Recovery After Total Intravenous Anesthesia (TIVA) Using Propofol and Inhalation Anesthesia (IA) Using Halothane in Day Case Surgery

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Abstract

The aims of this study were to compare recovery by clinical tests, the Perceptual Speed Test (PST) and the Ball Bearing Test (BBT), home recovery, side effects and satisfaction of anesthesia between total intravenous anesthesia using propofol and inhalation anesthesia using halothane in day case surgery and to determine average cost per case of each technique from the provider's the perspective.

Forty patients were randomly allocated into TIVA and IA groups. The anesthetic times were 42.1 ± 26.47 minutes and 37.6 ± 14.75 minutes respectively.

Recovery was assessed by the time to orientation, sitting up, standing up and to success in obtaining baseline values of the PST & BBT. The observer was blinded to the anesthetic technique that the patient received. Recovery tests showed no difference between the two groups. The recovery times of TIVA and IA as assessed by the PST and BBT were 1.2 ± 0.41 and 1.1 ± 0.31 hour respectively.

From a home questionnaire, both groups showed no difference in the first 2-3 hours of home recovery, incidence of side effects and satisfaction of anesthesia. When asked about the difficulty in getting home, no TIVA patients complained of sleepiness whereas 6/16 IA patient did ($p = 0.018$).

The average cost per case of TIVA and IA was 642.15 and 363.15 bahts respectively.

Key word: Anesthetic Technique, Total Intravenous Anesthesia, Inhalation Anesthesia, Propofol, Halothane, Surgery, Day Case, Outpatient

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Increasing outpatient surgery is widely practiced throughout the world because of reduction of waiting lists, infection rates and economic benefits[1-3]. The anaesthetists are challenged to provide a brisk patient turnover rate without compromising safety and high quality of care. Total intravenous anesthesia (TIVA) is an alternative to the use of inhalation anesthesia (IA) due to better and faster recovery, less environmental pollution, reduction of the potential for administration of hypoxic gas mixtures[4]. Propofol is the shortest acting commercially available intraveneous anesthetic and suitable for day case surgery. However, inhalation using halothane is still commonly used in our country and costs less. The objectives of this study were:

1. To compare the recovery time assessed by clinical tests, the Perceptual Speed Test (PST) and the Ball Bearing Test (BBT) between these two techniques.
2. To compare home recovery, side effects and satisfaction of anesthesia.
3. To determine the average cost per case in each technique from the provider's perspective.

MATERIAL AND METHOD

The study was a randomized controlled trial and was approved by the Ethical Clearance Committee on Human Rights related to Research involving Human Subjects. It included patients with nasal fracture or dental patients requiring general anesthesia, aged 12-60 years, ASA I - II, not taking psychoactive drugs, and received no premedication before anesthesia. Patients with neurologic or psychiatric problems, obesity and illiteracy were excluded. 40 patients were randomly allocated to receive either TIVA or IA. The non-dominant hands were taken for intravenous cannulation. Semiclosed breathing system circuits with CO_2 absorber were used in the IA group. Patients were premedicated with fentanyl 1-2 μgkg^{-1} intravenously before induction of anesthesia. Propofol 2-2.5 mg kg^{-1} was given intravenously as the induction agent and succinyl choline 1.5-2 mg kg^{-1} IV for intubation. Muscle relaxation was maintained by vecuronium 0.08 mg kg^{-1} initially and 1 mg intermittently every 20-30 minutes. All patients were ventilated with tidal volume 10 cc kg^{-1} and rate 10 min^{-1} and were monitored by blood pressure every 5 minutes, pulse oximetry and ECG. During maintenance phase of anesthesia, TIVA patients were inhaled by O_2 6 l min^{-1} and infused propofol intravenously 10-12 mg kg-1 h^{-1} for 30 minutes and then reduced to 5-6 mg kg-1 h^{-1} but IA patients were inhaled by O_2 2 l min^{-1}, N_2O 4 l min^{-1} and halothane 0.5-0.75 per cent. Fentanyl 0.5 μgkg^{-1} were used as supplement every 45 minute in both groups. When the operation finished, propofol infusion or inhalation of N_2O and halothane was stopped and patients were administered with O_2 up to 6 l min^{-1}. Atropine 0.03 mg kg^{-1} and prostigmine 0.06 mg kg^{-1} were used for reversal. All patients were extubated when the criteria of returned protective reflex, normal respiration and ability to follow command were fulfilled. Paracetamol was used as postoperative analgesic and droperidol (0.5 mg) was given intravenously in patients with severe vomiting.

Measurements

Demographic data, total dose of drug used and the duration of anesthesia were recorded. Recovery were assessed by one observer who was blinded to which anesthetic technique the patient received. Recovery was assessed in 3 parts; Clinical tests, Paper & Pencil Test, Psychomotor test.

Clinical tests consisted of orientation. sitting up unaided and Romberg's test. For orientation, simple assessment included asking the patient for date of birth, place and the day of the week; success was when all questions were answered correctly. For sitting up unaided, success meant the patient could sit up for 30 seconds with little or minor dizziness or headache. For Romberg's test, the patient was asked to stand with eyes open and their feet close togethers; success meant they could stand still with slight swaying above the ankles or well balanced for 30 seconds. Time to assess clinical tests, orientation was assessed every 5 minutes after anesthesia ended; sitting up unaided was assessed every 15 minutes after patient's success in orientation and Romberg's test was assessed every 15 minutes after patient's success in sitting up unaided.

Paper and Pencil test consisted of the Perceptual Speed Test. The patient was instructed to circle the number shown at the beginning of each row and the score was the number of correct answers completed in 2 minutes. To eliminate the training effect, slightly different but equivalent sheets were used when the test was repeated.

Psychomotor test consisted of the Ball Bearing Test. The patient had to use a pair of forceps to place balls in a vertical tube, the score was the

number of ball bearings inserted in 40 seconds. To eliminate the training effect, the patient would train for 15 min before recording the baseline performance. To obtain the baseline data, patients performed 3 times and the last score was selected to be the control value.

We assessed PST and BBT every 1 hour after anesthesia ended until the PST and BBT reached control value ±10 per cent. Side effects such as nausea, vomiting or headache were recorded. Postoperative self-administered questionnaires were taken home by the patients to be completed 24 hours after discharge from the hospital. The questionnaires asked about subjective feelings regarding to their home recovery, side effects and satisfaction of anesthesia.

For cost analysis from the provider's perspective, we considered only the operating cost of the anesthetic techniques and ignored the costs that were similar in both groups such as intravenous catheter, intravenous fluid, syringe, endotracheal tube and supplies. We identified only drugs costs and equipment costs. Cost of halothane was calculated by PFTMC $(d2240)^{-1}$, at STP (P = agent concentration (%), F = fresh gas flow ($l\ min^{-1}$), T = time (min), M = molecular weight, C = cost of agent and d = density of liquid agent ($g\ ml^{-1}$)(5). Total cost was drug costs plus equipment costs. We amortized all equipment costs into equally annual cost and then calculated into cost per official working hour in 1 year(6). The assumptions of the useful life of anesthetic machine, vaporizer and infusion pump were 15, 15 and 5 years respectively. Discount rate was 10 per cent.

Statistics

Sample size calculation was done from a pilot study. Type I error was accepted at $\leq$ 5% and type II error at $\leq$ 10 per cent. The main outcome was recovery time assessed by the PST & BBT and half an hour was considered to be the minimum significant difference that had an impact on rapid turn over rate of recovery bed for outpatients. The sample size was 15 per group.

For statistical analysis, descriptive statistics were used to describe data. To test the difference between groups, the chi-square or Fisher-Exact test were used for discrete data. Independent *t*-test and Mann-Whitney U test were used for continuous data. Statistical significance was declared when p-value <0.05.

For economic analysis, cost minimization technique was used.

Table 1. Demographic data of patients in TIVA and IA groups. There was no statistically significant difference between the two groups.

	TIVA (n = 20)	IA (n = 20)
Age (yr)	23.45 ± 5.13	25.15 ± 8.59
Body weight (kg)	55.45 ± 9.67	58.10 ± 9.1
Height (cm)	164.00 ± 9.09	166.85 ± 7.30
Sex M : F	15 : 5 (75% : 25%)	17 : 3 (85% : 15%)
ASA 1 : 2	20 : 0 (100% : 0%)	19 : 1 (95% : 5%)
Diagnosis		
- fractured nose :	80%	80%
- dental problem	20%	20%
Duration of anesthesia (min)	42.10 ± 26.47	37.60 ± 14.75

Table 2. Recovery of TIVA and IA.

	TIVA	IA	P
Orientation (min)	5.25 ± 1.12	5.25 ± 1.12	1
Sitting up unaided (min)	21.75 ± 5.45	21.00 ± 3.48	0.938
Romberg's test (min)	37.55 ± 6.16	37.50 ± 8.35	0.433
Perceptual speed test and Ball Bearing test (h)	1.20 ± 0.41	1.10 ± 0.31	0.382

RESULTS

Groups did not differ in terms of age, weight, height, sex, ASA, diagnosis and duration of anesthesia (Table 1). All patients underwent anesthesia and surgery without complications. Time to success of clinical tests, orientation, sitting up unaided and Romberg's test were not different between the two groups (Table 2). The average times to complete the PST & BBT were 1.2 ± 0.41 hour and 1.1 ± 0.31 hour for TIVA and IA respectively (Table 2). Seventy-five per cent of questionnaires were returned from the TIVA group and 80 per cent from the IA group. The demographic and recovery characteristics of nonresponders of the two groups were analysed and no difference was found. The incidences of side effects during 24 hours after hospital discharge were not different between the two groups (Table 3, 4). Average cost for TIVA was 642.51 ± 176.62 bahts whereas IA was 363.15 ± 57.49 bahts (Table 5). Since both techniques show similar effectiveness on recovery, cost minimization was chosen to analyse which technique was more suitable and it was found that IA was more cost-effective.

DISCUSSION

Recovery

Adequate recovery from outpatient anesthesia requires rapid return to street fitness and propofol appears to offer advantages in this area. A

Table 3. Incidence of side effects during 24 hours after hospital discharge by home questionnaires.

	TIVA (n/total)	IA (n/total)	P
Nausea	0/15	2/16	NS
Vomiting	0/15	0/16	-
Dizziness	3/15	6/16	NS
Headache	8/15	11/16	NS
Sore throat	9/15	12/16	NS
Muscle pain	6/15	6/16	NS
Pain at injection site	1/15	3/16	NS

Table 4. Other home questionnaire results of TIVA and IA patients.

	TIVA (n/total)	IA (n/total)	P
Awareness during operation	0/15	0/16	-
Duration of hospital stay (h)	2.60 ± 1.61	2.27 ± 1.10	NS
Feeling back to normal self (h)	7.60 ± 12.78	3.56 ± 1.87	NS
Problem of getting home			
- Sleepiness	0/15	6/16	0.018*
- Unsteadiness	4/15	6/16	NS
- Others	1/15	3/16	NS
What he did, 2-3 h after home arrival			
- Rest	7/15	6/16	NS
- Slept	8/15	9/16	NS
- Worked	0/15	0/16	-
Satisfaction of anaesthesia			
- Very good	2/15	6/16	NS
- Good	11/15	5/16	
- Satisfactory	2/15	5/16	
- Poor	0/15	0/16	
- Very poor	0/15	0/16	
Willingness to choose similar anaesthetic technique next time	14/15	15/16	NS

*$p<0.05$ was declared as statistical significance.

Table 5. Average cost/case of TIVA and IA.

	TIVA (n = 20)	IA (n = 20)	P
Drug cost (baht)			
Atropine	5.67 ± 0.89	5.15 ± 0.81	
Fentanyl	32.45 ± 7.39	34.13 ± 9.47	
Propofol	459.38 ± 155.38	166.88 ± 27.89	
Succinyl choline	7.75 ± 0.77	8.00 ± 1.03	
Vecuronium	71.56 ± 21.70	65.94 ± 18.64	
Prostigmine	48.40 ± 10.69	41.80 ± 4.94	
O_2	2.54 ± 1.58	1.20 ± 0.41	
N_2O	-	16.02 ± 10.14	
Halothane	-	11.35 ± 7.18	
Total drug cost	627.75 ± 169.85	350.45 ± 53.66	0.000
Equipment cost (baht)			
Anaesthesia machine	12.02 ± 7.56	10.73 ± 5.07	
Vaporizer	-	1.95 ± 1.23	
Infusion pump	2.75 ± 1.93	-	
Total equipment cost	14.77 ± 9.47	12.68 ± 6.29	NS
Total cost (total drug cost plus total equipment cost)	642.51 ± 176.62	363.15 ± 57.49	0.000

standardised anaesthesia was employed to compare recovery from anesthesia using propofol infusion or halothane during maintenance phase. Propofol was given for induction in both groups, and the muscle relaxant used was similar. Assessment of recovery should include a number of tests. The tests used in this study were clinical tests (orientation, sitting up unaided and Romberg's test), paper and pencil test (PST) and psychomotor test (BBT). Gelfman's study of the validity of PST showed that this test was highly sensitive and free of practice effects and could discriminate recovery time or score between control group and treatment groups who received intravenous sedation[7]. From Steinberg's study, BBT had significant discrimination effect in recovery and the reliability of the test was 0.573-0.888 ($p < 0.001$)[8]. From this study, it was found that these tests were not too boring or too difficult for patients and did not need long training period before anesthesia.

Recovery results showed no difference between TIVA and IA with regard to the recovery period. Both anaesthetic techniques resulted in equally rapid recovery evaluated by the return of orientation, time to sitting up unaided, Romberg's test and the PST & BBT. Therefore, both techniques are recommended for outpatient anaesthesia especially for the operative time less than 50 minutes. From the previous studies, propofol resulted in faster recovery when compared with methohexitone[9-11] and isoflurane[12-15]. Most studies[15-18] found that recovery time varied by duration of anesthesia and combination of drugs used. So the authors did not apply the conclusion to a longer operation because the rapidity of recovery depends partly on the length of inhalation anaesthesia. The average anesthetic times of TIVA and IA were 42.1 ± 26.47 minutes and 37.6 ± 14.75 minutes respectively. The longer the anesthetic time, the more halothane deposited in tissue and recovery may differ. Nevertheless, most outpatient surgery has the duration of less than 1 hour. For longer operations, further study will be needed. The other reason to explain the recovery between two technique was not different was that the time of assessment of the PST & BBT might be too far apart to detect the difference. However, the disadvantage of early assessment is that it would disturb the patients.

Home questionnaire results

Studies on recovery should include the patient's perception of their function at home because the patient can offer a lot of information about their experiences after discharge. 75 per cent of questionnaires were received from TIVA and 80 per cent from IA. The characteristics of nonresponders were checked in both TIVA and IA groups and they were similar. It could be expected that the outcomes and the comparison of responders should be reliable.

a. Side effects

Nausea and vomiting were common complications occurring 25-55 per cent during the recovery period[19]. Contributing factors were pain, narcotic drugs, position changes, site of operation and anaesthetic drugs[20]. It is interesting to note that in this study no patient suffered from nausea or vomiting in TIVA and of 16 IA patients, 2 (12.5%) suffered from nausea and 0 (0%) suffered from vomiting. This suggested that propofol might reduce the incidence of postoperative emesis sequale[21].

b. Other results

From the reasons of difficulty in getting home, it was found that no patient from TIVA had sleepiness while 6 of 16 patients (37.5%) from IA did. This might reflect that TIVA patients recovered to street fitness better than IA patients. However, for the first 2-3 hours of home recovery, there was no difference in their activities.

No patients had awareness during operation. Patients' acceptance of the two anaesthetic techniques were high.

Cost identification

Since both techniques showed similar recovery, their costs were considered in order to choose which technique was more suitable by cost minimization analysis. By cost identification (Table 5), the authors did not calculate monitoring cost and personnel cost of anaesthesia, operation and recovery because the duration of anaesthesia, operation and recovery were the same in both groups.

The limitations of this cost identification are:

a. Sensitivity analysis by varying drug cost was not done, equipment cost and discount rate within a plausible range at a time was not done to assess the impact on the response. In this study the cost of propofol is the important effect because it is expensive now but in the future when it is widely used its cost will be reduced.

b. Indirect benefit from TIVA which is difficult to measure is that TIVA cause less pollution to both patients and staff.

c. This study does not take account of the patient's or society's viewpoint.

SUMMARY

From the study it was concluded that both TIVA and IA techniques resulted in similarly rapid recovery, the condition during the first 2-3 hours of home recovery, incidence of side effects and patient acceptance. By cost minimization technique, IA technique was recommended from the provider's viewpoint because its cost was less than the cost of TIVA and the effectiveness of recovery was the same in both groups.

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การฟื้นตัวของผู้ป่วยนอกที่มารับการดมยาสลบระหว่างเทคนิคการให้ยาสลบทางหลอดเลือดดำโดยใช้โปรโปฟอล และการให้ยาสลบ วิธีสูดดมโดยใช้ฮาโลเธน

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การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบการฟื้นตัวของผู้ป่วยนอกที่มารับการดมยาสลบ โดยใช้การทดสอบทางคลินิก, Perceptual Speed (PST), Ball Bearing (BBT), การฟื้นตัวที่บ้าน, อุบัติการณ์ของภาวะแทรกซ้อนและความพึงพอใจต่อวิธีการดมยาสลบ ระหว่างเทคนิคการใช้ยาสลบทางหลอดเลือดดำโดยใช้ Propofol (TIVA) และการให้ยาสลบวิธีสูดดมโดยใช้ Halothane (IA) และหาต้นทุนของทั้งสองเทคนิค

ผู้ป่วย 40 คน แบ่งเป็น 2 กลุ่ม คือ TIVA และ IA กลุ่มละ 20 คน โดยวิธีสุ่ม เวลาการดมยาสลบของผู้ป่วยทั้งสองกลุ่ม คือ 42.1 ± 26.47 นาที และ 37.6 ± 14.75 นาที ตามลำดับ

การฟื้นตัวของผู้ป่วยถูกประเมินโดยผู้สังเกตซึ่งไม่ทราบเทคนิคการดมยาสลบ โดยเปรียบเทียบเวลาจนกว่าผู้ป่วยจะมี orientation, สามารถนั่ง, สามารถยืน และจนกว่าผ่านการทดสอบ PST และ BBT ผลของการศึกษาไม่พบว่ามีความแตกต่างในการฟื้นตัวข้างต้นระหว่าง 2 กลุ่ม เวลาการฟื้นตัวของการทดสอบ PST และ BBT ของกลุ่ม TIVA คือ 1.2 ± 0.41 ชั่วโมง และ IA คือ 1.1 ± 0.31 ชั่วโมง

จากแบบสอบถามภายหลังการดมยาสลบ พบว่าทั้ง 2 กลุ่มไม่มีความแตกต่างในการฟื้นตัวที่บ้าน, อุบัติการณ์ของภาวะแทรกซ้อน และความพึงพอใจต่อวิธีการดมยาสลบสำหรับสาเหตุของปัญหาในขณะกลับบ้านพบว่า ไม่มีผู้ป่วยในกลุ่ม TIVA มีอาการง่วงนอนในขณะที่ผู้ป่วยกลุ่ม IA มีอาการง่วงนอน 6 ราย จาก 16 ราย ($p = 0.018$)

ต้นทุนยาและอุปกรณ์ของเทคนิค TIVA คือ 642.51 บาท และเทคนิค IA คือ 363.15 บาท เนื่องจากการฟื้นตัวของทั้งสองเทคนิคเหมือนกัน ดังนั้นเทคนิค IA มีความเหมาะสมกว่าเนื่องจากมีต้นทุนที่น้อยกว่า TIVA

คำสำคัญ : วิธีระงับความรู้สึก, การให้ยาสลบทางหลอดเลือดดำ, การให้ยาสลบวิธีสูดดม, โปรโปฟอล, ฮาโลเธน, การผ่าตัดแบบผู้ป่วยนอก

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