The Canadian four-centre study of anaesthetic outcomes: I. Description of methods and populations

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The objectives of this study were first to develop and institute a methodology for the study of anaesthetic outcome for parallel use in four teaching hospitals in Canada and second, to compare rates of morbidity and mortality associated with anaesthesia between the four centres. The basic design of the study was occurrence screening with anaesthetists entering data on patient demographics, anaesthetic and surgical factors. Research nurses reviewed anaesthetic records and hospital charts and interviewed patients postoperatively. Data on 37,665 anaesthetics were collected during 1988–89 in the four teaching centres. There were major differences found across the hospitals, particularly with regard to volume, patient case-mix, anaesthetic drugs and monitoring used. The use of parallel training, repeated consultations and use of rounds and inservices contributed to the reliability and validity of the data collection. We

conclude that outcome surveillance can be instituted in different hospital Departments of Anaesthesia with sufficient confidence to form the basis of comparison of anaesthetic outcome.

Key words

ANAESTHESIA: epidemiology, morbidity, outcome;
COMPLICATIONS: morbidity;
EPIDEMIOLOGY: anaesthesia.

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Cette étude avait premièrement pour objectif de développer et d'instituer une méthodologie pour étudier l'issue des soins anesthésiques et cela pour une utilisation parallèle dans quatre hôpitaux d'enseignement au Canada. Deuxièmement, elle avait pour objectif de comparer entre ces quatre centres les taux de morbidité et de mortalité associés à l'anesthésie. Les anesthésistes devant consigner les données démographiques des patients et les facteurs anesthésiques et chirurgicaux, la conception de base de l'étude reposait sur un dépistage systématique des événements défavorables. Des infirmières de recherche révisaient les dossiers anesthésiques et hospitaliers, et interviewaient les patients en post-opératoire. Des données sur 37,665 anesthésies ont été colligées en 1988–89 dans les quatre centres d'enseignement. Il y avait des différences importantes entre les hôpitaux, particulièrement en ce qui concerne l'achalandage, la variété des cas, les agents anesthésiques et l'équipement de surveillance utilisé. L'utilisation d'une formation parallèle, de consultations répétées, de tournées et de présentations au personnel ont contribué à la fiabilité et à la validité de la collecte des données. En conclusion, la surveillance de l'issue des soins peut être instituée dans divers départements hospitaliers d'anesthésie avec suffisamment de confiance pour constituer la base de comparaison de l'issue des soins anesthésiques.

The maintenance of quality in medical practice requires that those providing care define an acceptable standard of care, and take steps to meet that standard. Unfortunately, the recognition of "quality" is not always easy in practice, particularly in a specialty such as anaesthesia which lacks "diseases" or "cures," and facilitates treatments of patients rather than providing primary therapeutic benefit. To overcome such a problem the specialty has chosen to

utilize "indicators" of quality care, usually the presence or absence of adverse outcomes, as reflections of the care provided. If these measures are to be at all useful in comparisons between individuals or departments they must be shown to be both reliable (reproducible) and valid reflections of the care provided.

The objectives of the study were first to develop a methodology for the study of anaesthetic outcomes which could be used for institutional comparisons of rates of morbidity and mortality associated with anaesthesia. This report describes the implementation of parallel occurrence surveillance programmes in anaesthesia in four tertiary care hospitals across Canada, with consideration to the problems inherent in such programmes used as a basis for quality improvement activities. The results of the outcome analyses will be presented in subsequent manuscripts.

Methods

The basic design of the study was "occurrence screening," that is, all patients receiving an anaesthetic at any of the four hospitals were followed and included in the study.¹ This is in contrast to other study designs which involve sampling of patients or sampling of adverse events. In this study design, adverse events are determined in a prospective manner and since all patients are included, the advantage of the study design is that important events are much less likely to be missed.

For each patient undergoing a surgical procedure, anaesthetists completed a check-off form which included a series of patient-related, surgical-related and anaesthesia-related variables. Anaesthetists used the check-off form in addition to, or as a replacement for, the usual anaesthetic record. In three of the hospitals, this record simultaneously completed the anaesthetists' billing form, thus ensuring high compliance.

The first phase of the study was to develop a new

anaesthesia record to serve as the data collection instrument.* Aside from meeting the needs of the individual hospitals, the billing function, the data collection instrument, and the hospital chart, the form had to be relatively short and allow enough space for hand-written documentation. Several meetings were held to determine which items would be included and to develop guidelines for the inclusion of independent and outcome variables. It was decided that a fair degree of individual latitude would be allowed in the checking of a particular variable on the form, leaving the decision as to whether an adverse outcome had occurred to the judgement of the clinician at each institution. The decision not to use strict definitions for the variables was a pragmatic one. Since we were relying on compliance by all staff anaesthetists, not just volunteers, we could not ensure that the definition of the outcome variables would be strictly adhered to by all staff. As well, we were interested in testing variables which would reflect day-to-day decisions by practising clinicians. Rounds and inservices were held to acquaint the anaesthesia staff with the new form and the interpretation of the variables. In general, an outcome was to be included if it required action on the part of the anaesthetist (see Appendix I). After development of a prototype new form, it was piloted for six months at one hospital before adoption at the other sites.

For the recording of patient-related variables, anaesthetists were asked to rate preoperative medical conditions on a one to three scale. In general, this corresponded to a disease only diagnosed (1), a disease treated optimally (2), or a serious disease out of control (3). In addition, information on preoperative factors which may have affected the administration of that anaesthetic such as history of anaesthesia problems (personal or family), trauma, shock, full stomach or anatomical deformity. Anaesthetists also rated each patient preoperatively by using the American Society of Anesthesiologists' physical status scores.² As well, demographic characteristics of the patients including age and sex were collected. With regard to the surgical procedure, up to two procedures were recorded by converting the written operative procedure into the corresponding International Classification of Diseases procedure (ninth revision) code.³ The factors recorded relating to anaesthesia included monitors, primary technique employed and drugs utilized. While the initial data on patients and intraoperative events were entered by the physician-anaesthetist, all forms were reviewed by an anaesthesia research nurse for completeness and, when appropriate, the nurse would add items which the anaesthetist had failed to document. For example, the nurse would review the recording of blood pressure and note if there were

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*Available from the principal investigator, upon request.

marked increases or decreases not recorded by the anaesthetist.

Following the operative procedure, the form accompanied the patient into the PACU or Intensive Care Unit. Any adverse events in the postsurgical period were recorded by the PACU nursing staff who had received inservicing to familiarize them with the study. Again, the research nurse reviewed all PACU records to ensure that data collection was as complete and accurate as possible.

Within 72 hr of the surgical procedure for in-patients, the research nurse visited the patient and, using a standardized instrument,^{4,5} interviewed the patient about non-life-threatening problems and satisfaction with the anaesthetic experience. While the events surveyed were more in the nature of discomfort than the traditional adverse medical outcome, they may have a marked influence on the person's assessment of the anaesthetic. The interview questionnaire was developed by having two sets of two nurses interview the same patients ($n = 75$ patients). The results between the two interviewers on two separate occasions were then compared, namely between nurses A and B and B and C. In both exercises, the inter-nurse agreement was over 95%.

Also within 72 hr of the surgical procedure, the nurse reviewed all inpatient charts and recorded any post-operative adverse events. In addition, she checked hospital separation data to determine deaths occurring among study subjects. The completed forms were then returned to the attending anaesthetist for examination prior to data processing.

For outpatients, follow-up of all patients was not possible. In two hospitals, outpatients were phoned at home the day after the procedure. All outpatients were potentially included in the phone follow-up but persons undergoing a procedure of a sensitive nature were excluded. While every attempt was made to review outpatients' hospital charts, this proved difficult; only one hospital was able to review all outpatient charts completely.

To ensure reproducible data among institutions, nurses hired at each of the hospitals were trained by the project director at the coordinating centre. As well, the project director visited each of the other hospitals to help institute the study protocols. Thereafter, the four hospitals were in biweekly contact by telephone. In order to ensure complete coverage of all patients, two nurses were hired at each hospital, thereby providing coverage even for Saturdays and holidays. Data were sent on diskette to the coordinating centre each month and a data quality check was performed. Corrections were then made by each of the hospitals including the verification of the major adverse events recorded. In addition, further data quality checks and the addition of missing data were made at the end of

TABLE 1 Characteristics of the hospitals and proportion of cases captured

	<i>Hospital</i>			
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
# Months	13	12	12	10
# Cases per month	1100	700	625	725
% Day surgery	35.8	22.1	18.6	28.2
% 2+ Postoperative nights	54.1	55.8	73.6	68.2
% All patients interviewed	45.6	30.7	71.9	44.3
% Inpatients interviewed	62.4	39.3	73.0	61.5
% Interviewed within 72 hours	97.0	96.0	97.0	96.0
% All charts reviewed	67.4	64.6	99.6	71.4
% Inpatient charts reviewed	95.8	82.7	99.8	98.8
# Research nurse equivalents	1.9	0.9	1.7	1.2

the data collection period. For two hospitals, death data from the provincial Vital Statistics were available; this enabled the completeness of the death ascertainment to be compared with an independent data base. To allow for problems with training of staff (both medical and nursing), the first two months of data for each hospital were not used.

One of the main concerns with regard to morbidity and mortality studies of anaesthetic outcomes is the determination of the relative contribution of anaesthesia as opposed to surgical, patient or other variables.^{6,7} In order to do this, audit committees were formed at each hospital to review a random sample of cases where a major event had been identified. Before the review, three hospitals (nine anaesthetists) carried out a preliminary exercise where ten fictional cases were assessed according to the Edwards classification used by the New South Wales Committee on Anaesthesia Mortality^{7,8} (Appendix II). This classification has eight possibilities, but for purposes of analysis, four categories were used as follows: I-II anaesthesia, III-IV surgery, V-VI patient disease, VII-VIII cannot decide. Reliability of interobserver agreement was determined by the Kappa statistic;⁹ the Kappa statistic having a value between 0 and 1 is interpreted in a manner similar to a correlation coefficient. An increasing value suggests better agreement between the raters.

Results

Each of the four hospitals was a tertiary care teaching hospital with accredited training programmes in anaesthesia. For the final results, there were 13 months data for hospital A, 12 months data for hospitals B and C and ten months data for hospital D for a total of 37,665 anaesthetics. This represented essentially all adult subjects receiving anaesthetics for non-obstetrical procedures in the study period (1988-89).

Table I gives some of the characteristics of the four hospitals which varied widely in several aspects. The volume of anaesthetics administered per month was greatest for hospital A both in terms of outpatient and inpatient surgical procedures. There was also a greater proportion of outpatient procedures in hospital A. Among cases, the length of stay varied with 73.6% of hospital C's patients staying two or more postoperative nights. The degree to which we were successful in capturing follow-up information is also shown in Table I. The proportion of cases interviewed ranged from 30.7% to 71.9%; for inpatients the range was higher (from 39.3% at hospital B to 73.0% at hospital C). For those patients who were interviewed the majority were seen within 72 hours of the operation. At least two-thirds of all charts (82.7% for inpatients) were reviewed by the research staff. Why some hospitals were more successful in capturing follow-up data is explained in part by the number of research nurse equivalents per hospital. Those instances where either the patient could not be interviewed, or the chart could not be reviewed, related either to patient unavailability (early discharge) or the nuances of obtaining the record that was in transit within the hospital. There was no systematic pattern identified as to which patients lacked complete outcome assessment.

Table II presents the characteristics of the patients. The patient "case-mix" varied considerably across the four hospitals. There was a higher proportion of younger, ASA physical status 1, female cases at hospital A than at the other hospitals. On the other hand, cases at hospital B tended to be older, and have higher physical status scores. The cases at hospitals C and D were somewhat younger and the female/male ratio was less than one. With regard to preexisting medical conditions, 44 to 64% of patients had more than one illness. Hospital B had more patients with respiratory, cardiovascular, gastrointestinal, renal and neurological conditions than did the other hospitals. When only the proportion of preoperative medical conditions judged as "serious" was compared, there was little variation across the four hospitals except that hospital B had a much higher proportion of serious cases with "other cardiovascular" conditions. Overall, about 9 to 16% of patients had at least one serious medical factor complicating anaesthesia.

Regarding the surgical procedure, there were 46,250 operative procedures performed during the 37,665 anaesthetics administered. Hospital C had the highest proportion of emergency cases and hospital D the highest proportion of elective cases (Table III). Hospitals B and D appeared to have the greatest frequency of lengthy cases whereas hospital A had more shorter procedures. The classification of surgical procedures into the major ICD categories also reflects the specialization of each hospital; hospital A had

the greatest number of gynaecological cases as well as an orthopaedic dominance; hospital B had the highest proportion of cardiac procedures; hospital C sees more abdominal and orthopaedic procedures; hospital D specializes in neurological and cardiac procedures, and sees a very low proportion of gynaecological operations.

Table IV lists the factors which were thought to have an important influence on the administration of anaesthesia as assessed by the attending anaesthetist. There were similarities across the four hospitals for the proportion of cases having a previous problem with anaesthesia, metabolic derangement and shock. There were wider variations with regard to the rate of trauma, anticipated difficult airway, and full stomach. The proportion of cases who were current smokers ranged from 19 to 30%. The primary anaesthetic technique also varied across the hospitals. Hospital A had the highest proportion of monitored anaesthesia care whereas hospitals C and D had the greatest use of the inhalational technique. Regional anaesthesia was used in only 7 to 13% of cases. It should be noted that provincial fee schedules differ for the payment of "monitored anaesthesia care" leading to classification of many sedated patients as "general anaesthesia" on the billing form. However, the actual anaesthetic technique used was checked off on the study record sheet.

Table IV also presents the variations in monitoring across the four hospitals. The most noteworthy features are that all patients received ECG and blood pressure monitoring. The notable differences are that nearly all patients in hospitals B and C had pulse oximetry, but only hospital C had capnography for nearly all the patients. The use of volatile gases was not consistent across the four hospitals (for example, hospital C had the greatest use of halothane but used minimal enflurane). The use of narcotic agents also varied with fentanyl being favoured by hospital A and D but sufentanil favoured by hospital B. Hospital C chose not to differentiate between specific drugs; the use of "any narcotic" was about the same across the four hospitals.

There was poor degree of interrater reliability for the rating of the ten hypothetical cases. Overall there was agreement ($\kappa = 0.38$, $P < 0.05$) but within the four rating categories, the kappa values were 0.42 for category one (anaesthesia), 0.51 for category two (surgery), 0.30 for category three (patient-related), and 0.07 (not statistically significant) for category four (cannot decide). Anaesthetists as raters did not appear to have hesitations ascribing the adverse outcome to anaesthesia (as judged by the low proportion of cases in category four) as opposed to surgical or patient factors.

Discussion

It is generally agreed that the "outcome" study combined with a process review is the "state of the art" with regard

TABLE II Characteristics of patients

	<i>Hospital</i>			
	<i>A</i> (<i>n</i> = 14354)	<i>B</i> (<i>n</i> = 8489)	<i>C</i> (<i>n</i> = 7539)	<i>D</i> (<i>n</i> = 7283)
% Age < 40 yr	50.0	36.0	44.0	45.6
% Age > 70 yr	16.3	24.6	18.8	14.2
% Female	63.8	56.7	49.4	49.9
% Physical status score 1	45.3	29.3	40.9	38.5
2	35.8	39.9	34.3	33.4
3	15.1	22.8	19.3	20.8
4	3.4	7.6	4.1	6.6
5	0.4	0.4	0.4	0.7
<i>Preoperative medical conditions (%)</i>				
Asthma	2.5	3.1	2.4	2.9
COPD	9.6	13.1	10.5	4.2
Other respiratory	9.6	11.7	6.0	5.0
MI < 6 mo	0.6	2.0	1.2	0.9
MI > 6 mo	3.8	6.8	4.5	4.3
Hypertension	12.7	18.6	12.3	15.4
Arrhythmia	4.3	6.2	4.6	5.3
Congestive heart failure	2.4	4.0	2.9	2.2
Other cardiovascular	9.7	17.1	8.5	14.6
Cerebrovascular	3.0	4.7	1.7	4.4
Renal	4.3	5.4	4.1	2.7
Neurological	6.6	7.0	8.8	7.2
Hepatic	1.7	1.8	1.1	1.0
Diabetes	5.7	6.2	5.1	6.5
<i>Serious preoperative medical conditions %</i>				
Asthma	0.1	0.3	0.2	0.1
COPD	0.6	1.8	0.8	0.3
Other respiratory	1.3	1.6	0.8	1.2
MI < 6 months	0.2	0.8	0.2	*
MI > 6 months	0.2	0.8	0.1	*
Hypertension	0.4	0.9	0.5	0.6
Arrhythmia	0.6	0.6	0.4	1.2
Congestive heart failure	0.3	0.6	0.2	0.2
Other cardiovascular	2.2	5.8	1.4	1.6
Cerebrovascular	0.6	0.9	0.3	1.6
Renal	1.2	1.1	1.2	0.9
Neurological	1.6	1.6	2.3	0.6
Hepatic	0.3	0.3	0.1	0.1
Diabetes	0.5	0.5	0.5	0.6

*Not recorded.

to studies of the quality of medical care.^{10,11} Case-mix adjusted mortality rates have generally been used to compare hospitals in the United States^{12,13} and these studies have typically used hospital discharge databases coupled with intensive chart reviews of outlier hospitals,¹² a methodology similar to that used in this study. However, these studies did not consider anaesthesia as a potential contributor to the operative mortality. In addition, since anaesthesia does not deal with the treatment of specific diseases, the variables of importance for case-mix adjustment may differ from other specialties.

The main objective of the study was to determine if it was possible to compare outcomes from anaesthetic care provided in four separate hospitals. In order to make such comparisons, there must be a close scrutiny of the methodology of study and the premises leading up to acceptance of the results. Utilizing the general homogeneous medical environment in Canada's teaching hospitals, we sought to determine if outcomes from anaesthetic care can ever be compared.

In planning for this study, there were several research designs which we considered. First was voluntary report-

TABLE III Characteristics of surgical procedures

	<i>Hospital</i>			
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
	%	%	%	%
Emergency Procedures	12.5	12.1	15.6	8.2
<30 min	16.2	4.8	1.5	4.3
>240 min	8.2	12.3	8.0	13.1
<i>Surgical site (first and second procedure)</i>				
Neurological	3.9	2.5	4.3	6.4
Endocrine	0.6	0.8	0.3	0.6
Eye, ear, nose, throat	10.8	20.0	13.5	9.8
Dental	1.9	4.5	0.7	2.8
Respiratory	4.0	4.1	2.8	1.9
Cardiac	1.8	5.8	3.1	5.8
Peripheral vascular	3.3	2.4	1.9	5.3
Hematological lymphatic	0.9	0.9	0.1	0.5
Digestive	12.1	14.4	14.2	14.5
Urinary tract	5.5	7.2	6.1	5.2
Male genital	1.9	3.9	3.8	3.7
Female genital	30.3	15.2	12.8	8.3
Musculoskeletal	16.3	11.6	24.2	26.7
Integumentary	5.8	5.2	8.7	6.7
Miscellaneous	0.8	1.1	2.8	1.6

ing of adverse events as was done in the CEPOD study.¹⁴ This has the advantages of cooperation and is relatively less costly. However, the main problems with this approach are an underreporting bias, missing information due to the retrospective approach of data collection, and the limitation in the inclusion of adverse events. As well, the viewpoint of the consumer (the patient) cannot be determined with this approach.

The next design considered was that of studying a sample of anaesthetics either in each hospital or all anaesthetics in each hospital for a limited period of time (for example three months).¹⁵ This approach had the advantage of again being less costly, but had the drawback of reliability of the data collectors. By the time the data collectors would be trained, the time for data collection would have elapsed. The sample size would also be limited, and seasonal variations might be missed.

The final design considered was that of the "retrospective" approach. All records such as hospital logs, hospital charts, PACU data and anaesthetic records would be searched for adverse events. Once found, the appropriate information could be assessed by a panel of experts to determine the anaesthetic contribution. This method had the advantage of being relatively inexpensive. However, the disadvantages of the approach are a bias in underreporting, missing information, small sample size and limited inclusion of events. As well the participation of

the attending staff would be limited, and may lead to noncooperation.

After consideration of various potential designs, we opted for "occurrence screening" where virtually all cases were followed up. The advantages of occurrence screening are less problems with bias in reporting or case finding, and less problem with missing data. Many different outcomes can be considered including "minor" outcomes such as the satisfaction of the consumer. Nevertheless, we encountered various barriers during the execution of this research.

The first concerned the design of the anaesthesia form which was accomplished after months of consultation with appropriately interested persons. Because of the necessity of having the form meet requirements of both the hospitals and the staff anaesthetists, we were not successful in having all four hospitals use exactly the same form. However, in two hospitals it was identical while the other two used very similar instruments. For the follow-up portion of the study, all hospitals used the same instrument.

The next problem concerned compliance and reliability of the staff anaesthetists. In general, the staff was fairly cooperative, but disliked filling out additional forms during busy schedules. Clinicians were not all well versed in doing research, and did not always appreciate the need to be consistent in their recordings. Some also had some

TABLE IV Characteristics relating to anaesthesia

	<i>Hospital</i>			
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
<i>Factors affecting the administration</i>				
Previous anaesthetic problem	0.6	0.8	1.0	1.7
Trauma	1.0	0.5	2.5	0.7
Difficult airway	3.0	2.8	3.2	1.6
Full stomach	6.2	13.6	8.1	1.8
Metabolic derangement	2.6	2.6	2.7	1.2
Shock	1.3	1.3	1.7	0.8
Obesity	10.1	14.5	17.6	3.6
Emaciation	1.5	2.9	5.0	0.5
Smoker: 1-10 · day ⁻¹	6.1	5.8	10.0	4.1
Smoker: >10 · day ⁻¹	17.8	19.6	20.3	15.4
<i>Anaesthetic technique</i>				
Inhalation	52.3	59.6	75.0	76.8
Narcotic	12.2	14.1	7.6	10.3
Plexus block	1.5	0.6	1.7	1.8
Spinal	6.2	10.1	5.8	5.0
Epidural	2.6	2.6	1.6	0.5
Monitored anaesthesia care	26.8	13.9	2.1	4.0
Other	1.2	2.5	6.5	2.5
<i>Monitors</i>				
ECG, B.P.	98.9	99.0	99.6	98.7
FiO ₂	59.6	71.4	*	89.6
Neuromuscular	36.0	40.0	60.8	29.7
Precordial/oesophageal stethoscope	18.1	32.9	51.0	21.8
Temperature	19.1	38.9	52.8	36.7
CVP	4.5	9.5	6.3	10.3
Pulmonary artery	2.8	8.3	1.8	5.5
Pulse oximeter	37.9	94.7	90.7	55.7
End-tidal CO ₂	4.6	6.8	74.2	50.9
Urinary catheter	9.0	16.8	14.0	13.3
EEG/evoked potential	1.5	2.1	0.3	1.1
<i>Drugs</i>				
Nitrous oxide	57.8	58.5	73.7	74.3
Halothane	5.2	2.5	26.0	8.1
Enflurane	13.8	28.6	1.1	8.6
Isoflurane	38.0	33.8	52.3	68.5
Fentanyl	54.2	18.3	*	64.1
Sufentanil	26.7	60.9	*	5.4
Alfentanil	8.0	2.8	*	3.8
Any narcotic	89.9	81.6	80.5	72.8

*Not recorded.

difficulty with coding. They were also very concerned about medical-legal implications of the study, even in Canada's less threatening environment. Anaesthetists at hospital D appeared to have been either less compliant in recording information relating to "factors affecting the administration of anaesthesia" or had difficulties with operational definitions. For example, there appeared to be fewer patients who were obese or who smoked in that institution either due to failure of anaesthetists to record

such information or failure of the nursing researchers to complete the documentation the anaesthetists missed. However, the other information recorded by hospital D did not appear to differ when compared with other hospitals. It is unclear why one part of the data collection would be less complete than the other sections.

There were other problems identified in establishing a comprehensive outcome surveillance system. The definitions used in the study could not be defined in a strict

enough fashion; there were problems with some of the definitions being too vague, and with the number of items collected being too large. The research staff were generally committed, but yet had some difficulty with the complex coding systems and definition of some variables. Finally institutional differences beyond the control of the investigators may affect the results. For example, it was much more difficult for the research staff to interview patients at hospital B than at the other hospitals. This was due both to understaffing of the research team but also due to "patient flow" procedures in that hospital. Other elements included the size of the PACU (thus determining which types of patients went to intensive care or PACU), nursing staff ratios, and charting practices. Both the use of high-level observation units and more diligent postoperative examinations by physicians would increase the detection of postoperative events over those detected on a general postoperative ward.

There were major differences found across the institutions particularly with regard to volume, patient populations, and preferences for specific anaesthetic drugs and monitoring. At the same time, there were also similarities, especially in the predominant use of "balanced" general anaesthesia in all hospitals and the infrequent use of regional anaesthesia. Whether these factors influence outcome from anaesthetic care in any meaningful way is not yet known. Nonetheless, they were identified as some of the items necessary to consider in the analysis of anaesthetic outcome.

The interrater reliability of the rating of the ten hypothetical cases was less than desirable with kappa rating of 0.38. However, other studies of peer raters in anaesthesia have found very high agreement^{16,17} across raters; one study using the Edwards classification had kappa values of 0.791.¹⁷ Since the opinion of the practising clinician is considered as the "gold standard" against which other measures are compared, we considered that the ratings of actual cases could be reliably carried out by the audit committees at each hospital.

In summary, we have instituted and evaluated a parallel occurrence screening methodology in four teaching hospitals in Canada. We conclude that occurrence screening is possible in anaesthetic practice with a satisfactory degree of reliability and validity. However, the multiple variables that potentially influence anaesthetic outcomes (and therefore need to be considered) are not yet known and need further refinement before widespread implementation of occurrence screening can be advocated.

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Appendix I

Guidelines for outcomes used in the study

Intraoperative

Hypotension: a decrease of 30% in blood pressure from preoperative (ward) values or a drop in blood pressure requiring action (e.g., drug therapy) to maintain the blood pressure.

Hypertension: an increase of 30% in blood pressure readings from preoperative (ward) values or an increase in blood pressure requiring action on the part of the anaesthetist.

Cardiac arrest: no cardiac output; requiring CPR.

Ventricular arrhythmia: rhythm differing from preoperative status.

Supraventricular arrhythmia: rhythm differing from preoperative status.

Heart block: Brady arrhythmia requiring specific treatment.

Difficult intubation: more than one laryngoscopic attempt whether successful or not.

Upper respiratory: difficulty maintaining a patent airway by mask.

Aspiration: inhalation following vomiting or regurgitation.

Laryngospasm: transient upper airway obstruction.

Bronchospasm: audible wheezing on auscultation.

Other lower respiratory: other respiratory events not included above.

Failed technique: the necessity to switch from one anaesthetic technique to another or to cancel the case e.g., failed block or failed intubation.

Mechanical/equipment failure: problem with anaesthesia machine or other components during the case.

Excess blood loss: unusual for type of surgery of greater than 20% of blood volume.

Other surgical: surgical event of note other than excessive blood loss.

Anaphylactoid: appearance of hives, urticaria, hypotension and bronchospasm.

Drug incident: unintentional drug injection or other drug incident.

PACU

Nausea and/or vomiting: active expulsion of gastric contents or any volunteered complaint of nausea whether treated or not treated.

Hypothermia: temperature $<34^{\circ}\text{C}$ skin or $<35^{\circ}\text{C}$ nasal/oral, $<36^{\circ}\text{C}$ rectal.

Cardiac arrest: no output, requiring CPR.

Other cardiac: bradycardia, tachycardia, dysrhythmia or ischaemia whether treated or not treated.

Hypotension: low blood pressure given specific treatment.

Hypertension: high blood pressure given specific treatment.

Respiratory: any respiratory problem including hypoventilation, requirement for reintubation, pulmonary oedema, bronchospasm.

Neurological: seizures, motor deficit, sensory deficit.

Renal/metabolic: hypovolaemia, oliguria, hyperglycaemia or other metabolic disturbances.

Burns/skin damage: erythema, blistering, broken skin areas.

Musculoskeletal: complaints of soreness or limited motion not seen on visual inspection.

Psychological: agitation, hallucinations, unusual behaviour.

Transfer to ICU: transfer to intensive care unit for any reason.

Postoperative

Nausea: any nausea recorded on the chart.

Vomiting: any vomiting recorded on the chart.

Headache: any head pain (above ear level) except where the head was the operative site or history describes headache preoperatively.

Sore throat: any sore throat except where the throat was the operative site or nasogastric tube was used.

Back pain: any report of back pain except where back was operative site.

Paraesthesia: any report of numbness or tingling in any area of body except operative site.

Motor deficit: any new motor loss unrelated to surgical site and not due to immobilization.

Stroke: neurological deficit which was not present preoperatively.

Myocardial infarction: both EKG changes and fractionated enzyme changes must be present.

Angina: any chest pain not present preoperatively; relieved by nitroglycerine.

CHF: any pulmonary oedema not reported preoperatively.

Arrhythmia: any atrial or ventricular arrhythmia not present preoperatively.

Hypotension: 30% reduction in blood pressure compared with admission.

Hypertension: 30% increase in blood pressure compared with admission.

Other cardiovascular: any other cardiovascular problems not listed above.

Atelectasis/pneumothorax: must be diagnosed by chest x-ray or noted in progress notes.

Pulmonary embolism: diagnosed by lung scan or treated with heparin.

Pneumonia: must be diagnosed by chest x-ray or noted in progress notes.

Bronchospasm: audible wheezing as noted in chart.

Other lower respiratory: other respiratory problem not listed above.

Upper respiratory: laryngospasm, pharyngeal oedema or laryngo-oedema, epistaxis.

Psychological: disorientation or hallucinations not present preoperatively.

Oliguria: urine output of less than $30\text{ ml} \cdot \text{hr}^{-1}$ not responding to fluid challenge.

Hypovolaemia: low urine output (associated with hypotension) requiring fluid challenge.

Metabolic/electrolytes: any biochemical imbalance, e.g., hypoglycaemia, Na^+ , K^+ , BUN, creatinine.

Infection/wound dehiscence: any infection of surgical wound or separation of surgical wound.

Bleeding: any bleeding from surgical site either internally or externally.

Return to OR; return to operating room for any reason.

Death: death occurring in hospital within 72 hr of operation.

Appendix II

Edwards classification of the relationship of anaesthesia to operative morbidity and mortality*

Category Definition

- I Where it is reasonably certain that event/death was caused by the anaesthetic agent or technique of administration, or in other ways coming directly within the anaesthetist's province.
- II Similar cases, but in which there is some element of doubt as to whether the agent or technique was entirely responsible for the result.
- III Cases in which the patient's event/death was caused by both the anaesthetic and surgical technique.
- IV Events entirely referable to surgical technique.

* As modified by the New South Wales Committee (7).

Categories III and IV are those in which surgery made a contribution, and hence there is an overlap in Category III.

- V Inevitable event/death, e.g., cases of severe general peritonitis, but in which anaesthetic and surgical techniques were apparently satisfactory.
- VI Fortuitous event/death, e.g., due to pulmonary embolism.
- VII Cases which cannot be assessed despite considerable data.
- VIII Cases in which an opinion could not be formed on account of inadequacy of data.

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