# Minimizing cost of volatile inhalational anesthetics

P – The population that will be examined are male and female patients with a physical status (PS) of I-II requiring general anesthesia for surgery, ages 20-40.

I – The intervention being introduced is utilizing Sevoflurane (Ultane®) as the inhaled anesthetic for surgeries requiring general anesthesia lasting less than one hour.

C – The comparison group will be those utilizing Desflurane (Suprane®) as the inhaled anesthetic for surgeries requiring general anesthesia lasting less than one hour.

O – The use of Sevoflurane for surgery cases requiring general anesthesia for less than one hour will save money for the anesthesia department rather than using Desflurane.

PICO Question: Will the use of Sevoflurane rather than Desflurane in surgeries requiring general anesthesia lasting less than one hour save money for the anesthesia department?

## Abstract

Inhalation anesthetics are used millions of times every single day in surgeries requiring general anesthesia all over the world. Cost containment is anesthesia is no longer an option, it is an absolute necessity. Anesthetic drugs account for up to 6 percent of total hospital pharmacy costs and inhalation agents comprise over twenty percent of that as a whole. One of the areas most amenable to cost reduction in the anesthesia department budget is the use and choice of inhalational anesthetic. A quantitative quasi-experimental controlled trial was developed to determine if money could be

saved in the anesthesia department by utilizing Sevoflurane as the inhalational anesthetic for surgeries requiring general anesthesia less than one hour rather than Desflurane. The study chose males and females, ages twenty to forty, requiring general anesthesia at a mid-sized, urban, teaching hospital in South-Western Pennsylvania. Prices of anesthetic agents were gathered from the same facility and calculated to determine the total cost savings that would ensue with the use of the interventional inhalation agent rather than that used by the control group. The use of Sevoflurane for two-thirds of the cases which Desflurane was used saved the institution over twenty thousand dollars.

Key Words: Inhalational Anesthetics, Pharmacoeconomics, Desflurane, Sevoflurane, Anesthesia

# Introduction

Research Problem:

The cost of health services and technologies continue to increase exponentially while resources are finite. Developing effective strategies to minimize costs without compromising patient safety and quality of care are the most difficult challenges medical professionals experience. 13 Inhalational anesthetics comprise twenty percent of the drug expenses in anesthesia departments. The cost of inhalational anesthetics depend on their potency, which is their minimum alveolar concentration (MAC), the minimum amount of inhalational anesthetic needed in the lungs to facilitate the absence of movement to noxious stimuli, the fresh gas flows (FGF) used to deliver the anesthetic gas, the amount of anesthetic vapor released by each

milliliter of liquid, and the price of the inhalational anesthetics themselves. 2, 16

Inhalational anesthetics are used when general anesthesia is needed for surgery and patients do not have diseases or conditions which would preclude them from being able to utilize them (e. g. those who have malignant hyperthermia). The anesthesia provider decides which inhalational anesthetic is best for a given patient, based on their history and needs for the surgery. The problem exists when providers just use whichever anesthetic is most easily accessible at that time without minding any consideration as to the cost of the particular gas and the level of FGF they are using, which is purely a waste of money as the patient will lose heat and humidity, waste high levels of inhaled anesthetic, and demise cost containment for the anesthesia department.

Statement of Purpose

The purpose of this research study is to determine whether the implementation of Sevoflurane as the choice inhalation anesthetic for surgery requiring general anesthesia for procedures lasting less than one hour rather than using Desflurane will provide cost containment for the anesthesia department.

Objectives/Aims

The objective of this study is to provide an avenue of cost containment for the anesthesia department of a mid-sized, urban, teaching hospital and overall savings for the medical health system. This will allot more money in

the department budget to be spent on technological advances, and equipment used to better develop opportunities for patient safety, the ultimate goal of all medical professionals.

## Review of Literature:

Many studies explore different methods of cost containment in the anesthesia department. Almost all of the studies exclusively develop the notion of cost savings related to the fresh gas flows used to deliver inhalation anesthetics. “ Cost containment requires primarily a decrease in FGFs, but it may also be influenced by a rational use of the available halogenated agents.” 3 With the advances in technology and the ultra-modern anesthesia machines available, anesthesia providers should feel safe in using minimal FGFs to deliver anesthesia that would not harm their patients in any way. 3 Anesthetists can directly influence healthcare costs through the patterns in which they practice, which includes reducing the FGFs chosen during inhalational anesthesia, which will directly affect the amount of inhaled anesthetic delivered to the patient and ultimately the costs which are attributable to inhaled anesthetics. 10, 15

Depending on breathing systems used, which are mostly semi-open today, up to ninety percent of the anesthetic gases delivered escapes into the atmosphere completely unused. By using low-flow anesthesia, most of the patient’s air they exhale is recycled and then returned to the patient’s lungs after the carbon dioxide from the exhaled air has been absorbed. 15 There are also advantages of using low-flow anesthesia such as conserving the patient’s heat and humidity, making it less of a need to warm the patient externally, which will cut down costs on heating blankets and the like, as well

as maximized the rebreathing of the exhaled anesthetic, which will cut down on the amount of gas vented into the environment, 6 but there are cautions that anesthesia providers must take when using low FGFs, as titration in inhalation anesthetic is not as easily predicted.

Product labeling for Sevoflurane does include a warning that patient exposure should not exceed two hours using FGF rates greater than one and less than two liters per minute. 7 Also, it is not recommended at all to maintain FGFs less than one when using Sevoflurane as the patient's inhalational anesthetic of choice. These recommendations are to minimize the risk of exposure of the patient to compound A which in laboratory animals, has been shown to be linked to nephrotoxicity. There are no minimum flow rate designations that exist for Desflurane. 7, 8

Isoflurane is less expensive than Sevoflurane and Desflurane at equal dose and the same FGFs. 7 When comparing Sevoflurane with Desflurane as they are being used for surgeries lasting less than two hours, there was a ninety percent decrement time for Sevoflurane which approached the short duration of anesthesia matching that of Desflurane. However, when the duration of anesthesia increased over two hours, Sevoflurane's ninety percent decrement time approached that of Isoflurane. 7

The cost of inhaled anesthetic agent can be estimated by using an equation that provides the cost of anesthetic per MAC hour:

" Cost per MAC hour ($) = [(Conc.)(FGF rate)(Duration)(MW)(Cost per mL)] / [(2412)(D)]" 6

The cost of one milliliter of Isoflurane is twenty-three cents, Sevoflurane is forty-one cents, and Desflurane is eighty-three cents. Regardless of the fast onset and emergence Desflurane offers, the cost of administering Desflurane is greater than the cost of Sevoflurane at any FGF rate. 10, 11

The cost of inhaled anesthetic agent can be estimated by calculating the cost per MAC hour, which is the administration of inhaled anesthetic agent at 1 MAC for a one hour time interval. The cost can be calculated using the concentration percent on the anesthetic dial of gas delivered, the FGF rate chosen, the duration of the anesthetic (sixty minutes in this case), the molecular weight of the anesthetic agent (MW in grams), cost per mL of liquid agent (in dollars), a factor accounting for the molar volume of a gas at twenty-one degrees Celsius (a constant of two thousand four-hundred twelve), and the density of the agent (D in grams/mL).

“ Cost per MAC hour ($) = [(Conc.)(FGF rate)(Duration)(MW)(Cost per mL)] / [(2412)(D)]” 6

The cost per MAC hour can be seen in Table 2. Desflurane is associated with a shorter recovery as is Sevoflurane, but the differences between the two in terms of patient discharge cannot be consistently shown in research studies. 13 Gupta evaluated n= 246 patients for recovery time after undergoing surgeries less than two hours with either Sevoflurane or Desflurane. Patients given Desflurane were able to open their eyes sixty seconds before those who received Sevoflurane, P <0. 00001. However, when the patients went to recovery, those who went under Sevoflurane were responding much quicker

to command than those who had Desflurane by six minutes, P <0. 00001. No other differences were found between the two groups of patients 14.

When comparing Sevoflurane and Isoflurane for patients who are undergoing surgery for more than two hours, Gupta evaluated n= 634 patients. The patients who underwent Sevoflurane were able to open their eyes sooner, P <0. 00001, time to obeying commands, and time for home discharge, P= 0. 05. There is only a very minute favoring of Sevoflurane, but it is important to note these discharge statistics are only based on two trial studies. There were no differences found in postoperative complications between Sevoflurane and Isoflurane. 13, 14

Savings of more than one hundred thousand dollars resulted from the change of using Desflurane to using Sevoflurane in the operating rooms at Montefiore Medical Center in the Bronx, New York. Traynor noted that three bottles of Desflurane are needed to maintain a level of anesthesia equal to that of one bottle of Sevoflurane, making this agent much less expensive for the hospital to utilize, with no difference in patient discharge times. Reviews of Literature indicated that patients who received Desflurane could be extubated in the operating room about two minutes sooner than the patients who received Sevoflurane; an advantage seen meaningless in the large scale of the operating room sequences. 9, 15

## Methodology

The research design chosen was a quasi-experimental study. It involved the use of an experimental group and a control group. It is important to mention that the control group was compiled from hospital anesthesia records. The

study did not involve randomization as a medical facility’s computer database cannot throughput this information. Permission from a mid-sized, Southwestern Pennsylvania teaching hospital was granted and all information gathered from the facility involved no patient identifiers, including gender or age. The hospital’s Institutional Review Board (IRB) was provided all details of the research study and deemed the research experiment to be exempt and permission was granted to start the study without any changes in the study’s design. General anesthesia data spreadsheets were gathered from the hospital exemplifying a patient anesthesia case total for the month of July, 2012. From this information, it was determined there were a total of n0= 1, 459 general anesthesia cases and after careful analysis, it was found that n1= 500 cases lasted less than one hour and n2= 959 cases lasted equal to or more than one hour in length from the beginning of anesthesia delivery to the end of the surgical procedure, as seen in Chart 1 in Appendix A.

The Southwestern Pennsylvania hospital was asked to provide their costs for Desflurane, Sevoflurane, and Isoflurane inhalation anesthetics. These prices can be seen in Table 1 of Appendix A. Utilizing the equation to calculate the amount of inhaled anesthetic used during a general surgical case in a sixty minute time duration, MAC hour costs could be calculated as seen in Table 3. The pharmacy was also asked to provide how many bottles of inhalational anesthetic are bought and used annually in their operating rooms. These results are seen in Chart 2 and calculated annual costs of the anesthetics are shown in Chart 3 in Appendix C

The experimental group for the research procedure involved men and women, ages twenty to forty, with PS scores of I and II, who were undergoing general anesthesia for surgery cases lasting less than one hour. These patients were administered Sevoflurane as their inhalational anesthetic during surgery at a FGF rate of 2 liters per minute (LPM). To be sure all patients were given the same standard induction regimen, all drug doses were based on current body weight calculations. Propofol, a sedative hypnotic was given at 2 milligrams per kilogram (mg/kg). Fentanyl, an opioid analgesic was given at 5 micrograms per kilogram (mcg/kg). Midazolam, a benzodiazepine sedative was given at a standard dose of 2mg/kg. Lidocaine, a class 2 anti-arrhythmic agent was given at 1. 5 mg/kg. All patients participating in the study were given their induction medications at these doses provided.

In the preoperative area, all patients were given the right to participate or not participate in the research experiment as they were provided a letter of informed consent, which described completely that they would be treated no differently than any other patient and they were voluntarily consenting to participate in a research study as an individual, and in no way obligated to participate if they were unwilling to do so.

Those who were not involved in the experimentation are those patients who were unwilling to consent to participate in the experiment as an individual. Those with malignant hyperthermia were excluded from the study as they could not receive volatile inhalational anesthetics. Patients who required additional narcotic for pain during surgery were excused from participation. Those with chronic kidney disease or kidney failure were also not involved in

the experiment as Sevoflurane, the experimental variable could lead to kidney complications. Participants who only were given inhalational anesthetic for painful stimulation during intravenous sedation were also excluded from participation in this study.

It was important to determine which inhalational anesthetic was favored most by anesthesia providers at the Southwestern Pennsylvania hospital between Sevoflurane and Desflurane for general anesthesia cases lasting less than one hour. Surveys were sent out to all members of the anesthesia team as titled “ Survey 1” in Appendix D.

Ethics/Professionalism

Ethical considerations were regarded during the completion of the study from start to finish. All information gathered from a Southwestern Pennsylvania hospital was kept in confidence and destroyed at the finish of the study by professional paper shredding services. Participant names, ages, race, nationality, and medical histories were not gathered from the hospital and were blinded from the investigator, owing to complete confidence of all those who participated during a twelve month interval.

## Results

Results are pending until the quasi-experimental research study is completed.

## Discussion

Volatile inhalational anesthetics account for twenty percent of pharmacy costs in the anesthesia department. 10, 16 By using a pharmacoeconomic

model, it can be seen that careful choice of anesthetic for patients can represent a large cost containment for the anesthesia department in the hospital, without compromising patient care. All patients need to be considered a new case and may not fit into the pharmacoeconomic model because of family histories (e. g. malignant hyperthermia). However, when possible, using Sevoflurane for the choice inhalation anesthetic for general surgery cases rather than Desflurane for those lasting less than one hour can result in large cost savings for the anesthesia department. Over twenty thousand dollars could be saved if the Southwestern Pennsylvania hospital would utilize Sevoflurane over Desflurane for two-thirds of their total surgeries requiring general anesthesia for less than one hour.

It is important to mention that as a professional anesthesia student, FGF commonly observed with Sevoflurane are 2 LPM and FGF with Desflurane commonly observed are 2 LPM. The nephrogenicity associated with Sevoflurane is not commonly observed when this amount of FGFs are used. 7 With the use of 1 LPM FGF when using Desflurane, as there is no minimum FGF required to avoid physiological aberrance, 17, 19 there is also a great cost savings maintained for the anesthesia department.

Limitations

There are limitations in any study when research is conducted and from this study, results are limited to a single institution and this limits its external validity as a result. Randomization was not included in this research study as a convenience sample population was used at one hospital location. The study was not extremely descriptive as patients with higher PS scores were

not studied in this particular research project. This study is also missing research on older age groups, as participants' age twenty to forty were included only. As all of these limitations can be seen in the experimental study, the results from this research study cannot be imposed on larger populations and therefore generalizability is poor. Future research can make these findings representable and provide for better generalization.

Future Recommendations for Research

In future research, randomization should be used when developing research as this will strengthen the results. Larger sample populations should be used in defined, smaller age variances to be able to impose the results on a specific group of patients. Defined surgeries should be used in sample populations to show stronger significance when looking at varied surgical procedures their results. With the inclusion of the above criteria, the research study would be experimental rather than quasi-experimental, and results could be superimposed onto given populations with much stronger data observance.

Dissemination

This research project will appear in the May, 2013 edition of Anesthesia and Analgesia in its entirety with all results included. There will also be one hour lectures provided on these research findings at the University of Pittsburgh at Greensburg, Robert Morris University, and St. Vincent College, times and final adjusted locations are to be announced via bulletins, which be hung in the cafeterias of each of these locations.

## Conclusion

Inhalational anesthetics represent a significant cost for pharmaceutical costs in the anesthesia department. It is important for professional anesthesia providers to deliver cost-effective, safe anesthesia care to patients in surgery. When analyzing surgical procedures requiring general anesthesia for less than one hour, the use of Sevoflurane rather than Desflurane as the choice inhalation anesthetic in surgery can provide the anesthesia department an avenue of cost savings without compromising patient care. When Desflurane must be used for patients who cannot be administered Sevoflurane, it is important to keep in mind there is no recommendation for FGF rates, and cost savings can also be preserved by utilizing low FGFs when using Desflurane.

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# Appendix A

Table 1: Cost of Inhalational Anesthetic per a Southwestern Pennsylvania Hospital Pharmacy Records

Inhalational Anesthetic

Cost Per Bottle ($)

Total Volume in Bottle (mL)

Cost per mL of Liquid ($)

Sevoflurane (Ultane)

100. 82

250

0. 40

Isoflurane (Forane)

9. 73

100

0. 09

Desflurane (Suprane)

136. 37

240

0. 56

Reference 19.

Table 3: Calculated MAC Hour Inhalation Anesthetic Cost at a Southwestern Pennsylvania Hospital

FGF Rate (L/Min)

Isoflurane ($)

Desflurane ($)

Sevoflurane ($)

1

0. 31

9. 68

2. 71

2

0. 62

19. 36

5. 43

3

0. 93

29. 04

8. 14

All estimated costs are based on duration of 60 minutes and the formula proposed by Golembiewski.

Isoflurane calculations are based on concentration of 1. 15%, MW of 184g, cost per mL=$0. 09 and D of 1. 49 g/mL

Desflurane calculations are based on concentration of 6%, MW of 168g, cost per mL=$0. 56, and D of 1. 45g/mL

Sevoflurane calculations are based on concentration of 2. 0%, MW of 201g, cost per mL=$0. 40, and D of 1. 51g/mL

# Appendix B

Chart 1: Total Anesthesia Cases in July, 2012: Time Intervals from a Southwestern Pennsylvania Hospital

Reference 18.

Table 2: Estimated Cost per MAC Hour ($) of Inhaled Anesthetic Gases: Based on FGF Rates

FGF Rate (L/Min)

Isoflurane ($)

Desflurane ($)

Sevoflurane ($)

1

0. 5

12. 9

6. 0

2

1. 0

25. 9

12. 1

3

1. 5

38. 8

18. 1

All estimated costs are based on duration of 60 minutes and the formula proposed by Golembiewski.

Isoflurane calculations are based on concentration of 1. 15%, MW of 184g, cost per mL=$0. 15 and D of 1. 49 g/mL

Desflurane calculations are based on concentration of 6%, MW of 168g, cost per mL=$0. 96, and D of 1. 45g/mL

Sevoflurane calculations are based on concentration of 2. 0%, MW of 201g, cost per mL=$0. 90, and D of 1. 51g/mL

Reference 7.

# Appendix C

Chart 2: Number of Bottles of Inhalational Anesthetic Used Annually at a Southwestern Pennsylvania Hospital

Reference 19.

Chart 3: Annual Expenditure on Inhalational Anesthetics at a Southwestern Pennsylvania Hospital