Pharmacoeconomics: Cost Effective Choices

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"It is now almost universally believed that the resources available to meet the demands for health care are limited."
(Weinstein & Stason, 1977[1])

The concept that health care expenditures are out of hand is not new. Throughout the world governments continue to try to control health care costs. In particular, hospital costs, drug expenditures and physician reimbursement are examined closely. In the investigation of new drugs, demonstrations of efficacy and safety are no longer sufficient and must be accompanied by an evaluation of the cost implications—pharmacoeconomics—of their introduction. Anesthesia is targeted, not only as the users of drugs, but also as a component of hospital costs (2).

The three goals of this refresher course are as follows:

1. To explain the language of health care economics, particularly as applied to anesthesia—PHARMACOECONOMICS.
2. To summarize those studies concerned with cost-benefit and cost-effective analysis in the field of anesthesia—PROCESS ANALYSIS.
3. To identify the problems, omissions and misinterpretations of pharmacoeconomic studies in anesthesia practice—COMMON PROBLEMS.

For most patients, surgery is inconvenient. It interferes with their ability to earn a living and undertake family responsibilities, it interferes with community involvement, and it prevents them from continuing their normal daily activity. During the last 50 yr, developments of drugs used during anesthesia have improved the safety of surgery, decreased the incidence of postoperative complications, and allowed earlier discharge from hospital. However, the currently used drugs are still imperfect. Further progress is needed to provide continued improvement in the process of anesthesia and increased patient comfort. Although it is unlikely that such evolution will have any impact on anesthetic mortality and the incidence of severe morbid effects, the quality of our service should improve. Drug development is expensive. During the last 20 yr, additions to the anesthetists' armamentarium (induction agents, anesthetic vapors, analgesics, local anesthetics, muscle relaxants) have required capital investment by industry with the expectation that successful compounds will be profitable. The limitations imposed by cost controls in health care not only threaten new drug availability but also, in some institutions, have restricted access to several currently used, effective products.

Although attempts have been made to improve efficiency (reduced length of stay, same-day admission surgery, elimination of unproven therapy), for most patients in North America, access to medical care has deteriorated in the last decade. Waiting lists are longer and the cost to the patient has increased. Anesthesia has not been ignored. Drugs, like beans, are easy to count. The availability of effective drugs has been limited. Too often, withdrawal of supply has been haphazard and not founded on economic or pharmacological principles. Thus, the science of pharmacoeconomics has emerged in an attempt to produce a more logical foundation for changes in therapy. Although the principles are relatively new, it is hoped that by development and further analysis, effective treatment will continue at the lowest cost.

It is salutary to appreciate the size of the contribution of anesthetic drugs as a proportion of the hospital budget. Hawkes et al. (3) demonstrated in 1994 that pharmacy expenditure was approximately 5% of the hospital budget and that the anesthetic drug cost was 5% of the pharmacy budget. Inhalational anesthetics account for 1/3 of the cost, muscle relaxants for 1/4, and induction agents for 1/5. The remainder consists of local anesthetics, analgesics, IV fluids, and such. However, one should remember that the drug costs of anesthesia amount to only 50¢–$1/min. For most hospitals, the cost of supplies used during anesthesia is similar to drug costs.

Pharmacoeconomics

"Pharmacoeconomics is the description and analysis of the costs of drug therapy to health care systems and society" (4). It is concerned with three areas of analysis:

1. Comparison of drug therapy with other treatment modalities.
2. Cost effectiveness of alternative drugs.
3. Methods and procedures to improve cost effectiveness.

Specific tools have evolved to allow the orderly and comprehensive collection of data and its analysis (Table 1) (4,5).

Table 1. Tools for Pharmacoeconomic Analysis

1. Cost-Benefit Analysis
2. Cost-Effectiveness Analysis
3. Cost-of-Illness Analysis
4. Cost Minimization Analysis
5. Cost Utility Analysis

Cost-Benefit Analysis

The collection of all costs of treatment (drugs, personnel, process) and their consequences (return to employment, cost of nontreatment or eventual therapy). Both measures are expressed in financial terms ($). It is appreciated that while the costs of specific treatment are easy to obtain (drug costs) that of the consequences (eventual therapy, support costs) are variable and difficult to estimate.

Cost-Effectiveness Analysis

The costs of treatment ($) to achieve specific therapeutic objectives are assessed. The costs of anesthesia care (personnel, drugs, equipment) form part of the cost of surgical treatment.

Cost-of-Illness Analysis

An attempt to estimate the total cost of a period of illness including not only the specific and easily identified costs (such as hospital cost of admission, surgical procedures, personnel) but also the price of absence from work, employment of substitutes, provision for family, and community responsibility to others, special diets and continuing medical therapy until return to normal activity.

Cost Minimization Analysis

Comparison of the costs of alternative equivalent treatments. However, outcome is seldom the same (e.g., the shift from intermediate neuromuscular relaxants to generic pancuronium is associated with a higher incidence of postoperative residual weakness) (6).

Cost Utility Analysis

The outcome of treatment is measured in terms of quality of life, willingness to pay or patient preference for one treatment over another. Although this appears to be an index of consumer satisfaction, choices are influenced by several factors. As with the purchase of automobiles, education or vacations, the preparedness to pay should not be equated with utility. Attempts at defining outcome in terms of quality of life per additional year of life (QUALYs) may be suitable in measuring the effect of treatment of a fatal disease but are difficult to apply to anesthesia. However, the development of such indices is important, as modifications in anesthesia practice are likely to result in improved quality and not quantity of life.

Process Analysis in Anesthesia

It is clear that the economic impact of pharmacological therapy is more than the cost of the drugs themselves. Pharmaceutical agents are only part of the therapeutic regimen. This is particularly evident in anesthetic medical practice with its heavy demand on the frequent or constant attendance of personnel. In addition, attempts should be made to identify the secondary effects of drugs on the consumption of resources for example in the management of complications of therapy (postoperative emesis, anaphylactoid reaction, death). There are now several Cost Analysis studies of the process of care relevant to anesthesia, of which drug therapy plays a part.

Patient-Controlled Analgesia

Postoperative PCA is expensive. Before instituting the service equipment must be purchased and nursing, pharmacy and other staff trained in its safe use. Moote (7) estimated that the cost of providing PCA to 1200 patients per annum in a general hospital varied from $159–$255 per patient. Personnel costs accounted for 89% of the total and supplies for 11% of which the cost of morphine was only $11 (Table 2). The cost of the drug is irrelevant to the cost-effectiveness of the system. Some of the cost is borne by the hospital but the most expensive component, physicians' fees, is the responsibility of the third party payer.

In a recent, randomized, controlled study inpatients after hysterectomy Choiniere et al. (8) were unable to demonstrate improved analgesia or decrease in adverse reactions in women receiving PCA than in those receiving regular IM morphine. The cost of therapy was slightly more expensive in the PCA group ($33 vs $13). No attempts were made in this study to examine the differences in nursing time in the two groups or to evaluate patient satisfaction.

Intensive Care

Critical care is expensive and, as patient outcome is influenced by the process of critical care delivery (9). It

Table 2. Cost of Patient-Controlled Analgesia (PCA)

Supplies	$16
(Morphine: $11)	
Labour	$76
(Nursing, Labor, Other)	
Start-up costs	$15
Anesthesia	$51–146
TOTAL	$158–$253

Estimated costs of providing PCA to one patient in a general hospital with an Acute Pain Service treating 1200 patients per year. Start-up costs were spread over five years. %Adapted from Moote (7). <〉 <〉

is important to audit the process in terms of severity of illness, therapeutic interventions and nursing workload (10) so that cost-effective analysis can be performed. Wound infection after cardiopulmonary bypass leads to increased length of stay with an increase in cost of about $3,000 per patient affected. The cost of appropriate drug therapy is a small proportion of total cost but inappropriate choice of antibiotic will further prolong the length of stay (11).

The cost and outcome of very low birth weight infants treated in a neonatal intensive care unit showed that infants weighing 1000–1499 g gained most benefit in terms of years of life saved. The outcome assessed was quality-adjusted life years and the cost of the treatment (including all continuing costs incurred after leaving hospital) was $3,200 for each year of life gained (12).

Surgical Day-Care and Same-Day Surgery

Three quarters of a hospital's budget provide salaries for nonphysician personnel. Financial driving forces, rather than patient preference and convenience, are the principal factors in a change of surgical practice in North America. Hospital administrators know the cost of a day in hospital so that the goal has become one of reducing the length-of-stay assuming that increased efficiency will save costs or, at least increase activity for the same cost. In the US, admission on the day of surgery may be demanded by reimbursement practices by third party payers. The goal of same-day admission surgery is to provide patients and medical staff with cost-effective surgical care (13).

Performing surgery in an ambulatory care environment or on the day of admission adds cost. For example, if the patient is not admitted overnight, those processes that are usually completed on the evening before surgery, (nursing education, anesthetic and surgical evaluation, laboratory testing, medical student, and resident education), must be performed elsewhere. Admission and preparation areas will be required and, before discharge from hospital, recovery rooms will need to be enlarged and waiting rooms added and staffed. Newer and more expensive drugs may be needed to ensure rapid wakening from anesthesia and provisions for analgesia and antiemetics will be necessary (14). Few have attempted to replace these activities with preadmission clinics, although they are popular with patients, or to reconcile the total costs of performing surgery the "new way." Nevertheless, it is anticipated that at least the "hotel costs" of feeding, cleaning, and laundry will be reduced or eliminated. However, those patients who continue to be admitted are likely to be sicker and, therefore, to require more intensive care. For some areas, such as ophthalmic, plastic, and otolaryngological surgery, ambulatory surgery units are ideal. Attempts have been made to extend same-day admission surgery programs to more major surgery. With appropriate care, some patients may be admitted on the day of cardiac surgery (15). Considerable savings can be made by changing practice patterns in cardiac surgery (16), but most have shown that although length of stay may be reduced, the cost savings are minimal (17). Considerable savings are possible when patients undergoing carotid endarterectomy are managed more efficiently. Same-day admission, reduced intensive care unit stay, and discharge on the day after surgery can be achieved safely and with a saving of $2000 per patient (18), an amount much greater than likely to be achieved from savings on anesthetic drugs.

Anesthesia

To date, most pharmacoeconomic studies in anesthesia have been restricted to cost effectiveness investigations with the implied purpose of cost reduction. It is easy to track anesthesia in terms of drug acquisition costs (19), but comparative studies and attempts to determine the outcome of equivalent anesthetic techniques are beginning to be reported (20), and differences are difficult to determine. Todd et al. (21) were unable to demonstrate any important differences in short-term outcome (intracranial pressure, hemodynamic variables, emergence, hospital stay, postoperative neurological deficits) of patients undergoing craniotomy randomized to one of three anesthetic techniques. Patients anesthetized with fentanyl/nitrous oxide had a higher incidence of vomiting than those anesthetized with either propofol/fentanyl or N_2O/isoflurane. The difference in the costs of these drugs ($100 per patient maximum) was inconsequential in the total cost of the procedure. Also, more sensitive indices of morbidity are required before assuming that the treatments were equivalent. In a comparison of four general anesthetic techniques for general surgery the total cost (operating room plus ward) varied from $1800 to $2100, but the differences were not statistically significant (22). Retrospective comparison of the costs of general anesthesia and IV regional anesthesia for outpatient hand surgery demonstrated that IVRA resulted in net savings of $23 per patient

(23). However, in 11% of patients IVRA was unsuccessful and required conversion to general anesthesia.

The complicated interrelationship (24) among providers (anesthesiologists), payers (government, insurance companies), facility (hospitals), and technology (drugs, equipment) demonstrates that emphasis on only one component (cost of drugs) is likely to have only a limited effect on the cost and provision of anesthesia care.

Inhalational Anesthetic Agents. Calculating the cost of administering an inhalational agent from the acquisition price of the liquid is complicated. The amount used will depend on the volume of vapor from each mL of liquid, fresh gas flow rate (FGF), effective potency (% at the vaporizer to achieve constant alveolar concentrations), and unit volume price. Thus, the low FGF with closed circuits leads to decreased consumption although time to equilibration to a new concentration time will be longer. It has been estimated that because equilibration is achieved more rapidly for poorly soluble vapors, the cost of supplying 1 MAC anesthesia for 1 h using low FGF (<1 L/min) is less using desflurane than isoflurane. This occurs because of desflurane's lower solubility despite its greater unit cost (25). However, in clinical practice the introduction of sevoflurane and/or desflurane usually results in an increase in anesthesia drug costs!

There are several guides to estimating the cost of inhalational agents with the following basic format (19):

$$\text{Cost} = \text{P(insp\%)} \times \text{F(FGF)} \times \text{T(min)} \times \text{M(MW)} \times \text{C(\$/L)} / 24.12 \times \text{D(Density)} \times 100$$

It must be emphasized that these calculations need to be correlated with the actual values obtained in clinical practice.

Neuromuscular Blocking Drugs. Several of the cost minimization analyses concerning anesthesia drugs have been concerned with neuromuscular blocking drugs. By converting from the intermediate drugs—atracurium, vecuronium—to pancuronium, the possibility of large savings (26,27) without added risk have been claimed (2). However, any return to the greater use of pancuronium in place of atracurium or vecuronium is likely to be associated with residual paralysis in the postanesthetic recovery room (6) even after intraoperative neuromuscular monitoring and reversal of their effects.

The acquisition costs of relaxant drugs to facilitate tracheal intubation (approximately $2 \times ED_{95}$) varies from $1 for succinylcholine to $13-$16 for atracurium, vecuronium, or mivacurium. The cost of maintaining adequate relaxation during surgery (>90% block) will vary from $6/h for succinylcholine to $2.25 for pancuronium and $8 for atracurium or vecuronium. Costs of reversal agents are similar for atropine-neostigmine and atropine-edrophonium ($1.50), which is a little less than for glycopyrrolate-neostigmine ($2.50) (28). However, such data require considerable interpretation to be useful. For example, how can the cost of muscle pains after succinylcholine or the morbidity of prolonged weakness in the recovery room after long-acting relaxants be estimated? Drug costs depend on the number of ampoules opened and not on the amount of drug given. Savings might be possible if a sufficient number of anesthetists converted to using short-acting relaxants (such as mivacurium) allowing earlier discharge from the recovery room, but these would only be achieved if the number of nursing staff in the area was decreased.

Rathmell et al. (29) attempted to determine the cost-benefit of replacing pancuronium with doxacurium or pipecuronium during cardiac anesthesia. They concluded that the greater cardiovascular stability of doxacurium and pipecuronium did not justify the 10-fold increase in cost.

Common Problems

Principles of Cost-Effective Analysis

Six basic principles govern the proper execution of cost-benefit and cost-effective analysis (Table 3):

1. There should be an explicit statement of the perspective of the analysis. That may concern society, insurers/third party payers, hospitals, physicians, or patients.
2. There should be a description of the benefits of the program or technology being studied.
3. The types of costs should be specified, including direct and indirect costs, cost of side effects, and costs from additional health care required as a result of the program.
4. Costs should be discounted if the timing of the costs and benefits are different.
5. Sensitivity analysis should be performed to test important assumptions.
6. Measurements of efficiency such as cost-benefit or cost-effectiveness ratios should be calculated and, preferably, expressed as the marginal or incremental costs of the proposed of therapy.

Unfortunately, recent investigations have not usually satisfied these criteria either in the field of general medicine (7) or, more specifically, in the use of pharmaceuticals in critical care (8). The most frequently omitted principles are those examining perspective, discounting, sensitivity analysis, and efficiency. In mathematical terms, health care costs, (C_{TOT}), equal the sum of the direct and indirect cost of treatment, including physician time, hospital, medication, and laboratory costs (C_{Rx}), plus the cost of side effects of

Table 3. Prerequisites for Cost-Effectiveness Analysis

1. Proper Perspective
2. Description of Benefits
3. Analysis of Costs
4. Discounting of Costs
5. Sensitivity Analysis
6. Calculation of Efficiency Ratios

treatment (C_{SE}) minus the savings of costs attributable to prevention and alleviation of disease (C_{MORB}) plus the cost of treating diseases that would not have occurred if the patient had not lived longer as a result of earlier successful treatment (C_{LL}) (1):

$$C_{TOT} = C_{Rx} + C_{SE} - C_{MORB} + C_{LL}$$

Although such considerations are difficult to apply to anesthesia, the comprehensive principles of accounting for all costs are important.

Conclusion

At a time of severe cost reduction in medical care, anesthetic practice is threatened. In some areas, such as the provision of ambulatory surgery and the adoption of same-day admit surgery policies, radical changes have occurred. These measures are likely to result in considerable savings to the hospitals because, as length of stay is reduced, the number of staff can be decreased. Less progress has been made in the application of pharmacoeconomic analysis to anesthetic procedures. Comparison of the acquisition costs of alternative drugs is too simplistic because the data need careful interpretation. Also, the impact that is likely to be made by minor modifications in the anesthetic drug budget is too small to produce any real change in health care financing. There is a need to develop a comprehensive pharmacoeconomic approach to anesthesia so that evaluation of the total cost of anesthesia care to the hospital, patient and payer can be performed to determine whether pharmaceutical switching is effective and safe.

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