

# Addition of sevoflurane to the formulary: Impact on a surgical daycare unit

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## ABSTRACT

**Objectives:** To determine the impact of sevoflurane on anesthetic-related patient outcomes and on anesthetic acquisition costs in a surgical daycare unit (SDU).

**Methods:** A retrospective observational study comparing 50 historic controls from August 1995 – October 1995 (Phase 1) to 50 patients who received sevoflurane for dental or gynecologic procedures from August 1996 – October 1996 (Phase 2) in the SDU.

From the health record, we obtained information on patient characteristics, procedure characteristics, anesthetic regimen characteristics, toxicities, ancillary drug, and time interval outcomes related to admission, recovery and duration of stay. From total SDU anesthetic expenditures we estimated the mean

anesthetic expenditure per procedure in the SDU prior to and after introduction of sevoflurane.

**Results:** There were no apparent differences in toxicities, ancillary drug use and time interval outcomes between the sevoflurane group and the control group with the exception of median time interval between recovery room admission and “conscious-drowsy” state for gynecology patients. Mean anesthetic costs per SDU procedure were \$10.23 in Phase 1 and \$12.30 in Phase 2.

**Conclusions:** The use of sevoflurane in outpatient anesthesia did not permit quicker recovery or earlier discharge of patients undergoing dental or gynecologic procedures nor did it result in any cost advantage over other agents. Its role, therefore, appears limited to an inhalational alternative to propofol for induction anesthesia in the outpatient setting.

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## RÉSUMÉ

**Objectifs :** Connaître les effets du sévoflurane sur les résultats de l'anesthésie pour les patients ainsi que sur le coût des anesthésiques dans un service de chirurgie de jour (SCJ).

**Méthodes :** Étude rétrospective par observation consistant à comparer, parmi des patients du SCJ, 50 patients témoins traités entre août et octobre 1995 (Phase 1) à 50 patients ayant reçu du sévoflurane pour une intervention dentaire ou gynécologique entre août et octobre 1996 (Phase 2).

Nous avons tiré des dossiers de santé les renseignements suivants : caractéristiques des patients, de l'intervention et de l'anesthésique utilisé, toxicités, médicament auxiliaire, période écoulée entre l'admission et le rétablissement, durée du séjour. À partir des dépenses totales du SCJ, nous avons estimé le coût moyen de l'anesthésique par intervention avant et après l'adoption du sévoflurane.

**Résultats :** Nous n'avons constaté aucune différence apparente entre les résultats relatifs aux toxicités, à l'utilisation de médicament auxiliaire et aux durées entre le groupe traité au sévoflurane et le groupe témoin, exception faite de la période médiane écoulée entre l'admission à la salle de réveil et l'atteinte de l'état « conscient-somnolent » chez les patientes ayant subi une intervention gynécologique. Le coût moyen de l'anesthésique par intervention au SCJ s'est élevé à 10,23 \$ en Phase 1 et à 12,30 \$ en Phase 2.

**Conclusions :** Par rapport aux autres agents anesthésiques, le sévoflurane utilisé comme anesthésique en chirurgie externe n'a pas accéléré le rétablissement ou la libération ni procuré d'avantages sur le plan des coûts. Son rôle semble donc limité à offrir une solution de rechange au propofol comme anesthésique inhalé pour provoquer l'anesthésie en contexte de chirurgie externe.

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## INTRODUCTION

Sevoflurane is a new inhalational anesthetic agent first marketed in Canada in the spring of 1996. Sevoflurane lacks the pungent effects of other inhalational agents and demonstrates rapid onset, emergence and recovery properties and, thus, is useful for both induction and maintenance anesthesia.<sup>1,2</sup> These pharmacologic properties are touted as its advantages over conventional inhalational agents and intravenous propofol. Its time effects suggest that sevoflurane may be of greatest benefit in an outpatient setting (surgical daycare unit) where short procedures are performed.<sup>1-3</sup>

The issue of cost-effectiveness of anesthetic agents has been addressed recently by Philip.<sup>4</sup> In addition to acquisition costs, there are the associated costs of administering an inhalational agent — equipment costs, for instance — that must also be considered. To confer economic benefit, the acquisition and associated costs of sevoflurane would have to be lower per case than other traditional agents with equal or better outcomes, or the use of sevoflurane would have to permit a greater number of surgical procedures per day. We were unable to locate any published evidence

to support these hypotheses. The role of sevoflurane in the institutional setting, therefore, remains unclear.

In this major tertiary care centre, 1995 fiscal year expenditures for anesthetic agents were approximately \$95,122 (Cdn.). In June 1996, as a formulary feasibility trial, sevoflurane was introduced for unrestricted use to the surgical daycare unit (SDU) at our institution. The goals of this trial were to assess the impact of sevoflurane on anesthetic-related patient outcomes and on anesthetic acquisition costs for the SCU at our institution.

## METHODS

This study was a 2-phase, retrospective observational assessment comparing a group of patients who received sevoflurane for dental or gynecologic procedures in the SDU to an historic control group of patients who received other anesthetic agents (propofol, isoflurane and/or thiopental) for dental or gynecologic procedures. While propofol and thiopental are administered via the intravenous route, isoflurane and sevoflurane are administered via inhalation and require product-specific vapourizers.

The 50 patients in the control group were randomly selected from a health record list of 1151 patients who underwent dental or gynecologic procedures during a 3-month period (August 1995 – October 1995, called Phase 1 for our purposes) 1 year before sevoflurane became available. These 2 surgical services were responsible for 52% of all procedures performed in SDU and patients from these services routinely required general anesthesia. The 50 patients in the sevoflurane group were then randomly selected from a list of 229 dental and gynecologic patients who had been identified as having received sevoflurane for anesthetic induction and/or maintenance purposes during a 3-month period (August 1996 – October 1996, called Phase 2 for our purposes) 1 month after sevoflurane was introduced to the formulary. Anesthetists for the 4 SDU operating rooms with sevoflurane vapourizers generated this list.

The health record was the primary source of data. Data were collected on patient demographics, procedure characteristics and characteristics of the anesthetic regimen. Outcome data included anesthetic-related toxicities, ancillary drug use, and time interval outcomes related to admission, recovery and duration

Table I — Patient characteristics

Parameter	Control group	Sevoflurane group	p value
Number of patients	50	50	
Female (%)	94	92	NS*
Mean age in yrs (and range)	32.9 (14– 78)	31.7 (16–64)	NS†
Mean weight in kg (and range)	61.6 (42–106)	61.8 (41–91)	NS†
Surgical type (and %)			p=0.015§
Dental	9 (18)	20 (40)	
Gynecologic	41 (82)	30 (60)	
Comorbid illness (%)			p=0.009§
None	44 (88)	33 (66)	
1 or more	6 (12)	17 (34)	

\* Not significant, Fisher's exact test  
† Not significant, Student's t-test (2-sided)  
§ Chi-square test

of stay. For both phases, information regarding time interval outcomes and patient recovery was documented in the health record by SDU personnel in accordance with existing hospital guidelines.

Two investigators collected, entered and analysed the data using an inferential statistical software package (SPSS for Windows, Version 6.2). Patient characteristics were analysed using the Chi-square test (categorical data) and Student's t-test (continuous data). Time interval outcomes, stratified by procedure, were analysed using the Wilcoxon rank-sum test.

Anesthetic expenditures adjusted for patient volume were determined for each phase. The anesthetic costs per case were calculated by dividing the total acquisition costs of propofol, isoflurane, thiopental and sevoflurane by the number of SDU patient discharges as reported by the hospital's Departments of Corporate Planning and Finance and Health Records. Costs reflected the use of anesthetics for both induction and maintenance anesthesia. An equivalent mix of outpatient surgical cases that required general anesthesia was assumed in each phase.

## RESULTS

### Patient characteristics

Table I shows a comparison of the demographic and clinical characteristics of the study groups. Patient demographics were similar; however, more patients underwent dental procedures and had comorbid illnesses in the sevoflurane group ( $p=0.015$  and  $p=0.009$ , respectively). All further analyses were, therefore, stratified by surgery type to account for the difference in procedures between groups. Data were stratified by comorbid illnesses.

### Anesthetic use

Before sevoflurane was introduced, propofol induction followed by isoflurane maintenance was the most common combination (63%) employed. In the sevoflurane group, sevoflurane induction and maintenance occurred most commonly (74%), followed by propofol induction and sevoflurane maintenance (23%). A combination of the two inhalational anesthetic agents was used in less than 3% of patients.

### Anesthetic-related toxicities and ancillary drug use

There were no significant differences between groups in the documented incidence of anesthetic-related side effects. The following side effects were observed for each phase (Phase 1, Phase 2): nausea (2%, 6%), restlessness (2%, 2%), and vomiting (2%, 2%). In addition, there were no documented differences between the two phases in the frequency of ancillary drug use (e.g. narcotics, benzodiazepines, skeletal muscle relaxants, antihistamines).

### Time interval outcomes

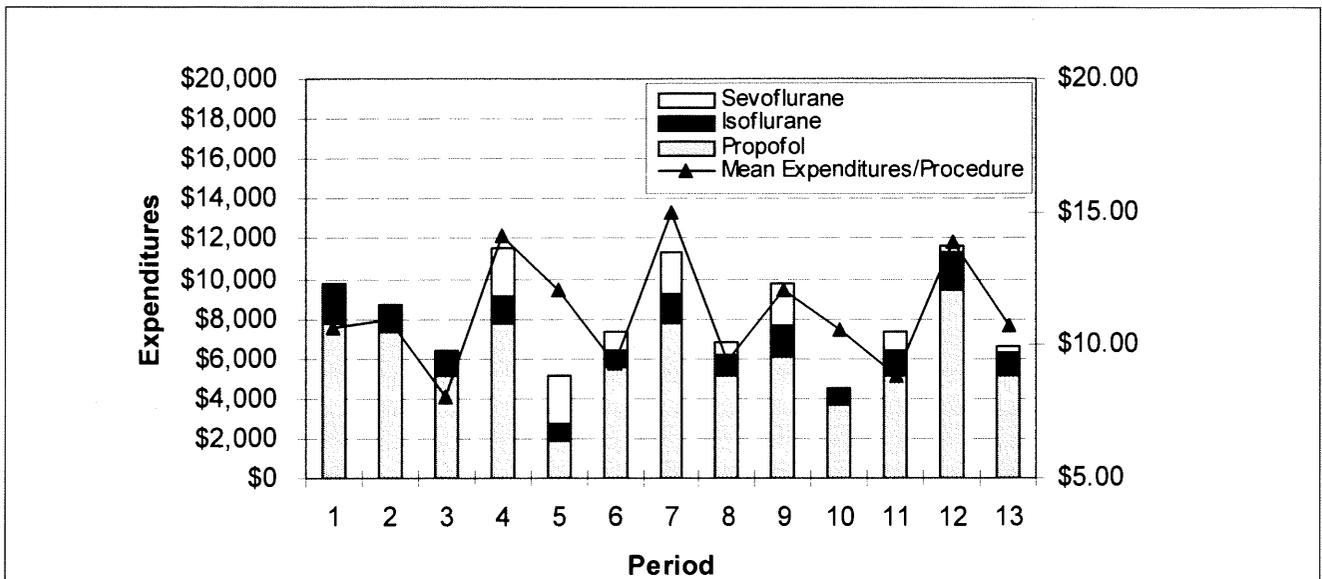
Table II summarizes time interval outcomes, stratified according to study phase and surgery type. Gynecologic procedures tended to be shorter in duration than dental procedures, although patients tended to remain in SDU for a similar length of time (approximately 4.5 hours). With the exception of the median time interval between admission to the recovery room and the achievement of a conscious-drowsy state ( $p=0.012$ ), there were no differences in time interval outcomes as a result of sevoflurane use in gynecology patients. No differences were found for patients who underwent dental procedures. Further analysis revealed no differences in time interval

Table II — Time interval outcomes in study groups stratified by surgical procedure

Interval measured	Time intervals per surgery type in minutes (and range)			
	Gynecologic (n=71)		Dental (n=29)	
	Control group (n=41)	Sevoflurane group (n=30)	Control group (n=9)	Sevoflurane group (n=20)
Duration of surgical day unit stay	261 (182–409)	238 (170–463)	261 (193–330)	280 (207–477)
Duration of operation	15 (4–36)	20 (4–90)	32 (21–46)	34 (12–120)
Anesthesia start to operation start	5 (1–18)	6 (2–18)	10 (1–15)	10 (2–18)
Anesthesia end to recovery room admission	1.5 (1–5)	1 (1–4)	1 (1)	2 (1–7)
Recovery room admission to conscious-drowsy state	0 (0–32)	0 (0–12)*	0 (0–10)	0 (0–5)
Recovery room admission to conscious state	31 (13–71)	30 (0–140)	26 (12–46)	27 (15–60)
Recovery room admission to discharge	121 (56–196)	114 (66–308)	119 (85–208)	127 (35–322)
Conscious to discharge	116 (22–180)	89 (48–285)	93 (59–170)	104 (20–305)

\* $p=0.012$  (Wilcoxon rank-sum test)

**Figure 1 — Surgical day unit anesthetic fiscal year expenditures. The formulary feasibility study trial (Phase 2, the sevoflurane group) conducted during period 4–7. Phase 1, the control group, data not shown. Isoflurane \$57.49/100mL bottle, sevoflurane \$300/250mL bottle, propofol \$21.51/50mL (10mg/mL) vial, as per hospital contract.**



outcomes in patients with comorbid illnesses compared to those with none.

### Anesthetic acquisition costs

The mean anesthetic expenditure per patient across all surgical procedures in the SDU was \$12.30 during Phase 2, compared to \$10.23 in Phase 1. There was a similar number of patient procedures in each phase (1964, Phase 2; 1854, Phase 1).

Figure 1 shows the impact of sevoflurane on total anesthetic acquisition cost for the SDU for fiscal-year 1996. After the introduction of sevoflurane to the SDU, the mean anesthetic expenditure per procedure was \$11.64 for fiscal-year 1996 compared to \$10.03 for 1995 (16% increase). Sevoflurane expenditures for 1996 were \$12,000, representing 11% of total anesthetic expenditures in the SDU. Since completion of the study, sevoflurane use per period has decreased on average by 65%, although the anesthetic cost per patient procedure has been relatively stable.

### DISCUSSION

There has been much speculation in the literature that the use of newer inhalational agents in the outpatient surgery setting will result in faster recovery,

decreased length of stay, maximized use of operating room resources and a reduction in waiting lists.<sup>5</sup> Although these advantages appear promising, they are theoretical and have not been demonstrated under the rigorous conditions of a clinical trial. Comparative studies have not been able to show differences in time outcomes between sevoflurane and isoflurane in outpatient settings.<sup>6,7</sup> In addition, a recent study found that decreases in anesthesia controlled time do not necessarily result in the ability to schedule additional surgical operations per workday.<sup>8</sup> Therefore, the characteristics of anesthesia alone cannot reasonably decrease case times sufficiently to result in an economic benefit to the institution. These previous observations are in agreement with the results from our evaluation. We were unable to identify significant differences in time outcomes between patients who received sevoflurane and those who received other traditional agents. This observation may be due to rigidity in admission, anesthesia, surgery and recovery procedures such that minor changes in recovery time are unlikely to translate into additional procedures being performed.

In our evaluation, there were no apparent differences in the documented incidences of anesthetic-related toxicity between patients who

received sevoflurane and other anesthetic agents. This observation is consistent with those of other investigators who have seen either a similar incidence or fewer side effects with alternative agents in comparative trials.<sup>6,7,9</sup>

If there are no documented clinical advantages of sevoflurane over other agents for anesthesia, the decision to use it in an institutional setting should be based on relative acquisition and administration costs. Our evaluation revealed that we have not realized a cost advantage through introduction of this agent. Moreover, we underestimated the cost of sevoflurane because we did not consider other hardware costs specific to sevoflurane.<sup>4</sup> For example, the cost of a vapourizer is approximately \$3500–\$5500 (personal communication, Abbott Laboratories Ltd.).

It appears that there has been a trend toward a reduction in the use of sevoflurane since it was introduced to our institution. This observation seems to represent a shift in anesthesiologists' practice back to the use of traditional agents and is a reflection of the typical initial interest in a new drug. A period of increased use is usually followed by a period in which the use of the agent is determined by its relative merits. In this case, the initial novelty appears to have worn off fairly quickly.

There were several limitations associated with the study design we employed. This was a retrospective evaluation involving a pre-post study design. It is possible that conditions other than relative use of anesthetics (e.g. case mix, patient acuity, policy and staffing changes) may have changed in the SDU during the study, confounding our ability to detect the impact of sevoflurane use. As gas mixture and flow rates were inconsistently documented, we were unable to reliably calculate the anesthetic costs incurred by each patient in each phase. Thus, we were forced to utilize gross expenditures to estimate anesthetic cost per patient procedure. In addition, time intervals recorded in the health record may be imprecise; however, we believe that any subtle differences in time outcomes do not translate into a practical benefit as they do not result in quicker discharge times.<sup>6,7</sup> Due to time and manpower limitations, we were only able to assess a sample of 50 procedures per study phase. Consequently, the power of our statistical analyses was limited. Finally, our results should be considered

specific to this institution and should therefore be extrapolated to other practice sites with caution.

Rigorously conducted randomized trials are needed to determine the relative economic impact of sevoflurane versus other agents for various surgical procedures. A recent study by Wagner and O'Hara<sup>10</sup> compared the economic aspects of sevoflurane versus isoflurane anesthesia in women undergoing elective ambulatory surgery. Total charges for patients receiving sevoflurane were greater than those associated with procedures involving isoflurane and were primarily associated with prolonged anesthesia and surgical unit stay; however, the sample size was small (n=47 in total) and none of these differences was statistically significant. Additional limitations are that the study involved a mixture of surgical procedures. In addition, it was conducted in a United States setting and the authors utilized charge data as opposed to direct medical costs. Consequently, these results cannot be easily extrapolated to the Canadian health system.

In conclusion, the use of sevoflurane in outpatient anesthesia did not seem to permit quicker recovery or earlier discharge of patients undergoing dental or gynecologic procedures. In addition, the use of sevoflurane did not seem to result in any cost advantage over traditional agents. Since its availability on the formulary, sevoflurane use has decreased considerably in our institution; thus, its role in an outpatient setting remains unclear. A possible role for sevoflurane may be as an inhalational alternative to parenteral propofol for induction because it lacks the pungent effects of other inhalational agents.

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