts in perioperative stroke. Ultimately, the survey contained 23 questions, which was within the recommended maximum of 25 questions.[18] Demographic questions included those about age, sex, race, and highest education level achieved. We also determined the patient's preferred spoken language to help account for any potential communication limitations. The patient's individual perioperative stroke risk profile was assessed using questions about known risk factors for perioperative stroke (body mass index [BMI], smoking, hypertension, recent myocardial infarction, prior transient ischemic attack [TIA] or stroke, chronic obstructive pulmonary disease [COPD], renal failure, dialysis, and atrial fibrillation).[3,10,11] Next, patients were questioned about their knowledge of their own perioperative stroke risk using quantitative (0.01%, 0.1%, 1%, 5%, or 10%) and qualitative (lower, similar, or higher than the average patient) risk scores, as well as their knowledge about the risk of dying after perioperative stroke (extremely rare < 1%, rare < 5%, uncommon < 25%, common 25–75%, or very common 75–100%). We asked patients to mark their level of worry about perioperative stroke on a standardized line using a visual analogue scale (VAS) (from not at all worried [0] to extremely worried [10]). Finally, patients were asked whether they had discussed perioperative stroke with a physician and their level of satisfaction with the information provided (dissatisfied, somewhat dissatisfied, somewhat satisfied, or satisfied). Surveys were piloted on five patients attending the clinic at Vancouver General Hospital and modified for clarity and flow based on verbal feedback. For example, we initially included a magnifier scale (to address low incidence) for patients to estimate their absolute risk of perioperative stroke,[19] but it was subsequently removed based on patient feedback. The complete survey is provided in the ESM eAppendix.

Data analysis

We pre-specified a sample size of convenience of 600 responses with 300 responses per site. We did not have previous data on which to base a sample size calculation, and instead estimated the approximate number of surveys we could potentially obtain within a consecutive four-week period at each site. We anticipated that we would have a high response rate (i.e., > 80%) given that the patients would have ample opportunity to complete the survey while waiting in the clinic.

Data are described as mean (standard deviation [SD]) or median [interquartile range (IQR)]. Based on their answers

Table 1 Patient factors associated with increased perioperative stroke risk

Age ≥ 62 yr old
Hypertension requiring medications
Myocardial infarction within 6 months
History of transient ischemic attack
History of stroke with or without deficits
Current smoker
Chronic obstructive pulmonary disease
Acute renal failure
Pre-existing dialysis
Atrial fibrillation

Modified from Mashour *et al*. 2011.[3] Atrial fibrillation was added to the risk factors identified in this study

to questions about identified perioperative stroke risk factors (Table 1),[3] patients were classified into low- (two risk factors or less, 0.1% risk), medium- (three to four risk factors, 0.7% risk) or high-risk (five or more risk factors, 1.9% risk) for perioperative stroke. Each patient was given a stroke risk score based on the number of risk factors, and all risk factors were weighed equally, as previously described.[3] We also included atrial fibrillation as a risk factor as this has been shown to predict stroke with a similar effect size as prior history of stroke.[10,11] Low-risk patients (two factors or less) were considered to have accurately predicted their risk if they selected a risk profile lower than or similar to the average patient, and medium-risk (three to four risk factors) and high-risk (five or more risk factors) patients were considered to have accurately predicted their risk if they selected a qualitative risk profile higher than the average patient (survey question 19, ESM eAppendix). Comparisons between low-, medium-, and high-risk patients were analyzed using a Chi squared, Fisher's exact (cell numbers less than 5), or Kruskal–Wallis analysis of variance (VAS scores). Adjustments for multiple comparisons were done with a Bonferroni correction.

For exploratory purposes, we created a stepwise multivariate logistic regression model with backward elimination to identify variables associated with underestimation of stroke risk in the cohort of patients classified as medium- and high-risk of perioperative stroke based on their risk factors. Patients were considered to have underestimated their stroke risk (the dependent variable) if they considered themselves to be at lower or similar risk of perioperative stroke compared with the average patient (lower qualitative risk of stroke). Candidate predictors (independent variables) were chosen because they were either risk factors for stroke, relevant demographic factors shown in prior risk-prediction studies,[12,15,20] or other potentially relevant factors. Candidate factors were: VAS score for worry, age, sex, BMI, race, preferred language other than English, highest education level achieved, previous surgery, prior discussion about stroke, medium-*vs* high-risk stroke category, and stroke risk factors (i.e., history of stroke, hypertension, COPD, chronic kidney disease/dialysis, or atrial fibrillation). A significance level of 0.05 was used for exclusion from the model and patients with missing variables were omitted from the final model. The effect size for each independent predictor was assessed using adjusted odds ratios. Model discrimination was evaluated using the area under the receiver operating characteristic (AUROC) curve and calibration was assessed using the Hosmer–Lemeshow goodness of fit test, where poor fit is indicated by $P < 0.05$. Variables were tested for pairwise interactions and collinearity. A two-sided P value < 0.05 was considered significant, with the exception of the logistic regression model where a P value < 0.01 was considered significant because of the exploratory nature of **our** model. All data analysis was performed using STATA 12.1 (StataCorp, TX, USA).

Results

Study population

Seven hundred and seventy-three patients were eligible for the study, and 600 surveys were completed (response rate 78%) (Figure). The overall number of missing variables was < 2%, and the most commonly unanswered question was level of patient satisfaction with information on perioperative stroke (n = 27, 4.5%), followed by estimating the risk of dying after perioperative stroke (n = 20, 3.2%), and estimated stroke risk percentage (n = 15, 2.5%). Two patients were missing data in one of the variables used to calculate the stroke risk score/category and were omitted from this part of the analysis.

Patient characteristics are presented in Table 2, stratified by perioperative stroke risk. Overall, 51% (308/600) of patients were male, 80% (482/600) Caucasian, 88% (526/600) had prior surgery, and 43% (256/600) had ≤ high school education (Table 2). Four hundred and seventy-nine, 104, and 15 patients were classified as low-, medium-, and high-risk, respectively, based on known risk factors for perioperative stroke. Patients classified as medium- and high-risk of perioperative stroke (based on risk factors) had a median [IQR] of 3 [3,4] and 5 [5,6] stroke risk factors, respectively, compared with 1 [0–2] stroke risk factors in the low-risk population ($P < 0.001$) (Table 1). Patients classified as medium- or high-risk of perioperative stroke (119/600, 20%) were more likely to be undergoing general surgery or urology procedures and less likely to be

Table 2 Study population characteristics, stratified by predicted perioperative stroke risk

Variable	Overall $n = 598$*	Low-risk $n = 479$	Medium-risk $n = 104$	High-risk $n = 15$	P value
Male, *n* (%)	308 (51)	246 (51)	53 (51)	9 (60)	0.80
BMI ($kg \cdot m^{-2}$), mean (SD)	28 (6)	28 (6)	28 (6)	27 (4)	0.64
Race, *n* (%)					0.80
Caucasian	482 (80)	387 (81)	80 (77)	13 (87)	
Asian	62 (10)	47 (10)	14 (13)	1 (7)	
Other	56 (9)	45 (9)	10 (9)	1 (7)	
English as preferred language, *n* (%)	568 (95)	455 (95)	96 (92)	15 (100)	0.35
$\leq$ High school education, *n* (%)	256 (43)	204 (43)	46 (44)	6 (40)	0.91
Prior surgery, *n* (%)	526 (88)	419 (87)	91 (87)	14 (93)	0.79
Procedure category, *n* (%)					0.047
Orthopedic	294 (49)	241 (50)	45 (43)	8 (53)	
General surgery	95 (16)	70 (15)	21 (20)	4 (27)	
Urology	69 (11)	50 (10)	17 (16)	2 (13)	
Gynecology	35 (6)	30 (6)	5 (5)	0 (0)	
ENT	28 (5)	25 (5)	3 (3)	0 (0)	
Spine	25 (4)	23 (5)	1 (1)	1 (7)	
Plastic	12 (2)	10 (2)	2 (2)	0 (0)	
Thoracic	14 (2)	11 (2)	2 (2)	0 (0)	
Vascular	10 (2)	3 (1)	6 (6)	0 (0)	
Dental	10 (2)	10 (2)	0 (0)	0 (0)	
Timing of surgery, *n* (%)					0.06
Next day	114 (19)	93 (19)	19 (18)	2 (13)	
Within a week	259 (43)	213 (44)	38 (37)	7 (47)	
Within a month	118 (20)	95 (20)	22 (18)	0 (0)	
More than a month	42 (7)	33 (7)	8 (8)	1 (7)	
Unknown	67 (11)	45 (9)	17 (16)	5 (33)	
Stroke risk factors					
Age (mean, SD)	62 (15)	60 (15)	71 (9)	75 (9)	
Smoker, *n* (%)	68 (11)	44 (9)	23 (22)	1 (7)	
History of TIA/stroke, *n* (%)	39 (7)	10 (2)	21 (20)	7 (47)	
Hypertension, *n* (%)	253 (42)	162 (34)	79 (76)	12 (80)	
MI, *n* (%)	47 (8)	28 (6)	14 (13)	3 (33)	
MI in last 6 months, *n* (%)	5 (1)	1 (0)	2 (2)	2 (13)	
COPD, *n* (%)	27 (5)	10 (2)	14 (13)	3 (20)	
CKD, *n* (%)	24 (4)	7 (1)	15 (14)	2 (13)	
Dialysis, *n* (%)	10 (2)	1 (0)	8 (8)	1 (7)	
Atrial fibrillation, *n* (%)	80 (13)	10 (2)	56 (54)	14 (93)	

BMI = body mass index; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; ENT = ears, nose, and throat; IQR = interquartile range; MI = myocardial infarction; SD = standard deviation; TIA = transient ischemic attack. *Two patients were missing a stroke risk score and were unable to be categorized. Patients were classified into low risk (two risk factors or less), medium risk (three to four risk factors) or high risk (five or more risk factors) of perioperative stroke

undergoing gynecology or otolaryngology procedures. The majority (373/600, 62%) of participants attended the preoperative clinic within one week of their surgery. Of note, 7% (39/600) of patients had a history of stroke or TIA. Of these 39 patients, nine were scheduled to undergo surgery within six months of their stroke or TIA.

Table 3 Patients' perceptions of perioperative stroke, stratified by predicted perioperative stroke risk

Variable	Overall $n = 600$	Low-risk $n = 479$	Medium-risk $n = 104$	High-risk $n = 15$	P value
Calculated stroke risk (%)*	0.2	0.1	0.7	1.9	
Perceived stroke risk, *n* (%)					0.20
0.01%	332 (57)	278 (59)	46 (47)	8 (53)	
0.1%	160 (27)	130 (28)	27 (28)	3 (20)	
1%	60 (10)	39 (8)	17 (17)	3 (20)	
5%	14 (2)	10 (2)	4 (4)	0 (0)	
10%	18 (3)	13 (3)	4 (4)	1 (7)	
Perceived risk of stroke relative to the average patient,** *n* (%)					0.001
Lower or similar risk	548 (93)	450 (95)	86 (86)	12 (80)	
Higher risk	41 (7)	23 (5)	14 (14)	3 (20)	
Perceived risk of dying after stroke, *n* (%)					0.47
Extremely rare; < 1%	92 (16)	70 (15)	22 (21)	2 (13)	
Rare; < 5%	210 (36)	173 (37)	32 (34)	4 (27)	
Uncommon; < 25%	192 (33)	161 (34)	24 (25)	7 (47)	
Common; 25–75%	80 (14)	61 (13)	17 (18)	2 (13)	
Very common; 75–100%	7 (1)	5 (1)	2 (2)	0 (0)	
VAS score for worry, median [IQR]	1 [0–2.5]	1 [0–2]	2 [0.5–4]	2 [0.5–4]	0.001
Prior stroke risk discussion, *n* (%)	90 (15)	59 (12)	24 (23)	6 (40)	< 0.001
Satisfied with discussion, *n* (%)	447 (78)	357 (78)	77 (79)	12 (80)	0.98

IQR = interquartile range; VAS = visual analogue scale

Note: Two patients were missing a stroke risk score and were unable to be categorized into a risk category

* Patients were classified into low risk (two risk factors or less), medium risk (three to four risk factors), or high risk (five or more risk factors) of perioperative stroke. Predicted stroke risk was based on the estimates provided by Mashour *et al.* 2011.[3] The overall population risk was calculated from the number of patients in each category

**Estimation of stroke risk was missing from 11 surveys: six low-risk patients and four medium-risk patients

Patient stroke risk prediction

Patients' perception of their stroke risk varied by their assigned risk category based on known risk factors (Table 3). Using the distribution of patients in each of the risk categories and the risk estimations published previously,[3] we calculated an overall predicted risk of perioperative stroke of approximately 0.2% in our study population (Table 3). Most patients (332/600, 57%) perceived their quantitative perioperative stroke risk inaccurately at one in 10,000 (0.01%), although the risk estimation amongst low-risk patients was improved when asked about their qualitative risk compared with the average patient: 95% (450/473) predicted their stroke risk accurately (i.e., similar or lower than the average patient undergoing the same surgery). In contrast, only 14% (14/100) of medium-risk patients and 20% (3/15) of high-risk patients predicted their qualitative stroke risk accurately (i.e., higher than the average patient undergoing the same surgery).

Next, we performed an exploratory multivariate logistic regression analysis to identify independent predictors of underestimation of stroke risk in the population of patients at medium- or high-risk of stroke ($n = 115$, four patients excluded because of missing data). Independent predictors of underestimation of stroke risk are listed in Table 4. Model discrimination and calibration were acceptable (AUROC 0.86, Hosmer–Lemeshow Chi squared 5.61, $P = 0.691$). We did not identify collinearity or interactions between the included variables. Using a more stringent threshold of $P < 0.01$, we identified two independent predictors of underestimation of stroke risk: ≤ high school education (adjusted odds ratio [OR], 27.3; 95% confidence interval [CI], 2.6 to 287.7; $P = 0.006$) and chronic kidney disease (adjusted OR, 0.13; 95% CI, 0.03 to 0.58; $P = 0.008$).

Overall, 494 patients (85%) believed that dying after perioperative stroke was rare or uncommon. Nevertheless, patients classified as medium- and high-risk were more worried about perioperative stroke than those classified as low-risk, and patients who accurately perceived their qualitative risk were more likely to be worried than patients who did not. The median [IQR] level of worry on a scale from 0 to 10 was 1 [0–2], 2 [0.5–4], and 2 [0.5–4] for

Table 4 Independent predictors of underestimation of perioperative stroke risk in the medium- to high-risk patient cohort identified using logistic regression (n = 115)

Variable	Adjusted OR	95% confidence interval	P value
VAS score for worry*	0.75	0.59 to 0.95	0.02
≤ High school education	27.3	2.6 to 287.7	0.006
Chronic kidney disease	0.13	0.03 to 0.58	0.008
Body mass index ($kg \cdot m^{-2}$)*	0.87	0.77 to 0.99	0.03

OR = odds ratio; VAS = visual analogue scale

*OR per point

Patients were classified into low risk (two risk factors or less), medium risk (three to four risk factors) or high risk (five or more risk factors) of perioperative stroke

patients classified as low-, medium-, and high-risk, respectively (difference across categories P = 0.001). Within the patients classified as medium- and high-risk (n = 115), those who correctly perceived their elevated stroke risk had higher median [IQR] level of worry of 3 [2–6] compared with 1.25 [0.5–4] for patients who underestimated their risk (P = 0.013).

Stroke risk counselling and satisfaction

Only 15% of patients (90/600) of patients had discussed perioperative stroke with a physician prior to seeing the anesthesiologist in the preoperative clinic (Table 3). Patients classified as medium- and high-risk were more likely than those classified as low-risk to have discussed stroke risk previously (low-risk 59/479 [12%] *vs* medium-risk 24/104 [23%], P = 0.008 and low-risk 59/479 [12%] *vs* high-risk 6/15 [40%], P = 0.004, P values adjusted for multiple comparisons). Although the percentage of patients who had discussed the risk of perioperative stroke was low, the majority of patients (446/571 [78%]) were satisfied with the information they had received about the possibility of stroke after surgery.

Discussion

Our study shows that patients at elevated risk of perioperative stroke (classified as medium- or high-risk based on known risk factors) presenting for non-cardiac, non-neurologic surgery frequently do not appreciate their elevated relative risk of perioperative stroke. Although the level of worry about perioperative stroke was higher amongst medium- and high-risk patients compared with low-risk patients, the overall level of worry in the survey respondents was low (median [IQR] VAS score 1 [0–2] out of 10). In addition, most patients inaccurately believed mortality after perioperative stroke was uncommon or rare (85%). In our exploratory analysis, we identified characteristics of patients classified as medium- and high-risk who were more likely to underestimate their stroke risk (lower education level and absence of chronic kidney disease). These characteristics may help to identify specific patients who might benefit from targeted education. Given that higher risk patients frequently underestimate their actual perioperative stroke risk relative to other patients, and only a minority of these patients have discussed stroke risk prior to meeting an anesthesiologist, the preoperative consultation may offer an important opportunity for risk counselling.

Our study results are similar to previous research showing that patients tend to underestimate risks and overestimate benefits in a wide range of settings. For example, osteoporotic patients underestimate fracture risk,[14] neurofibromatosis type 1 patients underestimate brain cancer risk,[21] patients with atrial fibrillation insufficiently appreciate associated risks,[17] and African-American men commonly underestimate their prostate cancer risk at the time of biopsy.[13] A recent study showed that patients' underestimation of risks was significantly greater than their overestimation of benefits associated with medical or surgical care.[22] Of particular relevance to this study, non-surgical patients at high risk for stroke typically underestimate this risk.[16,20,23]

Risk perception may be imprecise for a variety of reasons: sex, ethnicity, and education levels have been implicated.[12,15] Of interest, patients who are younger, smoke, or are being treated for hypertension are more likely to perceive a higher stroke risk.[20] Our results confirm that a lower education level independently predicted underestimation of perioperative stroke risk, and this relationship was the strongest of the included variables. Understanding the benefits and risks of an intervention is a critical part of informed consent. Fortunately, education can increase patient awareness and improve knowledge and risk perception. In one study, for example, after a three-month public educational campaign, the percentage of patients who considered themselves at high-risk of stroke

increased from 32.7 to 41.9%.[24] In another study, patients who remember discussing stroke risk with a physician were more likely to acknowledge their increased risk.[23]

Few of our survey respondents (15%) had discussed perioperative stroke prior to their anesthetic consultation, which emphasizes the role for anesthesiologists to ensure adequate patient counselling on this matter. Although patients typically have the opportunity to review perioperative risks with a range of healthcare providers such as surgeons, family physicians, internal medicine physicians, and nurses, our results show that stroke is not usually addressed, even in high-risk patients. Of note, the overall predicted stroke risk in our population (based on risk factors) was 0.2%, which is about twice as high as that identified in the National Surgical Quality Improvement Program (NSQIP) database (0.1%),[3] suggesting that these patient populations may not be analogous. On the other hand, this may simply result from our inclusion of atrial fibrillation as a risk factor, which was not applied to the NSQIP database. The risk of stroke in the general surgical population is $< 1\%$, a value below the threshold often used for patient disclosure to achieve informed consent.[25] Nevertheless, patients understandably want to discuss rare complications if they have serious consequences.[26] Interestingly, 78% of patients were satisfied with their discussion on perioperative stroke although we acknowledge that an underestimation of stroke risk, and associated sequelae, may still persist despite this high satisfaction score. In a previous study, most anesthesiologists believed it was important to discuss stroke risk with patients although less than half did so routinely.[27] Such discussions may be impeded by knowledge gaps regarding perioperative stroke risk amongst anesthesiologists.[27,28] Surprisingly, we identified patients scheduled for elective non-cancer surgery within six months of stroke or TIA, despite evidence that a nine-month interval is warranted.[29] This likely reflects a knowledge gap in perioperative healthcare providers and highlights the need to increase awareness of perioperative stroke.

Our study has several strengths and limitations. We believe that the sampling of a broad spectrum of surgical patients from two different hospitals and provinces contributes to the generalizability of our findings. Nevertheless, we acknowledge that our study population and site-specific healthcare practices may still not be representative of other centres and only reflect two distinct areas of Canada. For example, patients in other centres may be more aware of perioperative stroke if educational initiatives were instituted in their community. Our survey was not developed using standard methodology and its reliability and validity has not been established. In addition, our results are based on patient self-reporting of stroke-related risk factors without verifying these in their medical records. We asked patients about quantitative risk using percentages rather than natural frequencies, which may have been more difficult to understand. Finally, the results of our exploratory analysis to identify predictors of underestimation of stroke risk should be interpreted with some caution, given the limitations of our survey tool. Moreover, the study was likely underpowered to draw firm conclusions, particularly as this was not one of the primary objectives of our study.

In conclusion, this study suggests that patients at higher than average risk of perioperative stroke frequently fail to perceive this potential complication, and report a low level of anxiety on this matter. Amongst patients classified as medium- or high-risk of perioperative stroke, we identified several risk factors associated with underestimation of stroke risk, including lower level of education. Only a minority of patients had discussed perioperative stroke with a physician prior to their anesthesiology consultation, which highlights the need to ensure that adequate counselling has occurred. This study highlights the need to improve the informed consent process concerning perioperative stroke. Future studies should focus on potential strategies to address this issue, including education strategies for patients and healthcare providers about perioperative stroke after non-cardiac, non-neurologic surgery.

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Authors contributions All study authors helped design the study, interpret the data, and contributed to the final version of the manuscript. *Taren Roughead*, *Alana M. Flexman*, and *Jason Chui* collected the data and *Alana M. Flexman* analyzed the data.

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