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The real cost of total intravenous anaesthesia: cost versus price

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This paper outlines the comparative cost analysis performed on three types of day case general anaesthetic maintenance techniques, namely total intravenous anaesthesia (TIVA) using propofol, and volatile anaesthesia, using oxygen, nitrous oxide and either enflurane or isoflurane. The general anaesthetics studied were administered to patients undergoing oral surgery, minor gynaecological surgery, ear nose and throat (ENT) surgery and knee arthroscopy as day cases in a busy teaching hospital day surgery unit (DSU). Both direct and indirect costs were included in the overall costing, including follow-up data concerning the use of medical resources in the post discharge period. The results suggest that total intravenous anaesthesia is comparable in cost to more traditional volatile anaesthesia, especially for day case operations of less than 30 min duration. TIVA was also associated with less negative outcomes at 24 h follow up and may thus be associated with greater patient satisfaction.

Key words: Day surgery, total intravenous anaesthesia, propofol, cost

Introduction

Total intravenous anaesthesia (TIVA), involving induction and maintenance with an infusion of propofol, is widely used in the day surgery setting. The technique offers many advantages of particular relevance to the anaesthetic management of the day case patient, including rapid, high quality induction and recovery[1], coupled with a low incidence of postoperative nausea and vomiting[2]. In the current financial climate, however, where there is increasing pressure on healthcare systems to rationalize costs, total intravenous anaesthesia is often regarded as expensive and not significantly superior to cheaper forms of anaesthetic maintenance to warrant the increased cost incurred.

When considering the cost of any day case anaesthetic technique, Wetchler has urged that all costs, both direct and indirect, be taken into account[3]. Not only must the price or acquisition cost of anaesthetic drugs be considered, but so too should other direct costs, including drug wastage, adjuvant therapy and equipment costs. Indirect costs are less obviously associated with the anaesthetic technique utilized, yet the clinical events that precipitate them may have a large effect on overall outcome and on patient satisfaction. Indirect costs, including the cost of nursing, admission, duration of day unit stay, complication rates and their treatment, constitute a large proportion of the total anaesthetic cost, yet are seldom included in the overall cost analysis.

Several studies have highlighted the cost implications arising when all costs are considered, rather than simply the price of the anaesthetic drugs utilized[4,5], but none have included the cost implications of follow up and post-discharge complications. This study attempts to compare the costs of TIVA and volatile anaesthesia used over a 4 yr period in a major South Australian teaching hospital day surgery unit (DSU), including in that costing those indirect costs incurred in the post-discharge period.

Method

The study involved the retrospective analysis of our day surgery database, containing data on the 10 000 patients who have received day surgery in our day unit between 1990 and 1994. Data is collected routinely on all patients, information being entered long hand onto appropriately designed forms by both the anaesthetist and nursing staff and entered by hand into a computerized database. The data collected and analysed in this study included follow-up information at 24 h collected using telephone follow up, and is listed in Table 1.

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Table 1. Parameters measured

Duration of surgery
Duration of unconsciousness in stage 1 recovery
Duration of stage 1 recovery stay after return of consciousness
Duration of stage 2 recovery stay
Incidence of postoperative nausea and vomiting in stage 1 recovery
Treatment of postoperative nausea and vomiting in stage 1 recovery
Incidence of postoperative nausea and vomiting in stage 2 recovery
Treatment of postoperative nausea and vomiting in stage 2 recovery
Incidence of unanticipated hospital admission
Incidence of follow up by GP for anaesthetic-related reasons
Incidence of follow up by hospital A&E Department for anaesthetic-related reasons
Incidence of anaesthetic-related complications during DSU stay

The patient database was analysed, grouping together data concerning each operative group and anaesthetic maintenance technique. Four operative groups were found to be suitable for study and included oral surgery, minor gynaecological surgery, ear, nose and throat (ENT) surgery and knee arthroscopy. Three anaesthetic maintenance regimes were identified for comparison, namely: propofol, air and oxygen; enflurane, nitrous oxide and oxygen and finally, isoflurane, nitrous oxide and oxygen.

Mean values for the parameters listed in Table 2 were calculated. The hospital pharmacy and finance departments were consulted regarding drug prices and staffing rates. Fees for general practitioner and hospital follow up were obtained from the regulatory authorities.

The acquisition costing of the propofol used for anaesthetic maintenance was performed by analysing 100 randomly selected day surgical procedures undertaken in our unit. The mean value for the amount of propofol infused per min of surgical time was calculated from the total amount of propofol infused and the duration of surgery. This rate of propofol consumption was then applied to all the operations studied and the total amount used was costed accordingly. The quantities of medical air and oxygen used during TIVA were based on routinely used fresh gas flows (FGF) of 2 l min^{-1} of air and 1 l min^{-1} of oxygen into a circle system.

Table 2. Parameters calculated

Cost of the propofol, air and oxygen utilized during surgery
Cost of the enflurane, nitrous oxide and oxygen utilized during surgery
Cost of the isoflurane, nitrous oxide and oxygen utilized during surgery
Staffing costs
Postoperative nausea and vomiting costs
Admission costs
GP follow up costs
A&E Department follow up costs
Complication costs

As circle systems and relatively low flow fresh gas regimes are routinely utilized in our unit, the estimation of the quantities of enflurane or isoflurane used during volatile anaesthetic maintenance was also based on these fresh gas flow rates. Standardized vaporizer settings were also used so that the amount of enflurane consumed was based on a vaporizer setting of 3% in 6 l FGF for the first 5 min of surgery (4 l min^{-1} nitrous oxide and 2 l min^{-1} oxygen), followed by a setting of 2% in 3 l FGF for each remaining min of surgery (2 l min^{-1} nitrous oxide and 1 l min^{-1} oxygen). Similarly the amount of isoflurane consumed was based on a vaporizer setting of 2% in 6 l FGF for the first 5 min of surgery (4 l min^{-1} nitrous oxide and 2 l min^{-1} oxygen), followed by a setting of 1% in 3 l FGF for each remaining min of surgery (2 l min^{-1} nitrous oxide and 1 l min^{-1} oxygen).

Nursing costs were evaluated as follows: in stage 1 recovery ('time to wake'), while each patient was still unconscious and where each patient was nursed by a single nurse throughout, staffing costs were calculated based on the nurse's hourly rate of pay multiplied by the fraction of an hour the patient remained unconscious. Thereafter in stage 1 recovery ('time to sit'), staffing costs were calculated at half the nurse's hourly rate of pay multiplied by the fraction of an hour the patient remained in that clinical area. Stage 2 recovery time (time to 'fit for discharge'), where five patients were potentially nursed by one nurse throughout, was costed at a fifth of the nurse's hourly rate of pay multiplied by the fraction of an hour the patient remained in that clinical area.

The cost implications of pre- and intraoperative antiemetic prophylaxis were calculated. The staffing costs of treating postoperative nausea and vomiting (PONV) were also included, based on both the price of the drugs concerned and staffing time involved. Similarly, the drug costs and staffing time involved in the treatment of intra- and postoperative complications relating to anaesthesia were included in the final total costings.

The cost of both general practitioner (GP) consultation and unplanned Accident and Emergency (A&E) Department visits were incorporated into the overall cost for each anaesthetic maintenance technique, the costs involved being based on the published fees. Such information was only available for the first 24 h post discharge. Only those consultations precipitated by anaesthetic-related problems or symptoms were included.

Finally, the mean costs of unanticipated hospital admission were included in the final cost of each anaesthetic maintenance technique. Only those admissions precipitated by anaesthetic-related problems or symptoms were included.

The analysis of cost for the three anaesthetic maintenance techniques studied was intended to be comparative, focusing on those costs unique to each anaesthetic technique. Therefore those costs incurred during all three types of anaesthetic, such as the cost of propofol for induction of anaesthesia, were not included in the final overall costing. The results concerning the incidence of negative outcomes were not subjected to statistical analysis.

Results

The four operative groups and three anaesthetic maintenance regimes studied comprised a total of 3750 patients. The demographic variables, including the mean duration of each operation and number of patients in each group are shown in Table 3. Table 4 illustrates the acquisition and total costs associated with each anaesthetic maintenance regime, for each type of operation. Table 5 illustrates the differences in cost between TIVA and both enflurane- and isoflurane-based anaesthesia, in relation to the duration of each operative group.

Tables 6 and 7 illustrate the outcome data relevant to each operative type and anaesthetic maintenance regime, including recovery times, PONV incidence rates and the incidence of unanticipated admission and anaesthetic-related complications occurring during the patients' stay in the DSU, and general practitioner and A&E department follow up in the first 24 h post discharge.

Discussion

This study was undertaken by the retrospective analysis of our database. Patients were not formally randomized to receive a particular anaesthetic maintenance technique. We believe that a retrospective analysis is valid for the comparison of costs, however, the potential for bias with regard to some outcome measures cannot be overlooked. Furthermore, the small number of TIVA anaesthetics relative to the use of volatile maintenance makes statistical comparison difficult and no analysis of outcome data was undertaken. While we have tried to cost as many related costs as possible, many indirect costs were not evaluated which may have had a bearing on the final costs. It is our belief that the cost implications of patient satisfaction cannot be overlooked, despite the obvious difficulty in costing such an outcome measure. Similarly, while it proved impossible to provide more than an estimate of the cost of drug wastage, Hitchcock et al.[6] have shown the potential costs involved.

The costing of TIVA maintenance based on a sample of 100 TIVA anaesthetics, to generate an amount of propofol utilized per min of surgery is a new idea and one which removes the necessity to collect data about the weight of each patient. Those regularly using TIVA in the day surgery setting will appreciate that unpremedicated, anxious day case patients often require

Table 3. Demographic data

Surgery type		*TIVA*	*Enflurane*	*Isoflurane*
Oral Surgery	Age (yr) mean (SD)	27.25 (12.04)	23.33 (8.53)	23.65 (7.82)
	ASA class	1 = 45 2 = 11	1 = 988 2 = 168 3 = 11	1 = 325 2 = 88 3 = 5
	Duration (min)	51.53	53.36	53.17
	No.	56	1167	418
Minor gynaecological	Age (yr) mean (SD)	31.48 (13.10)	36.40 (15.05)	39.95 (15.38)
	ASA class	1 = 118 2 = 19 3 = 2	1 = 633 2 = 178 3 = 15	1 = 26 2 = 17
	Duration (min)	23.50	25.97	26.81
	No.	139	826	43
Ear, nose and throat surgery	Age (yr) mean (SD)	36.28 (16.51)	34.12 (16.73)	32.74 (15.29)
	ASA class	1 = 31 2 = 15 3 = 1	1 = 278 2 = 69 3 = 12 4 = 1	1 = 25 2 = 10
	Duration (min)	29.90	33.77	31.09
	No.	47	360	35
Knee arthroscopy	Age (yr) mean (SD)	35.18 (16.68)	35.93 (15.54)	42.92 (16.68)
	ASA class	1 = 132 2 = 48 3 = 3	1 = 295 2 = 98 3 = 4	1 = 50 2 = 26 3 = 3
	Duration (min)	37.98	46.66	36.68
	No.	183	397	79

Table 4. Acquisition cost and total cost (in Australian dollars)

Operation		*TIVA* A$	*Enflurane* A$	*Isoflurane* A$
Oral surgery	Acquisition cost	34.50	12.64	10.60
	Total cost	51.34	37.12	32.78
Minor gynaecological	Acquisition cost	15.70	7.18	9.90
surgery	Total cost	30.74	31.75	27.82
Ear, nose and throat	Acquisition cost	20.01	8.71	7.17
surgery	Total cost	35.32	35.61	22.45
Knee	Acquisition cost	25.42	11.31	8.04
arthroscopy	Total cost	42.25	33.24	31.08

higher infusion rates than one would predict from the work of Roberts et al.[7]. In this study, often quoted when infusion rates for TIVA are discussed, all patients received temazepam premedication, followed by 3 μg kg^{-1} of fentanyl immediately prior to induction. This is not consistent with the practice of the majority of day case anaesthetists. Also with regard to weight, Sear has shown that adequate TIVA, again in premedicated patients could be delivered to patients within the weight range 60–90 kg using an infusion regime based on a weight of 70 kg[8]. The use of a fixed amount of propofol per min of anaesthesia to cost TIVA in day surgery therefore provides a reasonable estimate of the actual amount of propofol used, especially for shorter procedures. Unlike most previous assessments of anaesthetic costs[9], the amount of volatile anaesthetic used was based on fresh gas flows of 6 and then 3 l min^{-1}, as is the most common practice in our unit. Circle systems are used in every day case anaesthetic, although truly low fresh gas flows are seldom if ever used. It is our belief that in reality most anaesthetists practising in our unit utilize higher flows for longer periods than those used for costing purposes in this study. We believe that the manner in which the acquisition costs of the anaesthetics used were obtained is representative of the everyday practice in our DSU.

In day case anaesthesia while major morbidity and mortality are extremely rare, minor morbidity is common[10]. In addition, not only is there a definite morbidity associated with surgery and anaesthesia, but also the side effects of drugs used to treat or prevent that morbidity can cause further problems[11]. Anaesthetic techniques associated with intrinsically lower morbidity are therefore highly advantageous in the day surgery setting and the cost savings associated with such decreased morbidity may be used to offset the price of the drugs concerned. Our results suggest that TIVA is associated with a lower incidence of PONV and general practitioner and A&E department consultation post discharge than volatile anaesthesia with enflurane or isoflurane. In the light of work done by Orkin showing the importance to patients of avoiding nausea and vomiting[12], and the concerns expressed by Jackson et al.[13] over the increased workload imposed on general practitioners by the expansion of day surgery, such findings merit further more controlled investigation.

Table 5. Duration of surgery and cost differences between TIVA and enflurane (TIVA-E), between TIVA and isoflurane (TIVA-I) (in Australian dollars)

Operation	*Mean duration (min)*	*Cost difference TIVA-E A$*	*Cost difference TIVA-I A$*
Oral surgery	52.7	14.22	18.56
Minor gynaecological surgery	25.4	−1.01	2.92
Ear, nose and throat surgery	31.6	−0.29	12.87
Knee arthroscopy	40.4	9.01	11.17

This study illustrates the importance of considering all costs, both direct and indirect, when examining the cost of an anaesthetic procedure or technique. Lethbridge has pointed out that although anaesthetic costs contribute relatively little to the overall cost of any day surgery procedure, being only 6–10% of the total cost[14], indirect costs have a very marked effect on the overall cost of anaesthesia. While TIVA with propofol is widely regarded as an expensive form of anaesthetic maintenance, the results from this study would seem to suggest that the more anaesthetic-dependent costs are included in the overall cost analysis, the more comparable the cost of TIVA becomes relative to volatile anaesthesia. Morgan and Beech have stated that the costing of day surgery can vary depending on the manner in which that costing is performed and it seems that this also applies to the costing of anaesthetic techniques[15].

When examining the cost benefit ratio of any anaesthetic technique, several parameters have to be defined. As already stated, the potential benefits associated with the use of TIVA are particularly relevant in the day surgery setting. Also, the duration of anaesthesia may have some bearing on the cost benefit profile of TIVA. Our study suggests that TIVA is very cost effective,

Table 6. Outcome data: recovery times and incidence of postoperative nausea and vomiting (PONV)

Operation		*TIVA*	*Enflurane*	*Isoflurane*
Oral surgery	Recovery time 1	2 min	1.5 min	1.5 min
	Recovery time 2	56.8 min	56.9 min	57.5 min
	Recovery time 3	77.2 min	81.5 min	83.2 min
	PONV 1	8.9%	17.4%	18.1%
	PONV 2	7.1%	9.7%	13.8%
Minor gynaecological surgery	Recovery time 1	3.9 min	2.1 min	3.9 min
	Recovery time 2	46.7 min	60.4 min	51.7 min
	Recovery time 3	79.6 min	78.4 min	73 min
	PONV 1	10%	16.5%	2.3%
	PONV 2	2.1%	3%	0%
Ear, nose and throat surgery	Recovery time 1	3 min	1.3 min	1.6 min
	Recovery time 2	50.6 min	52.4 min	46.4 min
	Recovery time 3	83.2 min	79.9 min	73.6 min
	PONV 1	2.1%	6.3%	2.8%
	PONV 2	4.2%	1.6%	0%
Knee arthroscopy	Recovery time 1	4.8 min	1.7 min	2.9 min
	Recovery time 2	56.4 min	61.1 min	55.3 min
	Recovery time 3	77.0 min	82.6 min	82.3 min
	PONV 1	7.1%	16.3%	14%
	PONV 2	3.8%	2.5%	6.3%

relative to the use of volatile anaesthesia, for day case operations of less than 30 min duration. This needs further investigation. It may be that once the duration of surgery exceeds a certain length, the benefits of TIVA are no longer evident in the day case patient, due to the increased morbidity associated with prolonged surgery. Operation types, in which the use of TIVA may be advantageous, also need to be defined. TIVA may be more cost effective in operations associated with a high incidence of nausea and vomiting. The complete picture regarding the cost of any anaesthetic technique will need the investigation of all these factors.

Several studies have highlighted the potential savings associated with the shorter recovery period or time to 'fit for discharge' required following TIVA[16], although in our study recovery times were, if anything, more prolonged than with volatile anaesthesia. The informal manner in which such times were measured in our unit, as compared to formal studies of recovery time could explain this. However, while nursing staff time is undoubtedly an expensive commodity and the intensity of nursing is strongly correlated with postoperative morbidity, the potential cost reductions described are not readily achievable in practice. Even in a well organized day surgery facility using TIVA exclusively, recovery times and times to 'fit for discharge' are dependent on several factors, in addition to recovery from the effects from anaesthesia alone. For example,

Table 7. Outcome data: anaesthetic complications, admissions, GP follow up and A&E Department follow up

Operation		*TIVA*	*Enflurane*	*Isoflurane*
Oral surgery	Complications	1 (1.7%)	30 (2.6%)	10 (2.3%)
	Admission	0 (0%)	6 (0.5%)	1 (0.2%)
	GP follow up	0 (0%)	51 (4.3%)	15 (3.5%)
	A&E follow up	1 (1.7%)	42 (3.5%)	11 (2.6%)
Minor gynaecological surgery	Complications	2 (1.4%)	19 (2.3%)	2 (4.7%)
	Admission	0 (0%)	13 (1.5%)	0 (0%)
	GP follow up	1 (0.7%)	24 (2.9%)	2 (4.6%)
	A&E follow up	1 (0.7%)	14 (1.6%)	0 (0%)
Ear, nose and throat surgery	Complications	0 (0%)	16 (4.4%)	0 (0%)
	Admission	0 (0%)	11 (3%)	0 (0%)
	GP follow up	0 (0%)	4 (1.1%)	0 (0%)
	A&E follow up	0 (0%)	12 (3.3%)	1 (2.8%)
Knee arthroscopy	Complications	2 (1%)	12 (3%)	4 (5%)
	Admission	0 (0%)	1 (0.2%)	1 (1.2%)
	GP follow up	1 (0.5%)	3 (0.7%)	2 (2.5%)
	A&E follow up	0 (0%)	13 (3.2%)	1 (1.2%)

following laparoscopic cholecystectomy or gynaecological laparoscopy, a period of observation is frequently required independent of recovery from anaesthesia. Also, the only practical way to capitalize on the cost savings associated with shorter recovery times would be to reduce the number of nurses employed, which could reduce the potential throughput at busy times, thus increasing rather than reducing unit costs. Our study seems to show that the use of TIVA imposes less of a burden on general practitioners and hospital A&E departments. While this may seem unimportant to hospital-based budget holders, the potential savings in overall costs are both real and achievable. While the importance to patients of this decreased need for follow up is impossible to cost with any degree of accuracy, it constitutes the basis of a high quality day surgery service.

In future there will be increased pressure on anaesthetists, and indeed all healthcare workers, to justify the cost of the drugs they use. Already a prime determinant of whether or not a new drug is widely used is the acquisition cost or price of that drug. It is hoped that this paper will highlight how misguided such an approach can be. While it is appreciated that drug price will inevitably be a factor in determining the indications for the use of a particular drug, healthcare workers should concern themselves with cost-benefit profiles. The real issue is one of cost-effective quality care; the cost of overall care rather than simply the price of drugs used. It would seem sensible therefore to develop a costing system to enable such a process to be undertaken fairly and accurately. There is a need to appreciate that the choice of drugs used in day case anaesthesia can influence far more than the intraoperative period alone, and the subsequent outcomes can have enormous cost ramifications.

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