General Anesthesia

The changing pattern of anesthesia, 1954-2004: a review based on the content of the *Canadian Journal of Anesthesia* in its first half-century

[La transformation du modèle de l'anesthésie, 1954-2004 : une revue fondée sur le contenu du premier demi-siècle du Journal canadien d'anesthésie]

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Purpose: In order to review changes and progress in anesthesiology in the second half of the 20th century, and to recognize the first half-century of the Journal's existence.

Source: The content of the Journal from its inauguration in 1954 through 2004 was reviewed.

Results: Although the data base is that of the Canadian Journal, many of the contributions were from other countries, and for this reason the findings will have relevance both in Canada and elsewhere. The review suggests that anesthesiology evolved in two phases in this period: from 1954 to 1978 and from 1979 to 2004. The first was characterized by the introduction of new drugs and adaptation to new surgical techniques; the second, by a greater emphasis on clinical excellence, outcome, quality patient care both in the operating room and elsewhere in the hospital, and research.

Conclusions: Although profound advances in knowledge, techniques, and relationships, have shaped the pattern and practice of anesthesiology in this half-century, the basic concerns of anesthesiologists relating to the practice of anesthesia and to their patients remained unchanged. At the same time, the many advances that have shaped anesthesiology in this half-century have extended the understanding of the phenomenon of anesthesia and enhanced the quality of patient care, which gives rise to the hope that anesthesiologists will continue to fully achieve these twin goals in the next half-century.

Objectif: Passer en revue les changements et les progrès en anesthésiologie survenus pendant la seconde moitié du 20^e siècle et rappeler l'existence du premier demi-siècle du Journal.

Source : Le contenu du Journal a été revu, de son lancement en 1954 jusqu'en 2004.

Résultats : Même si la base de données est celle du Journal canadien, de nombreuses contributions viennent d'autres pays et, pour cette raison, les résultats seront pertinents tant au Canada qu'à l'étranger. La revue montre que l'anesthésiologie a évolué en deux phases pendant cette période : de 1954 à 1978 et de 1979 à 2004. La première a été celle de l'introduction de nouveaux médicaments et de l'adaptation aux nouvelles techniques chirurgicales ; pendant la seconde, l'accent a été mis sur l'excellence clinique, les résultats, les soins de qualité en salle d'opération, et ailleurs dans l'hôpital, et la recherche.

Conclusion : D'importances avancées dans les connaissances et les techniques et des nouvelles relations ont façonné le modèle et la pratique de l'anesthésiologie au cours de ce demi-siècle, mais les préoccupations de base des anesthésiologistes concernant la pratique de l'anesthésie et leurs patients sont demeurées les mêmes. Les progrès qui ont façonné l'anesthésiologie pendant cette période se sont étendus à la compréhension du phénomène de l'anesthésie et à l'amélioration de la qualité des soins aux patients, ce qui suscite l'espoir de voir les anesthésiologistes poursuivre pleinement leurs objectifs pendant le prochain demi-siècle.

IN 1962, in an article titled "The Pattern of Anaesthesia," 1962 Harold Griffith looked back over four decades of practice. When he started giving anesthetics "the average procedure was not easy for the anaesthetist or the patient, and ... inductions with open drop ether were often formidable battles."¹ In asking how anesthesia in 1962 had become so relatively trouble-free, he identified four factors: an unobstructed airway, adequate ventilation, and fluid and electrolyte balance. These

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FIGURE Front covers of Canadian Anaesthetists' Society Journal, 1954, and Canadian Journal of Anesthesia, 2004.

are still important, but the pattern of anesthesia is much less plagued by problems, and has become much more sophisticated and refined. What changes have made this possible?

To answer this question, and because it is appropriate in recognizing the role of the Canadian Journal of Anesthesia/ Journal canadien d'anesthésie (from 1954 to 1986 the Canadian Anaesthetists' Society Journal/ Journal de la Société canadienne des anesthésistes) in the development of anesthesiology, its content in its first half-century has been reviewed. This has been done in two ways: by comparing and contrasting the initial, July and October, issues of the journal in 1954 with the combined June and July issues in 2004, and by noting significant articles and editorials in all of the issues published from 1954 through 2004. Thus the pattern of anesthesia from 1954 through 2004 has been traced.

Two general conclusions can be drawn. First, the basic concerns of anesthesiologists relating to the practice of anesthesiology and the care of patients have not changed in 50 years; but, second, what has changed is the pattern of anesthesia. For anesthesiologists, the administration of anesthesia has become more fulfilling, and for patients the experience of anesthesia is today far less noxious and traumatic than it was a half-century ago. Since the Journal's contributions have been increasingly international in origin, these conclusions will have relevance to other countries besides Canada.

The Journal in 1954 and 2004 compared

Superficially, numbers 1 and 2 of volume 1 of the Journal for 1954 and number 6 of volume 51 for

2004 appear to be worlds apart. The format (Figure) is different, and the content almost reflects two different languages. After all, regarding content, what similarity does there seem to be between an article in 2004 on the use of recombinant human erythropoietin to reduce red cell transfusion in critically ill patients² and one on anesthesia for infants in a community hospital of 1954?³ Yet a closer look reveals similarities. In 1954 two articles concerned subarachnoid anesthesia^{4,5} and in 2004, seven.⁶⁻¹² In 1954 epidural anesthesia was discussed in three articles^{12,13} and in 2004, three.^{6,11-15} In 1954 there was an article on sympathomimetic amines in the treatment of shock,¹⁶ but the 2004 article on erythropoietin also is related to shock, for "insufficient global tissue perfusion is considered to be a trigger for the multiple organ dysfunction syndrome."² Obstetric^{4,8-13,15,17-20} and pediatric^{3,8,13,21} topics, oxygen problems,^{22,23} and laryngoscopy^{24,25} also are common to the 1954 and 2004 issues.

It would, of course, be facile to suggest that basic concerns have not changed over the years. Indeed, the changes are profound, in both the content of anesthesiology and the complexity and sophistication of the pattern of anesthesia and how it has been refined over the past half-century. The 2004 issue, for example, contains an editorial on fetal monitoring in a woman who underwent craniotomy for suprasellar meningioma in the 28th week of pregnancy,¹⁹ an article on comparison of the bispectral index with the A-line index for the detection of arousal,²⁶ one on Svo₂ measurements and co-oximetry,²⁷ and one on the influence of study design, originality, and consistency on acceptance or rejection of manuscripts by the Journal.²⁸ As advances such as endotracheal intubation and intensive care enhanced the pattern of anesthesia in 1962,¹ so the many advances since 1962 have obviously enhanced anesthesiology today.

To further appreciate the nature of the advances that have been made in anesthesiology, the content of all the issues of the Journal from 1954 to 2004 was reviewed.

The content of the Journal from 1954 through 2004

The content of the Journal in its first half-century suggests that anesthesiology in this period evolved in two phases. From 1954 through 1978, the main threads were the development and use of new drugs and agents and adaptation to new surgical techniques. But towards the end of 1978, articles and editorials began to reflect standards of patient care, fresh approaches to patient care and to education and research, and concerns outside the operating room. From 1979

through 2004, epidemiology, demography, investigation, outcome, quality of care, and cost-benefit ratios were emphasized, as were surgical and technological advances. So the content of the Journal from 1979 to 2004 has an increasing richness and complexity testifying to the involvement of anesthesiologists in a remarkably wide sphere of activities.

1954-1978

The introduction of new drugs and agents in the 1930s – divinyl ether, cyclopropane, thiopental, and hexobarbital, for example – continued after World War II. From 1954 to 1978, an enormous number of anesthetic agents were introduced. In fact, the war did not stem progress, but even indirectly expedited it. For example, war-time fluorine research, spawned by the need for high-octane aviation fuel and for enriched uranium-235, furthered the postwar fluorine-related research on potential anesthetic agents, which had actually begun as early as 1932. Halothane, introduced in 1956, was described in the Canadian Journal in 1957,²⁹ as was fluoromar.³⁰ Methoxyflurane was noted in 1961,³¹ enflurane in 1966,³² and isoflurane in 1971.³³ (Sevoflurane was an anomaly: though synthesized in 1975 and used in trials in 1981, apparent instability prevented it from being widely used until the 1990s).³⁴

Many *in vivo* agents were also developed in this first period of the Journal. The introduction of curare in 1942 by the Canadians Griffith and Johnson³⁵ forged a new pattern in anesthesia. It profoundly affected not only anesthesia but also intensive care. Patients were from then on deliberately paralyzed and artificially ventilated – at first by hand, and then by ventilators, which, too, proliferated. Other relaxants, virtually tailor-made, followed. Succinylcholine, which was introduced in 1951, is of interest because of its association with atypical cholinesterase³⁶ and malignant hyperthermia,³⁷ and its part in the study of pharmacogenetics in anesthesia, much of which was the subject of important work by Werner Kalow³⁸ and Beverley Britt in Toronto.³⁹

Other drugs shaped the pattern of anesthesia. Chlorpromazine, first mentioned in the Journal in 1955,⁴⁰ was followed by benzodiazepines such as diazepam,⁴¹ and the butyrophenones such as droperidol,⁴² which was used as an antiemetic and a premedicant and neuroleptic. The opioid analgesics then made an even greater impact. Fentanyl, noted in the Journal first in 1965,⁴³ was used as a neuroleptic, a premedicant, and an analgesic, as well as a stress-depressing agent in cardiac surgery, and again the pattern of anesthesia changed.

Because the barbiturates had drawbacks as induction agents, much effort was spent on developing the ideal induction agent. Pregnanedione (Viadril),⁴⁴ propanidid,⁴⁵ alphaxolone/alphadolone (Althesin)⁴⁶ and etomidate⁴⁷ all were described in the Journal. None, however, proved invaluable. However, two drugs introduced in this period did. One was ketamine, used because of its properties as a dissociative anesthetic and its lack of depressant effect on the circulation;⁴⁸ interestingly, among articles published in the Journal from 1987 through 2003 one on ketamine was cited most often.⁴⁹ The other valuable drug was propofol, which was first used in 1977 and had several advantages over thiopental.⁵⁰

Local anesthetic agents also proliferated and from 1954⁵² on they were noted in the Journal. Of later ones, bupivacaine was first referred to in the Journal in 1969 for its use in both surgery⁵³ and obstetrics.⁵⁴

Some of these anesthetic agents had imperfections. These included allergic, anaphylactic, or sensitivity reactions and some led to toxic effects from excessive biotransformation. Hepatic toxicity from halothane was reported in the Journal in 1959⁵⁴ and renal toxicity from methoxyflurane in 1972.⁵⁵ Toxicity associated with anesthetics was the subject of a symposium that was reported in the Journal in 1973.⁵⁶

The need to adapt to surgical requirements is illustrated by the development of surgery for transplantation of organs⁵⁷ and disorders of the heart and brain. Cardiac surgery, in particular, posed great challenges for anesthesiologists. The work of Canadians in the 1950s was reviewed by Earl Wynands,⁵⁸ and highlights are summarized here. The first paper by Canadians on anesthesia for cardiac surgery was written by Stephen Evelyn and Iain MacKay, of Toronto, in 1954; the first Canadian to publish an article on this field in the Canadian Journal was A. Code Smith, also of Toronto, in 1955, who discussed the use of hypothermia, the 'lytic cocktail' (chlorpromazine, promethazine, and demerol), as well as cardiopulmonary bypass; hypothermia in cardiovascular surgery was also reported by Barrie Fairley in 1957 and for cerebrovascular surgery by Stuart Vandewater a year earlier. The development of cardiopulmonary bypass and also of coronary artery bypass were quantum leaps in patient care, and many anesthesiologists in Canada contributed. They include, as well as Wynands, Emerson Moffitt, of Halifax; Ted Gain, of Edmonton; Bernard Paiement and Alex Wielhorski, and also Jose Rosales and Harold Davenport, of Montreal; William Dodds, of Vancouver; and John Atkinson, of Ottawa.

Technological advances also influenced the pattern of anesthesia from 1954 to 1979. Work on the Clark

oxygen electrode and the Severinghaus apparatus for measuring blood gas concentrations began in the 1950s, and an article on routine blood gas analysis was published in the Journal in 1969.⁵⁹ An article in 1966 described a portable peripheral nerve stimulator.⁶⁰ Other devices were electrocardiographic monitors, electronic sphygmomanometers, and pressure transducers. Arterial and venous pressures could now be measured directly, and concentrations of anesthetic agents in the blood could be analyzed.⁶¹ In a different category were two pieces of apparatus invented by Canadian anesthesiologists from London. One was the apparatus for demand analgesia designed by Michael Keeri-Szanto in 1971,⁶² one of the earliest of patient-controlled analgesia devices; the other was the streamlined breathing system (the 'Bain Circuit') invented by Jim Bain and Wolfgang Spoerel in 1972.⁶³

Many ventilators were introduced as a result of the introduction of curare in 1942 and the respiratory effects of the poliomyelitis epidemics of the early 1950s. Of ventilators referred to in the Journal in the 1960s,^{64–66} that invented by Dan Revell⁶⁷ may be noted because he worked in Winnipeg and later in Victoria. Epidemics of poliomyelitis stimulated ideas on respiratory care of medical patients with ventilators, and the very first issue of the Journal noted the role of the anesthesiologist in managing respiratory poliomyelitis.⁶⁸ This presaged the later role of anesthesiologists outside operating rooms.

In this first period of the Journal's existence there were relatively few articles on education, though the 1954 Journal does contain an article on instruction on laryngoscopy.²⁴ Similarly, there were few articles on research, though the second has a report of a clinical study of postoperative nausea and vomiting.⁶⁹ While few of the research articles published from 1954 to 1978 had the significance of those published later, four^{39,70–72} are included among key Journal articles of all categories nominated by the first three editors of the Journal in 1993 (Table).

1979-2004

The final issue of the Journal for 1978 marks a turning point in the history of anesthesiology in the 20th century in Canada. Several articles presage aspects of anesthesiology of increasing interest in the second half of the Journal's existence. Clinical topics include anesthesia for ambulatory surgery,⁷³ preoperative evaluation of the patient with myocardial disease,⁷⁴ anesthetic management for coronary artery bypass surgery,⁷⁵ and pollution of the air of the operating room.⁷⁶ An article on major issues facing academic departments of anesthesia illustrates newer concerns

TABLE Key articles published in the Canadian Journal of Anesthesia 1954-1978*

Ruston FG. Epidural anaesthesia in infants and children. *Can Anaesth Soc J* 1954; 1: 37–44.

Lucas GH. The discovery and pharmacology of cyclopropane. *Can Anaesth Soc J* 1960; 7: 237–56.

Virtue RW, Lund LO, Phelps M Jr, Vogel JH, Beckwitt H, Heron M. Difluoromethyl 1,1,2-trifluoro-2-chloroethyl ether as an anaesthetic agent: results with dogs, and a preliminary note on observations with man. *Can Anaesth Soc J* 1966; 13: 233–41.

Oyama T, Shibata S, Matusmoto F, Takiguchi M, Kudo T. Effects of halothane anaesthesia and surgery on adrenocortical function in man. *Can Anaesth Soc J* 1968; 15: 258–65.

Britt BA, Locher WG, Kalow W. Hereditary aspects of malignant hyperthermia. *Can Anaesth Soc J* 1969; 16: 89–98.

Craig DB, Wabba WM, Don HF. Airway closure and lung volumes in surgical positions. *Can Anaesth Soc J* 1971; 18: 92–8.

Keeri-Szanto M. Apparatus for demand analgesia. *Can Anaesth Soc J* 1971; 18: 581–2.

Bain JA, Spoerel WE. A streamlined anaesthetic system. *Can Anaesth Soc J* 1972; 19: 426–35.

Gelb AW, Knill RL. Subanaesthetic halothane: its effect on regulation of ventilation and relevance to the recovery room. *Can Anaesth Soc J* 1978; 25: 488–94.

* Source: *Gordon RA, Craig DB, and Bevan DR.* "The Society's Journal," In: Shephard DAE, *Watching Those Who Sleep: A History of the Canadian Anaesthetists' Society 1943-1993.* *Can J Anaesth* 1993; 40(6 Suppl): 164–5.

with education and research.⁷⁷ One article focused on the current status of research in Canada,⁷⁸ while specific research topics consisted of the following: the effect of subanesthetic concentrations of halothane on regulation of ventilation and its relevance to the recovery room,⁷² the relationship of cerebral blood flow and arterial oxygen saturation in hypoxia induced with nitrous oxide or nitrogen,⁷⁹ and the variability of the pulmonary vascular response to hypoxia in dogs.⁸⁰ An article on manpower problems⁸¹ dealt with a problem that would recur in the next quarter of a century.

These topics do not reflect all of the concerns in the period from 1979 to 2004, but they do suggest that the pattern of anesthesia was becoming more complex and that the approach to anesthesiology was more refined and sophisticated. This was not just because of new techniques in anesthesia, technological innovations, fresh concerns in and approaches to teaching, and a mature grasp of significant topics in research –

issues of interest related to the traditional triad of clinical practice, education, and research. Clinical work extended outside the operating room, as in treating pain, and serving areas such as the labour unit and the intensive care units. In addition, anesthesiologists had to deal more often with hospital and government administrators, and they had to deal with various organizational concerns: professional competence, patient safety, quality of care, outcome, technology, and cost-benefit ratios, as well as by the demands of patients, surgeons, hospital administrators, and surgeons.

The first issue of the Journal for 1979 opened with a report of a panel discussion on continuing professional competence.⁸² Of pressing concern was the question of voluntary *vs* legislative control of the maintenance of competence. While the system for maintaining professional competence would be overseen by the Royal College of Physicians and Surgeons of Canada, individual anesthesiologists would be responsible for ensuring the continuity of their education and competence. Two interested parties were local licensing authorities and hospitals and the public, and both were represented on the panel. A degree of accountability would increasingly be expected in anesthesiology, not only on the part of anesthesiologists themselves to their patients but also to hospital administrators and government authorities.

Such accountability was appropriate, for patients were better informed and less ready to accept postoperative death or a complication as an 'act of God.' Not only were the reasons for adverse events more clearly understood but the mortality associated with anesthesia had decreased over the years: one study published in 2001 revealed that, in 101,769 procedures, the mortality was 0.6 per 10,000.⁸³ As the death rate decreased, however, morbidity associated with anesthesia became of greater concern, and outcome became of increasing interest. In 1997 Chung and her colleagues reported that, among 775 patients having ambulatory surgery, some 43 adverse events occurred for every 1,000 operations; 65.29% of the events were related to the cardiovascular system and 10.84% to the respiratory system. A larger study of 17,638 patients showed that, while cardiovascular events occurred in approximately 7% of every 100 operations on patients 65 yr of age or older and in 1.35% in younger patients, adverse events affecting other systems were not more common in the elderly than in younger individuals.⁸⁵ As far as accountability is concerned, patients were concerned about the level of communication between anesthesiologists and themselves.⁸⁶

Outcome was a concern that was evident in a study of 112,000 patients from Winnipeg in 1986.⁸⁷ This

showed that concern over morbidity following anesthesia was not misplaced. From 1975 to 1978, at least one complication occurred in 7.6% of patients, but from 1979 through 1983 the incidence was 10.6%. Likewise, the incidence of complications in patients in the recovery room increased over time, from 3.1% to 5.9%. Thus even as late in the 20th century as 1986 the anesthetic experience, while associated with low morbidity rates in recent years, was still associated with "significant morbidity." This suggests that anesthesiologists will be occupied for some time in finding ways to reduce perioperative morbidity.

Such findings are consistent with Peter Duncan's observation in 1998 that, while Canadian anesthesiologists had indeed achieved a standard of excellence, the standard was not yet perfect.⁸⁸ While the Winnipeg study showed how issues affecting anesthetic morbidity may be clarified, as Carli and Lubian pointed out in 1999, the larger, perioperative picture must be considered.⁸⁹ Discussing epidural anesthesia with a local anesthetic and an opioid as a technique, they suggested using a multimodal therapeutic approach that is appropriate for the preoperative, intraoperative, and postoperative phases of anesthesia care. This approach was just one example of the concern about outcome on the part of the anesthesiologist as a perioperative physician.

On a smaller scale, postoperative nausea and vomiting and pain is one example of morbidity that generated continued efforts to understand and eradicate persisting problems. Of the former, Carol Stockall identified it in 1999, it is "a frustrating paradox; it is small stuff, but it is a big problem."⁹⁰ Greater success attended the understanding and control of postoperative pain and the side effects of treatment, and appropriate guidelines proved helpful.⁹¹

Evidence-based medicine also assumed increasing importance in the practice of anesthesiology, as in other fields of medicine. It was seen to provide a comprehensive approach to research and patient preference as well as clinical expertise.⁹² As well as concerning themselves with clinical excellence, anesthesiologists became increasingly mindful of the many aspects of quality of care in this period. The title of the editorial by Macario and Vasanawala spoke to this: "Improving quality of anesthetic care: opportunities for the new decade."⁹³ They concluded that anesthesiologists were under pressure from three groups of individuals, each of whom had their own ideas of quality of care. Surgeons sought timeliness of care from anesthesiologists; hospital administrators urged anesthesiologists to lower costs and avoid unnecessary care; and patients wanted anesthesiologists to relieve

pain and nausea and vomiting, as well as better informing them throughout the perioperative period.

A key element of quality of care is patient safety. John Wade addressed this in 2003 in an article titled "Patient safety in anesthesia – continuing challenges and opportunities."⁹⁴ One example of a challenge was eradicating cardiac arrest. As of 2001, while the incidence of cardiac arrest related to anesthesia was as low as 1.1 per 10,000 procedures, all cardiac arrests totally related to anesthesia were classified as avoidable.⁸³ Causes of cardiac arrest included hypoxemia, hypovolemia, and drug overdose, which were therefore essential to remove.

Errors in the administration of drugs were discussed in two contributions to the Journal by Beverly Orser and colleagues. In one paper they identified medication errors in a survey of 687 practitioners, and noted that, although the majority of errors were of minor consequence, most anesthesiologists had experienced at least one drug error at some time.⁹⁵ They recommended improved standards for drug labelling and the establishment of a Canadian system for reporting medication errors. In a second contribution, Orser concluded that medication error was then the leading cause of adverse events during anesthesia.⁹⁶ The frequency of drug error was also reported in an article from Norway. According to Fasting and Grisvold, the incidence was 11 in 10,000 procedures, but in a separate group the use of colour-coded labels on syringes and educational sessions did reduce the error rate from 1.38 per thousand to 0.869 per thousand.⁹⁷

The medical profession in general, and the specialty of anesthesiology in particular, thus became more concerned with ensuring patient safety. Recommendations were made in 2004 by the Baker-Norton report,⁹⁸ funded by the Canadian Institute of Health Research and the Canadian Institute for Health Information, and the Canadian Patient Institute and the Institute of Safe Medication Practice were formed to encourage practice that would enhance patient safety in practice. The Canadian Anesthesiologists' Society (CAS), which has long had guidelines that enhance patient care, struck its Patient Safety Committee in 2003.

All the foregoing concerns were subsumed under the central goal of anesthesiologists in this period: excellence in clinical practice. Honing the clinical art will always be key in providing first-class care, and Canadian anesthesiologists made notable advances in this respect. Some advances simplified approaches to the administration of anesthesia rather than arising from the use of new anesthetic agents, of which, in fact, desflurane⁹⁹ was the only innovative one in this period. Two

Canadian examples of consummate clinical excellence may be cited. One is management of the airway, as illustrated by use of the laryngeal mask airway^{100,101} and of the fiberoptic laryngoscope¹⁰² and development of procedures for predicting difficulty with intubation.^{103–106} These innovations enhanced patient care, besides simplifying a complex and not infrequently potentially hazardous aspect of the administration of anesthesia. The second example is the introduction of new practices with respect to preoperative fasting.^{107–109} Here, common sense prevailed over previous thinking, as preoperative guidelines on the interval before anesthesia when certain volumes and types of liquids may be given to preoperative patients became more liberal. These two examples also testify to the importance of clinically oriented research.

Such measures are examples of relatively straightforward ways of striving for patient safety, through clinical practice. However, fresh approaches to education contributed to refinement of the pattern of anesthesia. One example of such an approach is simulation,^{110,111} which enables anesthesiologists to learn how to deal with all aspects of critical incidents that they might meet in practice.

Research also made great headway in this period. In an editorial in 1992, Richard Knill discussed the future for anesthesia research in Canada.¹¹² Several factors impeded the conduct of research: the diminution in university funds that were allotted to research; the decreasing time available for scholarly endeavours, partly because of increasing demands on clinicians interested in research with respect to work in the operating room and in administrative matters; low recruitment of potential trainees for research; and lack of quality in scientific inquiry. The last point had been made in 1988 by Duncan and Cohen, who concluded that research from 1977 to 1986 had been "too confined in scope," having a relative shortage of innovative ideas and a narrow methodological approach.¹¹³ Knill made four recommendations: exploration of areas previously ignored; recognition of the importance of a full understanding of the nature, genesis, and means of managing a relevant clinical problem; focusing research projects on scientific problems and questions that are important to the advancement of knowledge; and fostering the development of research skills and techniques. Beverly Orser and Donald Miller brought concerns of researchers up to date in 2002, when they pointed out that, while the clinical and scientific advances in the previous 50 years had been unprecedented, unless it became understood that "to remain at the cutting edge requires constant rejuvenation and renewal," research in Canada would contin-

ue to lag behind that elsewhere.¹¹⁴ Such problems emphasized the need to train clinician scientists.

From 1992 to 1999, Canadian contributions to research were estimated to be 3% of all anesthesia research in the world.¹¹⁵ Pharmacological topics and therapeutic use of anesthetic agents were the most common categories of research; lidocaine, opiates, fentanyl, propofol, and nonsteroidal analgesics were the foci of greatest attention. However, such research was perhaps not what those anesthesiologists who were most aware of research needs in Canada had in mind. Therefore the founding of the Canadian Anesthesia Research Foundation and the proliferation of research awards through organizations such as the Medical Research Council and pharmaceutical companies, as well as the CAS itself, served as much needed stimuli to anesthesia research in Canada. By the turn of the century, the Journal was publishing numerous papers based on research. Some topics had an obvious clinical application, such as ST segment analysis,^{116,117} while others, such as those on glutamate co-transporters¹¹⁸ more obviously concerned basic science. Such research might seem to be only of esoteric significance, but, as Joo and Orser pointed out, the work on glutamate co-transporters might well be relevant in due course to the clinical utility of anesthetics as peri-operative neuroprotectants, for example.¹¹⁹

Technological progress continued to shape the pattern of anesthesia. Anesthesia machines and monitoring equipment provide two examples of progress that made for excellence in anesthesiology as well as safer patient care. In 1986, in an article on monitoring equipment, Charles Hope and Donald Morrison stressed that understanding the basic components of the monitoring process was essential to its most efficient and effective use.¹²⁰ A decade later, Robert Byrick emphasized how technology assessment assisted decision-makers establish policies relating to the development, acquisition, and utilization of devices (as well as drugs).¹²¹ In such ways, anesthesiology in Canada was endeavouring to keep technologically advanced.

It is instructive to compare what was being monitored in the 1980s and 1990s in operating rooms and intensive care units with the situation 30 years earlier. Electrocardiographic monitoring of the function and state of the heart, earlier an exceptional exercise, had become routine, while transesophageal echocardiography,¹²² though hardly routine, came later. Monitoring of hemodynamic function, cardiac output, blood volume, and blood gas concentrations, as well as arterial and venous pressures, had become standard aspects of care, and, as was indicated in the June/July issue of the 2004 Journal, the state of the brain was moni-

tored, when appropriate, by compressed spectral assay and evoked responses.²⁶ As far as anesthesia itself is concerned, pulse oximetry, measurement and monitoring of inspired and expired oxygen and carbon dioxide concentrations, and analysis of concentrations of volatile agents had become mandatory.

As Jeremy Sloan noted in 2000, enormous advances had taken place in the previous 25 years.¹²³ He stressed the role of Canadian anesthesiologists in ensuring that anesthesia equipment would continue to be reliable and of high quality. Many Canadian anesthesiologists regularly contributed to the deliberations of such bodies as the CAS committees on standards of practice and technology and the technical committees on anesthesia, respiratory technology, and critical care equipment of the Canadian Standards Association. This was one of the many ways, in the last quarter of the 20th century, in which Canadian anesthesiologists continued to do much to achieve the fundamental objects of excellence in anesthesia and safety in patient care.

Conclusion

In 1847, John Snow said that "[t]he point requiring most skill and care in the administration of the vapour of ether is, undoubtedly, to determine when it has been carried far enough."¹²⁴ A century later, in 1943, it was possible for the CAS to state that its object was "[t]o advance the art and science of Anaesthesia and to promote its interests in relation to Medicine with particular reference to the clinical, educational, ethical and economic aspects thereof ....."¹²⁵ By 1943 anesthesiology had become a specialty and its practice consisted of much more than 'passing gas.' A decade after that, when the Journal was established, another object was enunciated, in the form of "a suitable Canadian medium for the presentation of original work by Canadian anaesthetists".¹²⁶ In the past half-century, these objects have shaped the pattern of anesthesia, and the advances have indeed been astonishing. While the data base for this review is that of the Canadian Journal, the findings will have relevance to anesthesiologists in other countries also. In general, they make it possible to emphasize the importance of what will continue to be a most important object – quality anesthesia care of patients.

This is not the place to forecast the future, but one cannot help but wonder when anesthesia will gain for anesthesiologists the ideal of a complete understanding of the nature of the phenomenon of anesthesia and for patients the Holy Grail of complete absence of morbidity and mortality. Neither goal may be wholly achievable, but the progress has been such that one can imagine both being within the realm of possibility.

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