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Cost-effective anaesthesia for outpatient arthroscopic knee surgery: spinal, desflurane, isoflurane or propofol anaesthesia?

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Abstract

Spinal anaesthesia (SA) is widely used in day surgery because it is easy and cheap. But how cheap is SA really, when compared to modern general anaesthesia with short-acting agents? The aim of this study was to compare SA to three modes of general anaesthesia in terms of the total costs of anaesthesia during outpatient knee arthroscopy (KA). There were 173 patients scheduled for elective KA randomised to receive SA with lidocaine, propofol infusion (PA), isoflurane (IA) or desflurane (DA) inhalation anaesthesia. The time spent in the operation theatre (OT) and the time to reach home readiness after postoperative care in the recovery unit (RU) were measured. The material and salary costs for the different anaesthesias were calculated. The total costs for IA and DA were significantly lower ($P < 0.05$) than those for SA or PA. Inhalation anaesthesia, with either isoflurane or desflurane, is more cost-effective than SA or PA in elective ambulatory KA.

Keywords: Ambulatory anaesthesia; Cost-effective anaesthesia; Desflurane; Home readiness; Isoflurane; Knee arthroscopy; Propofol; Spinal

1. Introduction

The practice of ambulatory anaesthesia, in common with the other aspects of health care, is subject to pressures on cost containment, as costs need to be balanced against the benefits of the new medical technologies and practices. Economic evaluations help to assess the likely impact on costs and outcomes following the introduction of new anaesthetic agents and practices in a cost-constrained environment.

There has been only a limited number of published economic evaluations of anaesthesia and its wider impacts on total procedural costs [1–6]. This may reflect the low proportion of institutional budgets accounted for by anaesthetic costs. However, anaesthetic agents particularly short-acting agents, can be expected to affect hospital budgets, not only in terms of usage and price but also in terms of their effects on patient recovery profiles and related patient management costs. Although the costs of anaesthetic agents may constitute only a small proportion of the total cost of a typical day-care episode [7–9], it is necessary to assess the financial impact of all potential resource cost drivers at each stage of the surgical process in order to determine the relative importance of anaesthesia decisions in the management of total procedural costs.

Spinal anaesthesia (SA) is widely used in day surgery because it is easy and cheap. But how cheap is SA really compared to modern general anaesthesia with short-acting agents? The aim of this study was to compare SA to three modes of general anaesthesia in terms of the total anaesthesia costs during outpatient knee arthroscopy (KA).

2. Methods

2.1. Patients and methods of anaesthesia

A total of 173 patients (ASA I or ASA II, age under 65 years) scheduled for elective KA were randomised to receive SA with lidocaine, propofol infusion (PA), isoflurane (IA) or desflurane (DA) inhalation anaesthesia. Informed consent was obtained from each participant and the protocol was approved by the Ethics Committee of the Medical Faculty, University of Oulu.

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SA ($n = 55$) was administered with lidocaine 50 mg/ml in 7.5% glucose 1.5–2.0 ml through a 27 gauge needle. The block was performed laterally through the lumbar III/IV space with the patient lying on the side to be operated. PA ($n = 32$) was anaesthetised with propofol, starting with a bolus 2 mg/kg i.v. followed by continuous infusion of 12 mg/kg per h for the first 15 min, 9 mg/kg per h for the next 15 min and, when necessary, 6 mg/kg per h until the end of surgery. IA ($n = 38$) was anaesthetised with isoflurane after a propofol bolus of 2 mg/kg. Isoflurane was given in rising concentrations up to 1 MAC before the skin incision. After that, the anaesthesia was maintained with isoflurane on the 1 MAC level. DA ($n = 48$) was anaesthetised with desflurane after the same induction dose of propofol as before. Desflurane inhalation commenced at doses of 7.25% for patients aged over 30 and 6% for those less than 30 years old. The goal was to reach 1 MAC before the skin incision and to continue at that level during the operation. All the general anaesthesia patients were relaxed with a single bolus of mivacurine 0.3 mg/kg and intubated. The patients were normoventilated ($EtCO_2$ 4.5–5.5%) with 30% oxygen in air. The fresh gas flow was constantly 2 l/min for all general anaesthesia groups. Alfentanil (0.5 mg) was administered for pain when needed. Before the operation began, 100 mg of ketoprofein diluted in 20 ml 0.9% NaCl was given to all groups. Postoperatively, all patients received 100 mg of ketoprofein i.v. or p.o. three times every 24 h and 0.05 mg of fentanyl i.v., when necessary for postoperative pain relief.

Home readiness was assessed according to Kari Korttila's criteria for safe discharge after ambulatory surgery [10].

2.2. Cost accounting

The direct costs [11] of the materials needed for certain types of anaesthesia and the work in the operation theatre (OT) and the recovery unit (RU) were calculated. The fixed costs [11] that remain unchanged regardless of the number of operations were ignored. The time spent in OT and in postoperative care in the RU before discharge were measured. The surgical team in the OT consisted of two doctors and three nurses. During the postoperative period, one nurse was able to take care of three patients. The average OT and RU salary costs per minute were calculated by dividing the total salaries with the OT and RU working hours.

The price for liquid drugs was calculated per quantity of each drug used in ml. The cost of inhalation anaesthetics is more elusive. These costs were calculated from the formula [12]:

$$\text{Cost in Finnish marks (FIM)} = PFTMC/2412d$$

where, P is the vaporiser concentration (Fi%); F is fresh gas flow (l/min); T is the duration of anaesthesia (min); M is molecular weight (g); C is the cost of anaesthetic (FIM/ml); d is density (g/l).

This calculation assumes that the gases are delivered from the machine at an atmospheric density corresponding to 21°C, which explains the factor 2412 in the formula.

M, C and d are agent specific and are defined as:

	Isoflurane	Desflurane
M (g)	184	168
C (FIM/ml)	3.3	1.4
d (g/l)	1.496	1.450

Statistics

The tests of normality (Kolmogorov–Smirnov and Shapiro–Wilk) were used. The Kruskall–Wallis test was used for the non-parametric variables and ANOVA for the parametric variables (post hoc Scheffe test). $P < 0.05$ was considered to be significant.

3. Results

There were no significant differences in demographic data, operation time and total stay in OT. The time before discharge in the spinal group was over 3-fold compared to all the general anaesthesia groups ($P < 0.001$) (Table 1.). All patients were alert 60 min after the operation and the mean incidence of postoperative nausea was 3.4% with no statistical difference between the groups.

The total anaesthesia cost (TC, including OT, RU and fixed costs) for 1-h elective day surgery in the Oulu University Hospital is 691 FIM (I FIM = 0.19 USD). The average OT anaesthetic material costs are 83.4 FIM (12.1% of TC) for SA, 164.2 FIM (23.8% of TC) for PA, 110.8 FIM (16.0% of TC) for IA and 123.3 FIM (17.8% of TC) for DA. The postoperative personal costs are 0.44 FIM/min per patient spent in the RU and the material costs 15.3 FIM/patient. The average RU costs were 88.7 FIM for SA (12.8% of TC), 39.7 FIM for PA (5.8% of TC), 41.4 FIM for IA (6.0% of TC) and 34.8 FIM for DA (5.0% of TC).

The anaesthetic material costs, without fixed costs for SA, PA, IA and DA, are shown in Table 2.

4. Discussion

The results on the total anaesthesia costs for these four different types of anaesthesia showed the two inhalation anaesthesias to be significantly cheaper than

Table 1
Demographic characteristics, duration of operation and total time spent in operation theatre (OT) and time to reach home readiness. The values are presented as medians and range (min–max)

	Spinal	Propofol	Isoflurane	Desflurane
Number of patients (n)	55	32	38	48
Age (years)	41 (16–63)	37 (17–65)	41.5 (17–61)	37.5 (16–64)
Men/women (%)	46/54	38/62	62/38	63/37
Height (cm)	170 (153–187)	170 (153–183)	173 (153–184)	175.5 (155–186)
Weight (kg)	75 (46–95)	72 (51–95)	75.5 (52–95)	75 (54–95)
Operation time (min)	20 (7–75)	18 (6–77)	20 (7–67)	16 (7–70)
Total stay in OT (min)	64 (41–114)	64.5 (43–145)	65 (44–121)	60 (40–112)
Home readiness (min in RU)	168** (90–260)	55 (22–107)	56 (23–165)	46 (19–154)

** $P<0.001$.

propofol infusion or spinal anaesthesia. Although spinal anaesthesia has the lowest material costs, the long recovery process in the RU makes it less economical than inhalation anaesthesias with isoflurane or desflurane. One reason for the long recovery process in the spinal group might be the high dose of lidocaine given to the patients. A 50–60 mg dose of lidocaine, as oppose to 75–100 mg, may result in more targeted anaesthesias.

Salaries make up the largest part of the costs and short-acting anaesthetic agents, which help to reduce patient recovery times, may produce a positive net effect by lowering the costs in terms of increased patient throughput.

The fresh gas flow is an important factor in determining the costs of inhalation anaesthetics. A reduction of the fresh gas flow rates from 8 to 4 l/min was associated with a 55% decrease in the cost of isoflurane, without any impact on the quality of care [13]. The practice of reducing flow rates to 1–3 l/min after an initial high flow rate for 5–10 min, when uptake is rapid, is a simple cost-saving measure [14]. If the 2 l/min flow rate, which was used in this study, had been lowered to 1 l/min, the cost difference compared to propofol would have been greater.

It has been suggested that the use of propofol for outpatient anaesthesia is cost-effective, as it results in more rapid recovery [15]. In this study, recovery from propofol anaesthesia took equally as long as recovery from isoflurane or desflurane anaesthesia. The material costs for propofol anaesthesia are twice as high as the material costs for spinal anaesthesia when the prices of wasted drugs are included. Propofol anaesthesia was most expensive, although the recovery profile was smooth. The overall incidence of postoperative nausea was low, and it had no effect on postoperative costs.

We conclude that the total costs for isoflurane and desflurane anesthesias were significantly lower than the costs of spinal or propofol anaesthesia. Inhalation anaesthesia, with either isoflurane or desflurane, is more cost-effective than spinal or propofol anaesthesia in elective ambulatory knee arthroscopy.

Table 2
Anaesthetic material costs without fixed costs for ambulatory knee arthroscopy

Anaesthesia	Cost
Spinal	172.1 FIM
Propofol	203.9 FIM
Isoflurane	152.2 FIM*
Desflurane	158.1 FIM*

* $P<0.05$.

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