The Canadian four-centre study of anaesthetic outcomes: II. Can outcomes be used to assess the quality of anaesthesia care?

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Since anaesthesia, unlike medical or surgical specialties, does not constitute treatment, this study sought to determine if methods used to assess medical or surgical outcomes (that is the determination of adverse outcome) are applicable to anaesthesia. Anaesthetists collected information on patient, surgical and anaesthetic factors while data on recovery room and postoperative events were evaluated by research nurses. Data on 27,184 inpatients were collected and the analysis of outcomes determined for the intraoperative, post-anaesthetic care unit and postoperative time periods. Logistic regression was used to control for differences in patient populations across the four hospitals. In addition, a random selection of 115 major events was classified by a panel of anaesthetists into anaesthesia, surgical and patient-disease contributions. Across the three time periods, large variations in minor outcomes were found across the four hospitals; these variations ranged from two- to five-fold after case-mix adjustment (age, physical status, sex, emergency versus elective and length of anaesthesia). The rates of major events and deaths were similar across three hospitals; one hospital had a lower mortality rate ($P < 0.001$) but had a higher rate of all major events ($P < 0.0001$). Of major events assessed by physician panels, 18.3% had some anaesthetic involvement and no deaths were attributable partially or wholly to anaesthesia. Possible reasons to account for these variations in outcome include compliance in recording events, inadequate case-mix adjustment, differences in interpretation of the variables (despite guidelines) and institutional differences in monitoring, charting and observation protocols. The authors conclude that measuring quality of care in anaesthesia by comparing major outcomes is unsatisfactory since the contribution of anaesthesia to perioperative outcomes is uncertain and that variations may be explained by institutional differences which are beyond the control of the anaesthetist. It is suggested that minor adverse events, particularly those of concern to the patient, should be the next focus for quality improvement in anaesthesia.

Puisque l'anesthésie, contrairement aux spécialités médicales ou chirurgicales, ne constitue pas un traitement, cette étude a cherché à déterminer si les méthodes utilisées pour évaluer les issues des actes médicaux ou chirurgicaux (soit la détermination d'une issue défavorable) sont applicables en anesthésie. Les anesthésistes ont colligés l'information concernant les facteurs reliés aux patients, à la chirurgie et à l'anesthésie, alors que les données concernant la salle de réveil et les événements post-opératoires étaient évaluées par des infirmières de recherche. Des données concernant 27,184 patients hospitalisés ont été colligées et l'analyse des issues déterminée

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pour les périodes intra-opératoire, de salle de réveil et post-opératoire. Une régression logistique a été utilisée pour contrôler les différences entre les populations de patients des quatre hôpitaux. De plus, une sélection au hasard de 115 événements majeurs a été classifiée par un groupe d'anesthésistes selon la contribution de l'anesthésie, de la chirurgie et de la maladie du patient. Pour les trois périodes considérées, de grandes variations dans les issues défavorables d'importance mineure ont été trouvées entre les quatre hôpitaux; ces variations s'étendaient de deux à cinq fois après ajustement pour la variété des cas (âge, condition physique, sexe, cas d'urgence versus cas électif, et durée de l'anesthésie). Les taux d'événements défavorables majeurs et de mortalité étaient similaires pour trois hôpitaux; un hôpital avait un taux de mortalité plus faible (P = 0,0004) mais avait un taux plus élevé pour tous les événements majeurs (P < 0,0001). Parmi les événements majeurs évalués par les groupes de médecins, 18,3% avaient un certain lien avec l'anesthésie et aucune mortalité n'était attribuable en partie ou en totalité à l'anesthésie. Les raisons pouvant expliquer ces variations dans l'issue des soins anesthésiques incluent la compliance à enregistrer les événements, un ajustement inadéquat pour la variété des cas, des différences dans l'inteprétation des variables (malgré les directives) et des différences institutionnelles dans les techniques de surveillance et les protocoles d'observation et d'inscription au dossier. Les auteurs concluent que mesurer la qualité des soins en anesthésie en comparant les issues défavorables majeures est non satisfaisant puisque la contribution de l'anesthésie à ces issues péri-opératoires est incertaine et que les variations peuvent être expliquées par des différences institutionnelles sur lesquelles l'anesthésiste n'a pas de contrôle. Il est suggéré que les événements défavorables mineurs, particulièrement ceux qui intéressent le patient, devraient être le prochain point d'intérêt pour améliorer la qualité en anesthésie.

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Currently there is widespread interest in assessing the quality of patient care with a particular emphasis on outcome of care. One measure of quality has been to compare mortality rates across hospitals with adjustments for differences in patient case-mix.[1-4] Studies of surgical patients and factors predicting mortality have not included anaesthesia as a potential factor in operative deaths. Anaesthesia, unlike other medical or surgical specialties, does not usually constitute treatment and is inextricably linked to the surgical procedure. The question therefore arises: can methods used to assess medical and surgical treatments (that is, the focus on adverse outcome) be applicable to anaesthetic care?

There have been few studies examining the quality of care in anaesthesia, especially with regard to outcome. As well, the question of interhospital comparisons of anaesthetic care has not been directly addressed. Therefore we performed a study of anaesthetic-related outcome in four Canadian teaching hospitals. Both outpatient and inpatient surgical procedures were included; due to marked differences in patient populations and case-mix for day surgery, only results for inpatients are presented here.

Based upon earlier work,[5] corrections for differences in patient and surgical case-mix measures were made to facilitate comparisons across the four hospitals for important outcomes during three time periods: in the operating room, during the immediate postoperative recovery phase, and within 72 hr of the surgical procedure.

Methods

At four teaching hospitals in Canada from December 1987 to March 1989, data on patient populations, surgical procedures and anaesthetic techniques were collected for 37,665 anaesthetics, full details of which have been presented elsewhere.[6] Of these, 27,184 anaesthetics were administered to inpatients. Inpatients are defined as any patient experiencing at least a one-day postoperative stay in the hospital (with or without a preoperative overnight stay); patients who died on the same day as surgery were classified as inpatients or outpatients according to the procedure and hospitalization scheduled for that patient. Anaesthetists recorded patient, surgical and anaesthetic characteristics and checked off intraoperative adverse events from a list on a specialized anaesthesia record. The record accompanied the patient into the Postanaesthesia Care Unit (PACU) where the nursing staff recorded selected adverse events experienced by the patient. The records and hospital charts of inpatients were reviewed by trained anaesthesia research nurses who coded outcomes from a predefined list of major and minor adverse events associated with surgery and anaesthesia which had been determined from consultation with practicing anaesthetists.

TABLE I "Case-mix" characteristics for inpatients by hospital

	Hospital							
	A *n = 9,213*		*B* *n = 6,610*		*C* *n = 6,133*		*D* *n = 5,229*	
	n	%	*n*	%	*n*	%	*n*	%
*Age**								
<50 yr	4,332	47.0	2,496	37.8	3,043	49.7	2,444	46.8
≥50 yr	4,881	53.1	4,114	62.2	3,090	50.3	2,785	53.2
Sex								
Females	4,720	51.2	3,353	50.7	2,837	46.3	2,371	45.3
Males	4,493	48.8	3,257	49.3	3,295	53.7	2,858	54.7
Physical status†								
1 and 2	6,671	72.0	4,079	61.8	4,361	71.4	3,238	61.9
3–5	2,582	28.0	2,531	38.2	1,738	28.6	1,991	38.1
Anaesthesia time (min)								
<210 min	7,802	84.7	5,408	81.8	5,343	87.1	4,071	77.9
≥210 min	1,411	15.3	1,202	18.2	790	12.9	1,158	22.2
Emergency	1,669	18.1	909	13.7	1,138	18.6	580	11.1
Chart review								
Completed	8,828	95.8	5,432	82.7	6,119	99.8	5,168	98.8
Within 24 hr	4,198	47.8	1,640	30.2	2,618	43.1	2,575	50.2
Within 25–36 hr	2,904	33.1	1,779	32.8	2,436	40.1	2,047	39.9
>36 hr	1,676	19.1	2,005	37.0	1,023	17.0	506	9.9

*Age was missing for 10 cases from Hospital D.
†Physical status was missing for 31 cases from Hospital C.

Research staff were instructed to code an event that occurred without assigning causation; for example, sore throats appearing in patients with naso-gastric tubes in place.

For the purposes of analysis, timing of adverse events was divided into three periods: intraoperatively, in the PACU, or postoperatively (within 72 hr of operation). Some patients bypassed the PACU and were sent directly to an Intensive Care facility; the results for these patients are considered separately. The reporting of adverse events during the postoperative period is based only upon those cases where the hospital chart was available for review.

The crude rate or occurrence per 1000 anaesthetics was computed for each adverse event by hospital. It is possible that differences in rates of adverse events may be due to differences in the patient populations treated at the four hospitals. To control for differences in patient populations, we used a number of "case-mix" variables. The choice of case-mix variables was based upon earlier work[5] used to predict mortality after surgery. These variables include age (<50 yr, ≥50 yr), sex, physical status scores (1 or 2 versus 3 or more), emergency case (yes or no), and anaesthesia time (<210 min, ≥210 min). Length of anaesthesia was used as a proxy for the complexity of surgery.[5] These variables were entered into a multiple logistic regression[7] and the adjusted relative odds for having a complication was calculated for each adverse event by hospital. For this analysis, Hospital A was used as the reference hospital and the risk of having an adverse event *as compared to Hospital A* was computed after controlling for differences across the four hospitals in patient age, sex, physical status score, emergency status and length of operation. If an adverse event was rare (fewer than 20 events per hospital), then that hospital was not included in the case-mix adjustment as the number of events would be too low for statistical analysis. A P value of 0.05 was used to determine statistically significant differences in the relative odds as compared to Hospital A.

From the list of perioperative adverse events, a random selection of 30 cases in each hospital was drawn for intensive case review by an audit committee consisting of three anaesthetists at that hospital. These cases included major adverse events defined before the start of the study: death, cardiac arrest, perioperative myocardial infarction or stroke, perioperative neurological events, malignant hyperthermia, aspiration or awareness. The cases were as-

TABLE II Crude and adjusted rates for adverse events in the operating room

	Rate per 1000 anaesthetics				*Relative odds† Compared with Hospital A*			
	Hospital				*Hospital*			
Event	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*D*
Hypotension	92.0	125.4	60.8	58.5	1.00	1.18*	0.67*	0.56*
Hypertension	17.1	41.6	22.7	40.0	1.00	2.18*	1.41*	2.33*
Cardiac arrest	1.6	2.6	1.3	0.4	–	–	–	–
Ventricular arrhythmia	7.7	11.6	10.3	4.6	1.00	1.28	1.42	0.55*
Supraventricular arrhythmia	19.2	32.8	12.6	4.4	1.00	1.49	0.69	0.21*
Heart block	3.4	8.2	2.6	8.8	1.00	2.01*	0.83	2.20*
Difficult intubation	7.3	12.1	7.3	7.5	1.00	1.65*	0.98	0.90
Upper respiratory/aspiration/ laryngospasm	3.0	2.4	5.9	4.8	1.00	0.80	1.90*	1.60
Bronchospasm	4.8	8.6	3.4	3.1	1.00	1.87*	0.70	0.59
Other lower respiratory	2.4	5.4	2.0	5.0	1.00	2.12*	0.85	1.91*
Failed technique	11.9	8.3	14.2	5.2	1.00	0.69*	1.15	0.43*
Mechanical/equipment failure	2.0	2.9	1.6	4.0	1.00	1.33	0.91	1.82
Excessive blood loss/other surgical	7.1	13.8	3.4	5.4	1.00	1.75*	0.54*	0.66
Anaphylactoid/drug incident	1.1	2.3	1.0	2.7	1.00	1.95	0.92	2.26

*$P \leq 0.05$ compared with Hospital A.

†Relative odds were computed after adjusting for hospital, age, sex, physical status, emergency status and length of anaesthesia. Hospital A was the reference category. Values less than one mean that the rate of the event was less than that of Hospital A; values greater than one mean the event was higher than that of Hospital A.

– Number of events was too small to compute adjusted relative odds.

sessed according to the Edwards classification.[8,9] The final assessment of attribution was based on a consensus of the three anaesthetists in each hospital.

Results

Table I presents the "case-mix" characteristics across the four hospitals revealing important differences in the types of patients treated with regard to age, sex, physical status and length of the surgical procedure. The length of anaesthesia (highly correlated with actual surgical time) was highest in hospitals D and B respectively reflecting a higher proportion of major vascular cases. Follow-up of cases was excellent with three hospitals achieving 96% or more completed chart reviews. However, the timing of follow-up was not uniform across the four centres. Hospital D research nurses saw the majority of its patients much earlier than the other hospitals.

Table II presents the crude and adjusted rates of adverse events in the intraoperative time period by hospital. Due to low frequencies some events were combined for analysis. There was considerable variation in the rate of these adverse events even after case-mix adjustment, but no hospital had consistently the highest or lowest rates. For example, out of 13 event comparisons, Hospital D had the highest rate for four and the lowest rate for seven comparisons. The differences were different ($P \leq 0.05$) for most comparisons except for mechanical/equipment failures or anaphylactoid/drug incidents where the comparisons did not reach statistical significance. For cardiac arrests, the number of events was too small for calculating case-mix adjusted rates. The largest differences in rates was about two-fold except for supraventricular arrhythmia where the differences between institutions approached five-fold.

Table III presents the crude and adjusted rates of adverse events in the immediate postoperative period. The cases included are only those patients who went to the regular PACU (not the intensive care unit). The most frequently seen adverse event was nausea and vomiting with rates ranging from 72.2 to 142.7 per 1000 anaesthetics across the four hospitals. Other events occurred less frequently and varied considerably among the four hospitals. Differences across most events were statistically significant with the exception of respiratory related problems where rates were not different from Hospital A. Hospitals A and C had the highest rate of unscheduled admissions to the intensive care unit ($P < 0.05$). The magnitude of the variation in rates across the hospitals was generally higher than for intraoperative events ranging from 1.5- to five-fold.

Table IV shows the postoperative outcomes for patients who went directly to Intensive Care Units after their

TABLE III Crude and adjusted rates for adverse events in the PACU‡

	Rate per 1000 anaesthetics				*Relative odds† Compared with Hospital A*			
	Hospital				*Hospital*			
Event	*A (8,537)*	*B (5,718)*	*C (5,480)*	*D (4,586)*	*A*	*B*	*C*	*D*
Nausea and/or vomiting	72.2	110.4	99.3	142.7	1.00	1.68*	1.54*	2.23*
Hypothermia	33.4	17.3	40.9	0.9	1.00	0.48*	1.52*	–
Cardiac arrest	0.5	0	0	0.7	–	–	–	–
Other cardiac	14.2	3.3	7.5	34.6	1.00	0.20*	0.59*	2.69*
Hypotension	26.7	17.6	15.5	51.9	1.00	0.58*	0.64*	2.08*
Hypertension	24.4	8.7	8.6	78.9	1.00	0.32*	0.39*	3.33*
Respiratory	25.6	30.9	20.4	29.5	1.00	1.19	0.88	1.10
Neurological	3.3	0.5	0.9	7.8	1.00	–	–	2.08*
Renal/metabolic	9.7	3.1	0.9	14.6	1.00	0.29*	–	1.37
Burns, skin damage/ musculoskeletal	0.7	1.4	1.8	3.9	1.00	2.13	2.80*	4.47*
Psychological	4.8	3.1	1.3	7.0	1.00	0.60	0.27*	1.45
Transfer to intensive care	7.7	4.9	10.0	3.5	1.00	0.68	1.62*	0.42*

*$P \leq 0.05$ compared with Hospital A.

†Relative odds were computed after adjusting for hospital, age, sex, physical status, emergency status and length of anaesthesia. Hospital A was the reference category. Values less than one mean that the rate of the event was less than that of Hospital A; values greater than one mean the event was higher than that of Hospital A.

‡Only patients in regular PACU. Intensive Care patients excluded.

– Number of events was too small to compute adjusted relative odds.

operation, bypassing the regular PACU. The percentage of inpatients thus managed was 7.7% for Hospital A, 13.9% for Hospital B, 10.7% for Hospital C and 12.5% for Hospital D. The relatively small number of cases was insufficient to allow for case-mix adjustment of some of the adverse events, most notably postoperative myocardial infarction and pulmonary embolism. While the frequencies of cardiovascular, respiratory and metabolic events were not unexpected, it is noteworthy that there was also considerable problem with nausea and vomiting and sore throats even among these more severely ill patients. Again, while there was a considerable variation in rates between the hospitals (even after adjustment for case-mix), no single hospital had consistently higher or lower rates, and variations up to five-fold were found.

Table V presents the results of reviews of cases who received care on the ward (as opposed to a intensive care facility). In this group of patients, the rate of "minor" events was very high, especially nausea/vomiting, headache and sore throat. Cardiovascular related events such as hypotension, hypertension and arrhythmias were also frequent. On the other hand, few patients demonstrated postoperative myocardial infarction or strokes at the four hospitals. While there was variation between hospitals with regard to rates of excessive bleeding, there was no significant variation in the rate of having patients return to the operating room.

The results of the physician panel reviews of the sample of actual major adverse outcomes are seen in Table VI. Of the 120 records selected there were 121 events (one patient having two events), two reviews were not completed and four events could not be confirmed when the hospital charts were examined (two cases of awareness and two cases of neurological deficit). This left 115 events in 114 patients in the review. Of these cases, 15 (13.0%) were judged to have varying degrees of anaesthesia-related contribution. Of 43 deaths reviewed, none were judged to be related to the anaesthetic component of the patient's care. Preexisting patient disease was the most frequently ascribed factor relating to the major event; eight cases (7.0%) were judged as having insufficient information for the panel to judge attribution. When the first three classifications are considered together (i.e., I–III), 21 events (18.3%) were classified as to having varying degrees of anaesthetic involvement.

Table VII summarizes the rates of major events and in-hospital deaths occurring in the four hospitals. Major events included in this analysis which were chosen before the beginning of the study were cardiac arrest, aspiration, malignant hyperthermia, neurological deficit, myocardial infarction, stroke and awareness. With regard to mortality rates, three of the hospitals showed similar rates with hospital D having less than half the rate of deaths ($P < 0.0004$). However, when major events are considered,

TABLE IV Crude and adjusted rates for postoperative events as determined by chart review for patients in intensive care

	Rate per 1000 anaesthetics				*Relative odds† Compared with Hospital A*			
	Hospital				*Hospital*			
Event	*A (705)*	*B (918)*	*C (654)*	*D (653)*	*A*	*B*	*C*	*D*
Nausea and/or vomiting	75.2	142.7	253.8	140.9	1.00	2.08*	4.08*	2.03*
Headache	9.9	7.6	7.6	4.6	–	–	–	–
Sore throat	8.5	13.1	21.4	1.5	1.00	1.51	2.47	–
Back pain	10.1	5.5	4.6	0	–	–	–	–
Paraesthesia/motor deficit/stroke	17.0	31.6	12.2	19.9	1.00	1.81	0.78	1.36
Decreased level of consciousness	58.2	43.6	‡	27.6	1.00	0.87	–	0.58
Myocardial infarction	10.1	6.6	13.8	13.8	–	–	–	–
Angina/CHF	76.6	43.6	61.2	19.9	1.00	0.48*	0.99	0.27*
Arrhythmia	356.0	366.0	224.8	264.9	1.00	0.99	0.58*	0.65*
Hypotension	262.4	318.1	259.9	352.2	1.00	1.16	1.23	1.75*
Hypertension	185.8	200.4	108.6	284.8	1.00	0.93	0.58*	1.87*
Other cardiovascular	75.2	379.1	4.6	105.7	1.00	7.08*	–	1.55*
Atelectasis/pneumothorax	127.7	200.4	56.5	203.7	1.00	1.50*	0.44*	1.75*
Pulmonary embolism	4.3	1.1	4.6	7.7	–	–	–	–
Pneumonia/bronchospasm/other lower respiratory	227.0	356.2	56.6	219.0	1.00	1.84*	0.23*	0.96
Upper respiratory	18.7	15.4	3.1	16.9	–	–	–	–
Psychological	62.4	88.2	29.1	55.1	1.00	1.28	0.53*	0.98
Oliguria	120.6	108.9	99.4	39.8	1.00	0.88	1.01	0.38*
Hypovolaemia	136.2	104.6	59.6	442.6	1.00	0.67*	0.44*	5.81*
Metabolic	144.7	174.3	12.2	393.6	1.00	1.34	–	5.03*
Infection	8.6	13.2	3.1	59.8	–	–	–	–
Excessive bleeding	72.3	44.7	13.8	140.9	1.00	0.57*	0.22*	2.34*
Return to OR	59.6	33.8	22.9	64.3	1.00	0.64	0.42*	1.25

*$P \leq 0.05$ compared with Hospital A.

†Relative odds were computed after adjusting for hospital, age, sex, physical status, emergency status and length of anaesthesia. Hospital A was the reference category. Values less than one mean that the rate of the event was less than that of Hospital A; values greater than one mean the event was higher than that of Hospital A.

‡Not recorded.

– Number of events was too small to compute adjusted relative odds.

hospital D had significantly higher rates of major morbidity than the other two hospitals ($P < 0.0001$). When deaths and the major events listed above are combined, hospital D alone had higher rates than the other hospitals (adjusted relative odds of 1.25, $P = 0.09$).

As noted above, during the case review process several inconsistencies were found in the data. Two cases of malignant hyperthermia were masseter muscle spasm; two of the cases of awareness were not confirmed and, aside from the patients suffering from postoperative cerebrovascular events, there were no long-lasting neurological deficits. Therefore the data was reanalysed using the limited definition of major events to cardiac arrest, myocardial infarction, stroke and deaths. Again there was no difference in rates between hospitals A, B, or C, but now hospital D had a significantly lower rate of occurrence of adverse outcomes as compared to the reference hospital (adjusted relative odds of 0.67, $P = 0.02$).

Discussion

There have been a number of mortality studies reported recently in the anaesthesia literature.[8,11] These, however, typically lack denominator information (that is, no information about the true number of surgical operations), resulting in rates being expressed from an estimation of the number of anaesthetics. Authors have attempted different methodologies to separate the role of anaesthetic services from surgical contributions, with no widespread consensus obtained. The larger studies were either from one institution[12,13] or, if from a broader region, did not consider institutional differences nor add a case-mix adjustment.[11,14] Finally, many studies have been conducted over such a prolonged period of time[8,13] that results may be challenged as not representative of modern anaesthesia and surgical practice. However, despite all the problems with studies of mortality in anaesthesia, one factor emerges: mortality rates attributable to anaesthesia are too low to be used to

TABLE V Crude and adjusted rates for postoperative events as determined by chart reviews for patients not in intensive care

	Rate per 1000 anaesthetics				*Relative odds† Compared with Hospital A*			
	Hospital				*Hospital*			
Event	*A (8,508)*	*B (5,692)*	*C (5,479)*	*D (4,576)*	*A*	*B*	*C*	*D*
Nausea and/or vomiting	210.8	162.7	199.1	113.9	1.00	0.74*	0.99	0.46*
Headache	15.3	21.8	23.7	6.3	1.00	1.43*	1.57*	0.40*
Sore throat	8.9	9.1	13.5	7.2	1.00	1.05	1.58*	0.76
Dental	0.2	0.2	5.5	1.1	–	–	–	–
Back pain	5.4	9.9	3.7	0.4	–	–	–	–
Paraesthesia‡	1.0	1.8	0.5	3.3	–	–	–	–
Motor deficit	0.2	1.3	0.2	2.4	–	–	–	–
Stroke	0.4	0.4	0.4	1.3	–	–	–	–
Decreased level of consciousness	14.0	4.7	1.8	5.2	1.00	0.32*	0.14*	0.37*
Myocardial infarction	0.1	0.4	0.2	1.8	–	–	–	–
Angina/CHF	2.1	1.8	1.8	2.6	1.00	0.68	0.94	1.25
Arrhythmia	8.0	7.2	3.5	7.9	1.00	0.85	0.48*	1.00
Hypotension	15.6	10.7	7.5	38.9	1.00	0.65	0.51*	2.45*
Hypertension	9.9	8.8	2.4	37.2	1.00	0.85	0.27*	3.53*
Other cardiovascular	3.9	5.8	0.4	5.5	1.00	1.61	–	1.51
Atelectasis/pneumothorax	5.9	11.6	2.2	3.7	1.00	2.01*	0.41*	0.57
Pulmonary embolism	0.1	0.2	0	0.2	–	–	–	–
Pneumonia/bronchospasm/other lower respiratory	16.5	18.3	4.2	18.4	1.00	1.10	0.27*	1.04
Upper respiratory	1.2	1.8	0.4	2.0	–	–	–	–
Psychological	8.9	18.8	8.9	22.7	1.00	1.83*	1.05	2.76*
Oliguria	6.6	2.6	3.7	5.2	1.00	0.36*	0.62	0.80
Hypovolaemia	14.3	14.4	4.6	27.1	1.00	0.99	0.35*	2.61*
Metabolic	2.8	3.7	0.2	21.9	1.00	1.25	–	7.74*
Infection	0.7	3.5	0.2	21.3	–	–	–	–
Excessive bleeding	4.3	11.2	3.7	11.6	1.00	2.58*	0.89	2.43*
Return to OR	4.0	4.0	5.1	5.0	1.00	1.14	1.38	1.15

*$P \leq 0.05$ compared with Hospital A.

†Relative odds were computed after adjusting for hospital, age, sex, physical status, emergency status and length of anaesthesia. Hospital A was the reference category. Values less than one mean that the rate of the event was less than that of Hospital A; values greater than one mean the event was higher than that of Hospital A.

‡Number of cases was too small to compute adjusted odds ratio even with combination of paraesthesia, motor deficit and stroke.

– Number of events was too small to compute adjusted relative odds.

compare hospitals, and therefore cannot reflect quality of care.

Morbidity studies are therefore recommended and indeed mandated by accreditation authorities.[15] There have been a number of small studies from single institutions[16–18] and one recent large multicentre study of morbidity from general anaesthesia across 15 hospitals.[19,20] The largest study of major morbidity from anaesthesia included over 198,000 anaesthetics from over 400 hospitals in France.[14] Despite the benefit from the study results and its recommendations (for example, the establishment of PACU's in French hospitals),[21] the study offered no institutional comparisons of outcomes nor case-mix adjustment.

We found large variations in rates of adverse outcomes for minor adverse events in four Canadian teaching hospital departments, but relatively homogenous rates for major outcomes. The possible reasons to account for the differences in minor outcomes include varying degrees of reporting compliance among staff, inadequate case-mix adjustment, difference in interpretation of variables, institutional differences, physician practice patterns, or true variations.

It is possible that the variations seen here were due to varying degrees of compliance among staff anaesthetists and research nurses. While there was some suggestion that anaesthetists in one hospital were less willing to record patient demographic factors and intraoperative events, this could not explain the variations seen for PACU and postoperative events (items collected by the hospital and research nursing staff) in that hospital. It is also unlikely

TABLE VI Results of case review of major events (n = 115)

Event	*I–II Anaesthesia**	*III–IV Surgery*	*V–VI Patient disease*	*VII–VIII Cannot decide*	*Total*
OR arrest	1	5	4		10
Motor deficit/paraesthesia	2	12	6	3	23
Postoperative stroke		4	9		13
Postoperative MI	2	1	5		8
Malignant hyperthermia			2		2
OR/PACU neurological			4		4
Regurgitation/aspiration	7			2	9
Awareness	3				3
Death		4	36	3	43
Total	15(13.0)	26(22.6)	66(57.3)	8(7.0)	115

*Total of I, II, III = 21 events (18.3%).

TABLE VII Crude and adjusted rates for deaths and major perioperative events among in-patients

	Rate per 1000 anaesthetics				*Relative odds† Compared with Hospital A*			
	Hospital				*Hospital*			
Event	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*D*
Deaths	10.0	8.8	9.3	4.2	1.00	0.77	0.96	0.42[a]
Major events‡	5.4	9.1	6.2	16.1	1.00	1.45[b]	1.20	2.53[c]
Major events/deaths	15.4	17.9	15.5	20.3	1.00	1.06	1.06	1.25[d]
Cardiac arrest/M.I./stroke/ deaths§	13.2	12.9	12.6	9.4	1.00	0.79	1.01	0.67[e]

*$P \leq 0.05$.

†Relative odds were computed after adjusting for hospital, age, sex, physical status, emergency status and length of anaesthesia. Hospital A was the reference category. Values less than one mean that the rate of the event was less than that of Hospital A; values greater than one mean the event was higher than that of Hospital A.

‡Includes cardiac arrest, aspiration, malignant hyperthermia, neurological event, myocardial infarction, stroke, awareness and death. Note that the denominator is # of anaesthetics, not # of patients and that the numerator is # event/deaths, not # of patients.

§Major events plus deaths as refined by peer review of cases – see text for details.

[a]$P = 0.0004$; [b]$P = 0.0537$; [c]$P < 0.0001$; [d]$P = 0.0920$; [e]$P = 0.0210$.

that research nurses in one institution were less diligent in recording than the other nurses given their parallel training. Thus it is unlikely that lack of compliance could explain all the variations in the results although some effect cannot be excluded. For example even a relatively easily defined endpoint, death, could be influenced by variation in the timing of the postoperative review. It is possible that patients at hospital D were seen too early and died subsequent to the review (Table I).

Our ability to "remove" differences in patient populations between the hospitals by case-mix adjustment may not be adequate. We used a combination of age, sex, physical status score, length of operation (as a proxy for surgical severity), and emergency status; these variables had been identified earlier as factors of significance to anaesthetic outcomes.[22–24] Further refinements in case-mix description will be necessary before more precise comparisons of outcome of anaesthetic care are possible. Nonetheless, it is unlikely that the five-fold magnitude of the differences seen here can be explained by lack of adjustment for yet to be defined variables.

It can be argued that variations in interpretation of the variables being collected can occur despite guidelines and definitions. This may account for the marked variations in the rate of outcomes such as hypovolaemia, infection rates or metabolic disturbances. It is equally possible that these differences are not due to misinterpretation of particular definitions but were due to differences in monitoring, charting and protocols for postoperative care between institutions. For example, one hospital reported essentially no cases of hypothermia. It was later found that temperatures were not routinely taken in their PACU (that hospital also had the highest rate of skin damage/burns). Other institutional differences may include the size and criteria

for use of the PACU and Intensive Care facilities, thus biasing the rates by influencing patient illness severity, nursing/patient ratios, patient monitoring, observation and charting, and the relative importance placed on transgression of patient comfort as opposed to technical determination of disturbed patient physiology. These may account for some of the larger variations seen. It is ironic, however, that if a hospital has a vigilant monitoring and charting system, it may be seen to have more "adverse" events. It is clear that the rate of events increases in proportion to the diligence of their search. However, given the general uniformity seen in Canada's health care system, it is unlikely that detection bias between hospitals would be as vast as between other jurisdictions.

We found little variation with regard to major outcomes, including postoperative deaths, although one hospital had a lower case-mix adjusted mortality rate. In addition, there appears to be little attribution of major events to what anaesthetists do. Results from other recent studies have also found that major adverse outcomes after anaesthesia may not reflect the anaesthetic administered (as opposed to the role of the patient's disease and surgical factors) in the genesis of major adverse postoperative events.[5,23,24] Thus the use of mortality rates or major events cannot be easily used as a measure of quality of care in anaesthesia for two reasons. First, the occurrence of such events is very rare, necessitating extremely large sample sizes; our study of over 25,000 was not large enough to detect differences in such events. Second, each event must be scrutinized by case review to determine the relative proportion of attribution due to anaesthesia. This also leads to expensive, time-consuming studies which would not be readily applicable in most institutions for routine use.

The similarity of rates of occurrence of major adverse outcomes found in this study and the cited references suggest that outcome analysis alone (particularly regarding major adverse events) will not suffice to differentiate one hospital or practice from another with respect to quality. Indeed, we are all aware of poorly administered anaesthetics that do not have adverse outcomes and others where exemplary care is associated with a poor result. Because of their extremely low incidence, these rare events cannot be used to assess the performance of an individual physician or department of anaesthesia where sound practice patterns result in safe care provided to the vast majority of patients.

It appears that extensive variations do exist between patients and hospitals with regard to "minor" outcomes of care. However, here again alternative explanations such as patient case-mix, compliance with reporting and most importantly, institutional protocols could explain most of the differences. Considering this, does it therefore follow that because these outcomes are different that the quality of anaesthetic care is also different? Such reasoning is the basis of programmes of quality improvement emphasizing outcome surveillance, but as we have shown, cannot be supported unless the patient case-mix, institutional variables and other factors yet to be described are clearly defined.

The occurrence of some unexpected event may then represent some "accident" evolving from an unique set of circumstances,[25] or a problem with the clinical science of anaesthesia. Quality must be defined by the efficient, effective and personalized delivery of anaesthetic care to the larger number of patients who do not suffer an adverse outcome. The failure of rates of adverse events to reflect the "quality" of a given anaesthesia unit then relates to this chosen definition. Seldom in daily living is the "quality" of an experience defined as a negative event (lack of a given adverse outcome), for to do so focuses excessively upon rare events of complex aetiologies. Such "outliers" do not reflect the care provided to the majority and overemphasis upon their frequency may detract from initiatives that elevate the overall standard of care.[26] Indeed, if the rate of a given adverse outcome is endorsed as a measure of quality, efforts to minimize its occurrence may detract from the prevention of other outcomes. Our results would suggest that, while differences in outcome occurred in the four different institutions, each of the four could be considered "of greatest quality" or the worst, depending upon which of the indicators is chosen.

How then can quality be assessed in anaesthetic care? Fundamentally, it must be related to the consumer, for only she or he can define the goals expected of our service. The few studies conducted have suggested that, apart from intact survival, patients are most concerned that the anaesthetist remain with the patient, and minimal discomfort be experienced postoperatively.[27] The "adverse outcomes" or medical model evaluated in this study, often used for accreditation standards,[15] appears to miss completely these consumer needs. Whether patient expectations reflect only the public's perception of the speciality of anaesthesia[28] or true attainment of quality, remains to be evaluated. However, it is doubtful that comparisons such as critically evaluated in this research will by themselves allow anaesthetists to conclude that "quality" has truly been achieved in their medical practice.

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