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Postoperative analgesia in children undergoing adenotonsillectomy under sevoflurane versus propofol-based anesthesia: a randomized controlled trial

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Abstract

Background: The field of pediatric pain management has changed greatly in the past decades. However, the number of children who experience moderate-to-severe postoperative pain, even with analgesic treatment, remains significant. If an intravenous or inhalational anesthetic would include in itself all components of general anesthesia, such as hypnosis, analgesia, and amnesia, it would represent an ideal anesthetic. There are some pieces of evidence that propofol may reduce postoperative pain. This debate on the early potential analgesic efficacy of propofol compared with sevoflurane during the postoperative period in children was evident. The aim of this study is to compare the postoperative potential analgesic effects of propofol-based versus sevoflurane-based anesthesia in children undergoing adenotonsillectomy.

Methods: This study was a prospective comparative randomized, double-blinded trial conducted on 60 children between 3 and 10 years of age and American Society of Anesthesiologists physical status I and II undergoing adenotonsillectomy under general anesthesia. Patients were randomly assigned to one of the following two equal groups: the sevoflurane group and the propofol group. The primary outcome was pain score assessed using the Faces Pain Scale postoperatively. The secondary outcomes included recovery time and adverse events within the first 4 h.

Results: The current study showed that the postoperative resting and swallowing face pain score was significantly lower in the propofol group than in the sevoflurane group, and postoperative agitation scores were significantly lower in the propofol group than in the sevoflurane group during the first 30 min of early postoperative period. No significant differences were found from 40 min to the fourth postoperative hour. Paracetamol consumption during the 4-h postoperative period was significantly greater in the sevoflurane group than in the propofol group, and the incidence of postoperative nausea and vomiting was lower in the propofol group than in the sevoflurane group ($P = 0.001$).

Conclusion: The use of propofol is more advantageous compared with sevoflurane for the induction and maintenance of general anesthesia in children undergoing adenotonsillectomy. It decreases early postoperative pain, analgesic consumption, postoperative agitation, and postoperative nausea and vomiting. However, the use of propofol in the induction and maintenance of anesthesia is associated with a prolonged recovery time.

Keywords: Adenotonsillectomy, Postoperative analgesia, Propofol, Sevoflurane

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Introduction

The field of pediatric pain management has changed greatly in the past decades. However, the number of children who experience moderate-to-severe postoperative pain, even with analgesic treatment, remains significant (Berde and Sethna 2002; Howard et al. 2008).

Overall, 70–80% of patients who undergo surgical procedures each year experience moderate-to-severe pain, despite treatment with all of the analgesic medications that are available (Owen et al. 1990; Thomas et al. 1998; Tan et al. 2010). For some patients, there may be no dose of an opioid that adequately relieves pain without causing respiratory depression, and intolerable nausea, itching, and constipation. However, inadequate treatment of pain results in an unnecessary suffering, prolonged hospitalization, and increased healthcare costs (Svensson et al. 2000). If an intravenous or inhalational anesthetic would include in itself all components of general anesthesia, such as hypnosis, analgesia, and amnesia, it would represent an ideal anesthetic. Propofol is the drug of choice for the induction and/or maintenance of anesthesia and sedation in the operating room and the ICU. It is a short-acting intravenous anesthetic that features high blood-tissue solubility and allows a rapid induction and rapid emergence. Propofol has γ-amino butyric acid agonist activity and produces dose-dependent central nervous system depression resulting in sedation and hypnosis (Dong and Xu 2002).

Propofol has varied effects on pain, depresses nociceptive transmission in neurons, and reduces the continuing nociceptive barrage (Jewett et al. 1992). It has been shown that propofol is associated with a significantly lower incidence of pain in the early postoperative period (Cheng et al. 2008). Sevoflurane acts as a significant analgesic in obstetric patients; the observation was originally made by Toscano et al. 2003.

Hypothesis 0

There is no difference between propofol and sevoflurane in early postoperative pain perception in pediatric patients undergoing adenotonsillectomy.

Hypothesis A

There is a difference between propofol and sevoflurane in early postoperative pain perception in pediatric patients undergoing adenotonsillectomy.

Patients and methods

This study was conducted after obtaining approval of the Ethics Committee of the Suez Canal University Hospitals, and after written informed consent was obtained from the parents of each participant.

Design, setting, and time

The study was a parallel group randomized controlled trial with 4 h of follow-up. It was conducted between October 2014 and August 2015 at the teaching hospital of the Suez Canal University hospital in the day-case operation theater.

Participants

Recruitment

Children of American Society of Anesthesiologists physical status I and II aged 3–10 years who were scheduled for elective adenotonsillectomy under general anesthesia were included in the study. The preoperative evaluation was carried out in anesthesia clinic.

Screening for eligibility

Exclusion criteria included parents' refusal, allergy to propofol or sevoflurane, the presence of a genetic syndrome, behavioral disorders, use of psychiatric medications, postoperative agitation score greater than 2, any contraindications for total intravenous anesthesia (i.e., obstructive sleep apnea), and language barrier. Patients requiring sedative medication before going to the operating room were also excluded.

Sample size

Sample size calculation was based on this equation:

$$N = 4d2(Z\alpha + Z\beta)2/D2,$$

where N is the number of the participants in each group; $Z\alpha$ is the value of standard normal distribution for P value 5% for two-sided test = 1.96; $Z\beta$ is the value of a standard normal for the desired statistical power 95% and it equals 1.64, D is the detectable difference between the means of postoperative pain score [Faces Pain Scale (FPS)] with patients under propofol-based (1.2) and sevoflurane-based (3.4) maintenance anesthesia, which was 2.2 (Toscano et al. 2003); and d is the within-group (sevoflurane-based) SD 1.5 (Toscano et al. 2003).

We required 25 patients in each group and the expected dropout of 15% was compensated for; 30 patients were enrolled for each group.

Randomization

Participants were randomly allocated to the intervention group using propofol and the control group using sevoflurane using block randomization.

Concealed allocation

The closed envelop method was used for randomization containing code for the propofol (group P) or the sevoflurane group (group S). To ensure allocation concealment, the envelopes were prepared by an anesthesia

nurse not involved in the study. Those enrolled after obtaining written informed consent were asked to pick one concealed envelope from the box and hand it over to the investigator concerned. The investigator was then assigned to receive either group P or group S according to the envelope code.

Blinding

Patients were blinded after assignment to interventions and randomly assigned into one of the two equal groups. It was a single-blinded study as the investigator was aware of both groups.

Interventions

Group S (1)

Anesthesia was induced and maintained using sevoflurane, varying its end-tidal concentration to keep the spectral entropy within the target range intraoperatively at around 50.

Group P (2)

Anesthesia was induced with propofol and maintained with total intravenous anesthesia using continuous intravenous infusion of propofol varying its rate to keep the spectral entropy within the target range intraoperatively at around 50.

After preoxygenation with 100% oxygen for at least 3 min, each child in both groups received fentanyl 1 μg/kg before intubation. Anesthesia in patients of the propofol group was induced with propofol 3 mg/kg bolus and maintained with propofol infusion (150–300 μg/kg/min) titrated to clinical effect and keep entropy (RE value) around 50. In the sevoflurane group, anesthesia was induced and maintained with sevoflurane 8 vol% and 2–3 vol% titrated to clinical effect and the RE value of 50. In both groups, 0.5 mg/kg rocuronium intravenously was administered to all patients to facilitate endotracheal intubation, and no further doses were administered. Thereafter, patients were manually ventilated with 100% oxygen until intubation after 3 min and with an entropy value of around 50% using MacIntosh laryngoscope and an appropriately sized endotracheal tube. After tracheal intubation, patients were mechanically ventilated with an oxygen–air mix ($FiO_2 = 0.3$), and end tidal carbon dioxide ($EtCO_2$) was stabilized at 35–40 mmHg. The depth of anesthesia was monitored with entropy. The dosage of propofol and sevoflurane was adjusted to maintain an adequate anesthesia depth as judged by the anesthesiologist from blood pressure, heart rate (HR) readings, clinical signs, and spectral entropy. Monitoring equipment (Datex-Ohmeda, Helsinki, Finland) connected to each patient included ECG, noninvasive blood pressure, pulse oximetry, peripheral nerve stimulator, and rectal temperature. Inspiratory oxygen concentrations together with end-tidal sevoflurane and carbon dioxide concentrations were continuously monitored.

The entropy electrodes were placed on the forehead and on the lateral angle of the orbit. The target state entropy (SE) and RE ranges were kept around 50 for surgical anesthesia. Normal saline in 5% dextrose at the rate of 4 ml/kg/h was administered during the perioperative period. At the completion of surgery, neuromuscular blockade, assessed for residual curarization using clinical and train of four (TOF) ratio, was antagonized with neostigmine 0.04 mg/kg and atropine 0.01 mg/kg. Thereafter, the patient was placed in the lateral decubitus position. The trachea was extubated when the gag reflex returned and the patient was breathing spontaneously and showing purposeful movement of all extremities and opened his or her eyes.

Measurements

Follow-up of patients for primary and secondary outcomes was carried out as follows:

1. Assessment of postoperative pain at rest and on swallowing using FPS (from five face drawings: 0 = no pain to 5 = extreme pain) was carried out during the first 4 h (at 0 time and every 10 min during the first hour and then every hour) in the postanesthesia care unit (PACU). Children were considered as having pain if they had a score greater than 2.
2. Time to first analgesic administration and early 4 h postoperative analgesic consumption were assessed. The rescue analgesic was intravenous paracetamol at a dose of 15 mg/kg.
3. The assessment of postoperative agitation was performed using a four-point scale based on the study by Aono et al. 1997: 1 = calm; 2 = not calm but could be easily calmed; 3 = moderately agitated or restless; and 4 = combative, excited, or disoriented. Grades 1 and 2 were considered nonproblematic behavior, and grades 3 and 4 were considered to indicate agitation. This agitation (grades 3 or 4) was treated with an intravenous bolus of fentanyl 0.5 μg/kg and was excluded from the study.
4. Pain and agitation scores, HR, and mean arterial pressure were recorded at time 0 and every 10 min for 1 h and then hourly up to 4 h postoperatively.
5. The following time intervals were recorded: time of anesthesia (from the start of induction to end of surgery); recovery times, including the time to extubation (from the end of anesthesia to extubation); the time between the end of anesthesia and the first adequate response to a simple verbal command; and time spent in the recovery room.

6. The occurrence of postoperative complications such as bradycardia, intense coughing, hypersalivation, laryngospasm, nausea, and vomiting was assessed.
7. In the recovery unit, all children received oxygen through face mask. HR, noninvasive blood pressure, and respiratory rate were recorded. The criteria for discharge from the recovery room included being fully awake, able to cough or breathe deeply, moving all limbs voluntarily, and maintaining an oxygen saturation greater than 93% in air.
8. All observations and measurements were recorded by an independent single anesthesiologist who was blinded to all anesthetic techniques used.

Primary outcome was the intensity of postoperative pain assessed using the FPS for 4 h postoperatively.

Statistical methods

The collected data were analyzed using statistical product and service solutions, 20.0 (SPSS Inc., Chicago, Illinois, USA). Qualitative data were presented as frequencies and percentages and quantitative data were tested for normality using the Shapiro–Wilk's test. Continuous normally distributed data were presented as mean and SD. Continuous non-normally distributed and ordinal data were presented as median and interquartile range. All analyses were carried out using the intention to treat principle. For comparison of independent groups, the unpaired t test was used for normally distributed data and the Mann–Whitney test was used for non-normally distributed data. Analysis of variance of repeated measures was used to test the changes in HR and mean arterial pressure from baseline up to 4 h in the two studied groups. Two-tailed tests P value was considered less than 0.05 and for multiple comparison less than 0.0045.

Results

Figure 1 shows the flow of participants in the study. There were no differences among groups in demographic data and both groups of the study were matched as regards age and sex. The patients' weight was statistically significantly lower in the sevoflurane group ($P = 0.031$). Moreover, the duration of anesthesia was shorter with sevoflurane ($P = 0.008$).

As regards HR, there was a statistically significant difference during all times of the measurements from the baseline and every 10 min up to 4 h postoperatively ($P < 0.001$ with 95% confidence interval) (Table 1).

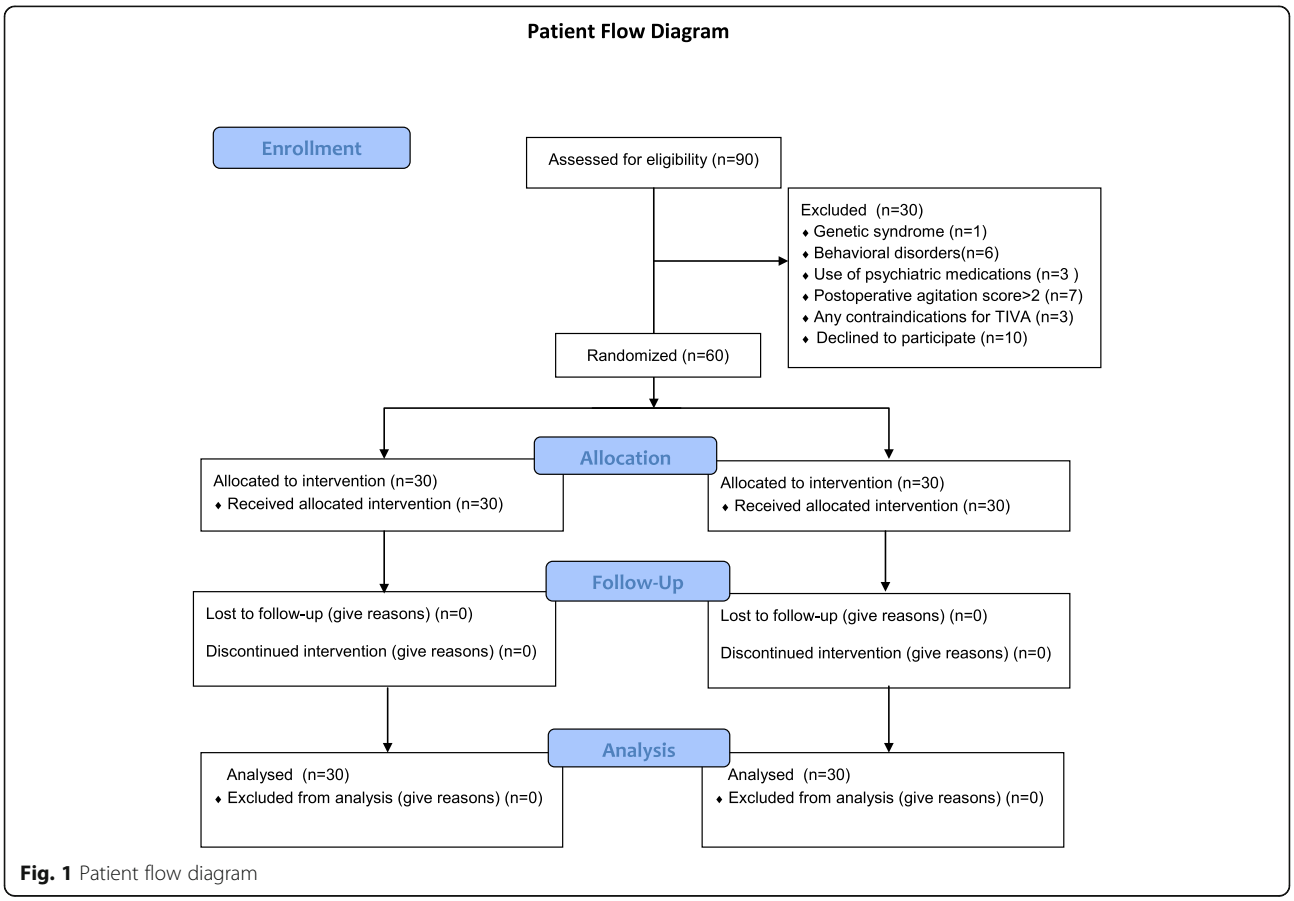

Fig. 1 Patient flow diagram

There was no significant difference between the two groups as regards mean blood pressure throughout the 4-h postoperative period (Table 2).

Postoperative resting face pain score was significantly lower in the propofol group than in the sevoflurane group during early 2 h postoperatively (0 min–2 h), with *P* value ranging from 0.003 to 0.001. However, no significant difference was noted in the third and fourth hours ($P = 0.021$ and 0.317, respectively) (Table 3).

Postoperative face pain scores on swallowing were significantly lower in the propofol group than in the sevoflurane group during the early 2 h of postoperative period (0 min–2 h) and no significant difference was noted in the third and fourth hours ($P = 0.030$ and 0.141, respectively) (Table 4).

The postoperative agitation scores were significantly lower in the propofol group than in the sevoflurane group during the first 30 min of the early postoperative period, and then no significant differences were found from 40 min up to the end of the fourth postoperative hour (Table 5).

Paracetamol consumption during the 4 h postoperatively was significantly greater in the sevoflurane group than in the propofol group [900 (737–1200) and 225 (0–356) mg, respectively; $P < 0.001$] (Table 6).

As regards time, the recovery time was significantly lower in the sevoflurane group than in the propofol group [7.83 (1.17) and 13.7 (3.35) mg, respectively; $P = 0.001$]. It also showed that the time between the end of anesthesia and first response to simple verbal command was significantly lower in the sevoflurane than in the propofol group [10.2 (1.91) and 16.5 (3.82) mg, respectively; $P = 0.001$]. As regards time to first analgesic requirement, it was nonsignificant ($P = 0.326$), and time spent in the recovery room was lower in the sevoflurane group than in the propofol group [7.63 (2.12) and 13.5 (2.92) mg, respectively; $P = 0.001$] (Figs. 2 and 3).

Table 1 Patient characteristics in the two studied groups

	Propofol group ($n = 30$)	Sevoflurane group ($n = 30$)	Unpaired *t* test	*P* value
Age				
Mean ± SD	7.2 ± 1.9	6.7 ± 1.6	1.09	0.280
Sex				
Male	14 (46.7)	16 (53.3)	0.267	0.606
Female	16 (53.3)	14 (46.7)		
Weight				
Mean ± SD	25 ± 4.8	22.5 ± 4.1	2.21	0.031*
Duration of anesthesia				
Mean ± SD	36.2 ± 7.7	31.1 ± 6.6	2.73	0.008

Data are represented as mean ± SD, *n* (%)
Homogeneity of variance
*$P < 0.05$, statistically significant difference

There was no statistically significant difference between the two groups in the occurrence of hypersalivation ($P = 0.3$) and laryngeal spasm ($P = 0.3$).

The occurrence of postoperative nausea and vomiting (PONV) was lower in the propofol group than in the sevoflurane group ($P = 0.03$).

Discussion

The main finding in the present study was that pain score assessed using the FPS during rest and swallowing 2 h postoperatively was decreased. Paracetamol consumption during the 4 h postoperatively was highly significantly decreased. However, the time to first request of analgesia was longer in the propofol group compared with the sevoflurane group but without significance (18.2 ± 57 and 3.2 ± 5.3, respectively) ($P = 0.326$).

These findings could add more evidence to the few available studies in the literature about the potential analgesic effects of propofol.

The postoperative analgesic effects of propofol during general anesthesia and its impacts on the perioperative pain were lacking in the literature.

Two randomized, double-blinded studies by Cheng et al. 2008 and Tan et al. 2010 have shown that propofol anesthesia decreases postoperative pain.

In the study by Cheng and colleagues, 80 women who underwent uterine surgery were anesthetized with isoflurane or propofol. In the propofol group, there was a lower incidence of pain and morphine consumption on the first postoperative day ($P < 0.01$).

Moreover, in the randomized, double-blinded study by Tan and colleagues, 80 patients undergoing diagnostic laparoscopic gynecological surgery were anesthetized with intravenous propofol or sevoflurane. There was a lower incidence of postoperative pain and morphine consumption during the first 24 h postoperatively in the propofol group ($P < 0.01$).

Propofol with opioid analgesics or barbiturates has an antinociceptive effect (Jewett et al. 1992; Aono et al. 1997; Toscano et al. 2003; Sun et al. 2005; Cheng et al. 2008). Propofol could reduce remifentanyl-induced hyperalgesia (Shin et al. 2010).

The results of analgesic effects of propofol are in accordance with those of Hassani and colleagues in their study on 88 premedicated children undergoing hernia repair. Anesthesia was maintained with propofol (group P, $N = 46$) or sevoflurane (group S, $N = 42$) and fentanyl. All children before surgical incision received rectal 40 mg/kg paracetamol. Before surgical closure, the wound margins were infiltrated with 0.5% bupivacaine. They found that the propofol group had a significantly lower proportion of patients who exhibited postoperative pain compared with the sevoflurane group (4.5 vs. 24.3%, respectively; $P < 0.05$).

Table 2 Postoperative heart rate changes (beats/min)

Heart rate (beats/min)	Sevoflurane group ($n = 30$)	Propofol group ($n = 30$)	Unpaired t test	P value	Mean difference (95% confidence interval of the difference)
Baseline	117 ± 7.5	113 ± 7.8	2.05	0.045*	4 (0.099–7.90)
0 min	157 ± 3.8	107 ± 7.8	31.1	< 0.001*	49.6 (49.6–52.9)
10 min	159 ± 3.9	100 ± 6.8	40.5	< 0.001*	58.9 (55.7–61.5)
20 min	156 ± 3.8	100 ± 6.9	38.5	< 0.001*	55.8 (52.9–58.7)
30 min	151 ± 3.1	100 ± 6.8	36.8	< 0.001*	50.7 (47.8–53.5)
40 min	144 ± 3.8	100 ± 6.6	33.7	< 0.001*	47.3 (44.5–50.2)
50 min	137 ± 2.8	99.5 ± 5.9	31.8	< 0.001*	38.1 (35.7–40.6)
60 min	137 ± 3.1	99.3 ± 6.3	29.3	< 0.001*	38.1 (35.5–40.8)
2 h	132 ± 3.1	99.8 ± 6.4	24.8	< 0.001*	32.7 (30.0–35.
3 h	134 ± 4.4	101 ± 5.8	24.9	< 0.001*	33.3 (30.7–36.0)
4 h	120 ± 6	113 ± 6.4	4.02	< 0.001*	6.50 (3.26–9.73)
One-way repeated analysis of variance	F (3.76, 108) = 430 $P < 0.001$*		F (3.94, 114) = 84.1 $P < 0.001$*		

Data are represented as mean ± SD
*$P < 0.05$, statistically significant difference

FPS score in the propofol group was 1.2 ± 0.6, compared with 3.4 ± 1.5 in the sevoflurane group ($P <$ 0.001) (Hasani et al. 2003).

A few studies have examined the analgesic effects of propofol in volunteers with induced acute pain. Anker-Møller et al. (1991) have found that, in healthy individuals, propofol decreased pain threshold and the amplitude of the evoked potential caused by nociceptive laser beam. Bandschapp et al. (2010) have exhibited a short duration of postoperative analgesia of propofol in human pain mode.

In contrast, Fassoulaki and colleagues studied 105 American Society of Anesthesiologists I–II patients undergoing elective abdominal hysterectomy or myomectomy. They found that the visual analog scale values at rest or after cough immediately in the PACU and at 2, 4, 8, and 24 h after surgery did not differ among the studied groups ($P = 0.40$, 0.39, 0.50, 0.47, and 0.06 at rest and $P = 0.67$, 0.45, 0.22, 0.26, and 0.29 after cough, respectively). The difference in the results could be attributed to variations in the target population and the type of surgery (Fassoulaki et al. 2008).

The analgesic impact of propofol could be attributed to its activity on γ-aminobutyric acid, type A receptors (Hunter et al. 2000), whereas volatile anesthetics act on different receptor sites, including γ-aminobutyric acid, type A, *N*-methyl-D-aspartate, and acetylcholine receptors (Yamakura and Harris 2000). However, it is dubious

Table 3 Postoperative resting face pain score during the 4-h postoperative period

	Propofol		Sevoflurane		Mann–Whitney U test	P value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)		
Resting FPS 0 min	0.700 (0.534)	1.00 (0–1.00)	3.73 (0.449)	4.00 (3.00–4.00)	0	< 0.001*
Resting FPS 10 min	1.53 (0.819)	1.00 (1.00–2.00)	2.50 (0.682)	3.00 (2.00–3.00)	180	< 0.001*
Resting FPS 20 min	1.23 (0.568)	1.00 (1.00–2.00)	2.02 (0.583)	2.00 (2.00–2.00)	164	< 0.001*
Resting FPS 30 min	1.10 (0.480)	1.00 (1.00–1.00)	1.73 (0.520)	2.00 (1.00–2.00)	198	< 0.001*
Resting FPS 40 min	0.966 (0.413)	1.00 (1.00–1.00)	1.33 (.479)	1.00 (1.00–2.00)	300	0.003*
Resting FPS 50 min	0.866 (0.345)	1.00 (1.00–1.00)	1.26 (0.639)	1.00 (1.00–1.00)	325	0.003*
Resting FPS 60 min	0.866 (0.345)	1.00 (1.00–1.00)	1.13 (0.345)	1.00 (1.00–1.00)	338	0.005*
Resting FPS 2 h	0.233 (0.430)	0 (0–0.25)	1.03 (0.413)	1.00 (1.00–1.00)	116	< 0.001*
Resting FPS 3 h	0.866 (0.345)	1.00 (1.00–1.00)	1.10 (0.402)	1.00 (1.00–1.00)	353	0.021
Resting FPS 4 h	.966 (0.182)	1.00 (1.00–1.00)	1.00 (0)	1.00 (1.00–1.00)	435	0.317
Friedman ANOVA, repeated measure	$\chi^2 = 122$ $P < 0.001$*		$\chi^2 = 200$ $P < 0.001$*			

ANOVA analysis of variance, *FPS* Faces Pain Scale, *IQR* interquartile range

Table 4 Swallowing face pain score during the 4-h postoperative period

	Propofol		Sevoflurane		Mann–Whitney *U* test	*P* value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)		
Swallowing FPS 0 min	2.17 (0. 592)	2.00 (2.00–3.00)	3.17 (1.05)	3.00 (2.00–4.00)	204	< 0.001*
Swallowing FPS 10 min	2.13 (0. 681)	2.00 (2.00–3.00)	2.77 (0.568)	3.00 (2.00–3.00)	238	0.001*
Swallowing FPS 20 min	1.50 (0.508)	1.00 (1.00–2.00)	3.33 (5.43)	2.00 (2.00–3.00)	142	< 0.001*
Swallowing FPS 30 min	1.27 (0.449)	1.00 (1.00–2.00)	2.90 (0.305)	3.00 (3.00–3.00)	12.0	< 0.001*
Swallowing FPS 40 min	1.13 (0.507)	1.00 (1.00–1.00)	1.70 (0.466)	2.00 (1.00–2.00)	216	< 0.001*
Swallowing FPS 50 min	1.00 (0. 371)	1.00 (1.00–1.00)	1.50 (0.508)	1.50 (1.00–2.00)	240	< 0.001*
Swallowing FPS 60 min	0.933 (0. 253)	1.00 (1.00–1.00)	1.47 (0.571)	1.00 (1.00–2.00)	238	< 0.001*
Swallowing FPS 2 h	0.933 (0. 253)	1.00 (1.00–1.00)	1.30 (0.534)	1.00 (1.00–2.00)	308	0.01*
Swallowing FPS 3 h	1.13 (0.345)	1.00 (1.00–1.00)	1.46 (0.681)	1.00 (1.00–2.00)	339	0.030
Swallowing FPS 4 h	1.23 (0.504)	1.00 (1.00–1.00)	1.46 (0.681)	1.00 (1.00–2.00)	371	0.141
Friedman ANOVA, repeated measure	χ^2 (9)=155 $P < 0.001$*		χ^2 (9)=175 $P < 0.001$*			

ANOVA analysis of variance, *FPS* Faces Pain Scale, *IQR* interquartile range

as to which of these activities are critical. The analgesic role of propofol stays indeterminate (Shafer and Nekhendzy 2008; Hasani et al. 2012).

Our study differed from previous studies, which is why we chose pediatric patients undergoing one type of surgical intervention, adenotonsillectomy. We measured pain in the early postoperative period and the first 4 h during and after recovery from anesthesia, because the intensity of pain is considered to be greater in children during this period and pain decreases as a natural course with time. The antiplatelet effects and respiratory depressant effects should be avoided during the selection of analgesia in adenotonsillectomy, which is absent in propofol. Children in the propofol group required less analgesic at that time. Moreover, the pain scores were lower and recovery time was shorter in the propofol group and the incidence of nausea and vomiting was lower.

The decrease in the HR during the first 2 h in the propofol group may be due to the early postoperative potential analgesic effect of propofol (Hasani et al. 2003).

The agitation score was lower in the propofol group compared with the sevoflurane group in the first 30 min. However, there were no statistically significant differences between the two groups during the rest of the 4 h postoperatively. This finding is in agreement with that of Pieters et al. 2010, who studied 42 patients who were randomized to undergo maintenance with either propofol or sevoflurane for adenotonsillectomy. For all patients, anesthesia was induced with sevoflurane and nitrous oxide (~ 60%). Emergence delirium and pain were assessed using the Pediatric Anesthesia Emergence Delirium and the Children's Hospital of Eastern Ontario Scale, respectively. They found that the incidence of emergence delirium was lower in the propofol group than in the sevoflurane group. The incidence of emergence delirium was assessed using a cutoff value of 16 or more. The number of patients with Pediatric Anesthesia Emergence Delirium scores of 16/20 or more at least once during the evaluation period was 12/19 (63%) in the sevoflurane group and 10/19 (53%) in the propofol group (Pieters et al. 2010).

As regards postoperative total analgesic consumption, the 4 h postoperative paracetamol consumption in the present study was greater in the sevoflurane group than in the propofol group [900 (737–1200) and 225 (0–356) mg, respectively; $P < 0.001$]. In agreement with this finding, Pieters et al. (2010) reported that postoperative fentanyl consumption was statistically lower in the propofol group than in the sevoflurane group (0.8 ± 0.6 and 1.2 ± 0.5 mg, respectively; $P = 0.045$).

In contrast, Fassoulaki and colleagues reported that the cumulative morphine consumption did not differ among the studied groups at 2, 4, 8, or 24 h postoperatively. The overall morphine consumed postoperatively

Table 5 Postoperative paracetamol consumption (mg)

Paracetamol consumption (mg)	Propofol group ($n = 30$) [median (IQR)]	Sevoflurane group ($n = 30$) [median (IQR)]	Mann–Whitney *U* test	*P* value
4 h postoperative analgesic requirement	225 (0–356)	900 (737–1200)	21	< 0.001*

Data are mean ± SD
IQR interquartile range
*$P < 0.05$, statistical significant difference

Table 6 Recovery time, time between end of anesthesia and first response to simple verbal command, time to first analgesic requirement, and time spent in recovery room

Time (min)	Propofol group ($n = 30$)	Sevoflurane group ($n = 30$)	Mean difference (95% CI)	Unpaired t test	P value
Recovery time	13.7 (3.35)	7.83 (1.17)	5.80 (4.48–7.11)	$t = 8.95$	< 0.001*
Time between end of anesthesia and first response to simple verbal command	16.5 (3.82)	10.2 (1.91)	6.36 (4.80–7.92)	$t = 8.15$	< 0.001*
Time to first analgesic requirement [median (IQR)]	0 (0–10.0)	0 (0–10.0)	–	$U = 218$	0.326
Time spent in the recovery room	13.5 (2.92)	7.63 (2.12)	5.93 (4.61–7.26)	$t = 8.99$	< 0.001*

Data are represented as mean ± SD
Equality of variance was violated
CI confidence interval, *IQR* interquartile range
*$P < 0.05$, statistical significant difference

was 28 ± 13.8 mg in the sevoflurane group, 25 ± 11.7 mg in the desflurane group, and 27 ± 16.1 mg in the propofol group ($P = 0.5$). This difference may be attributed to the following: their target population comprised non-normally distributed patients and required nonparametric tests, which was clear in the propofol group, and the different age group (21–59 years) or the different postoperative analgesia regimens, as we used paracetamol as postoperative analgesia, which is different from the previous study as they used morphine. Moreover, this difference could be attributed to different procedures (Fassoulaki et al. 2008). In addition, the difference in opioid consumption could not always be translated into variance in pain perception because of pharmacogenetical factors (Ginosar et al. 2009).

As regards recovery time, our study showed that recovery time was lower in the sevoflurane group than in the propofol group. This faster recovery can be attributed to the fact that sevoflurane has low blood/gas partition coefficient at 0.68 (Torri 2010).

This finding of the present study coincides with that of Hasani et al. (2003), who found that the mean recovery time for the sevoflurane group was significantly shorter than that for the propofol group (10.1 ± 1.3 vs. 16.5 ± 5.4 min, respectively; $P < 0.01$).

Our study showed that the time between end of anesthesia and first response to simple verbal command was shorter in the sevoflurane group than in the propofol group (10.2 ± 1.9 and 16.5 ± 3.8 min, respectively; $P = 0.001$) and the time to first analgesic requirement was earlier in the sevoflurane group than in the propofol group (3.2 ± 5.3 and 18.2 ± 57 min, respectively; $P = 0.02$). In addition, as regards the time spent in recovery room, our study showed that the time spent in the

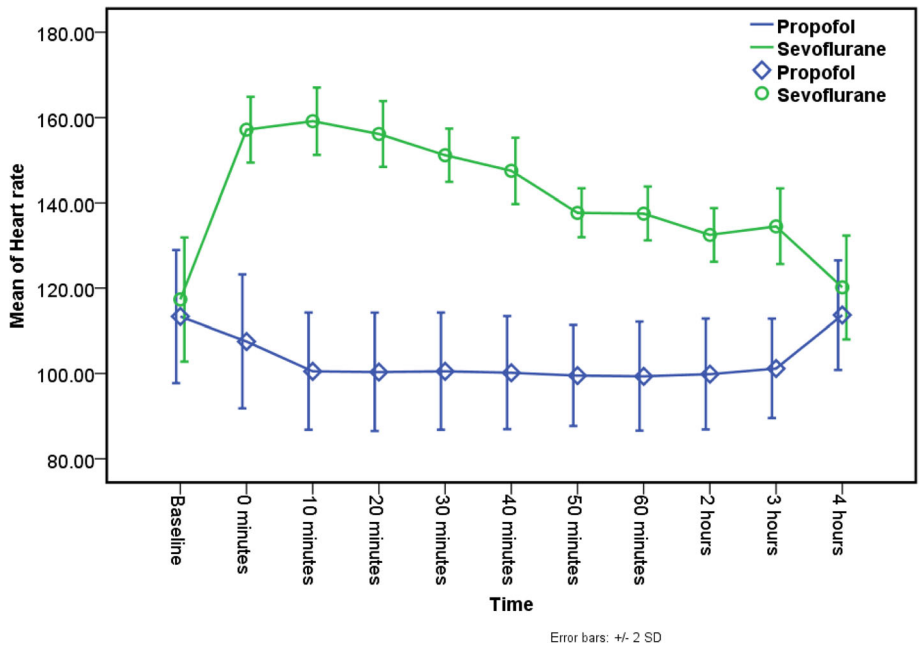

Fig. 2 Changes in mean heart rate from baseline up to 4 h postoperative in the two studied groups. A P value < 0.05 was considered significant

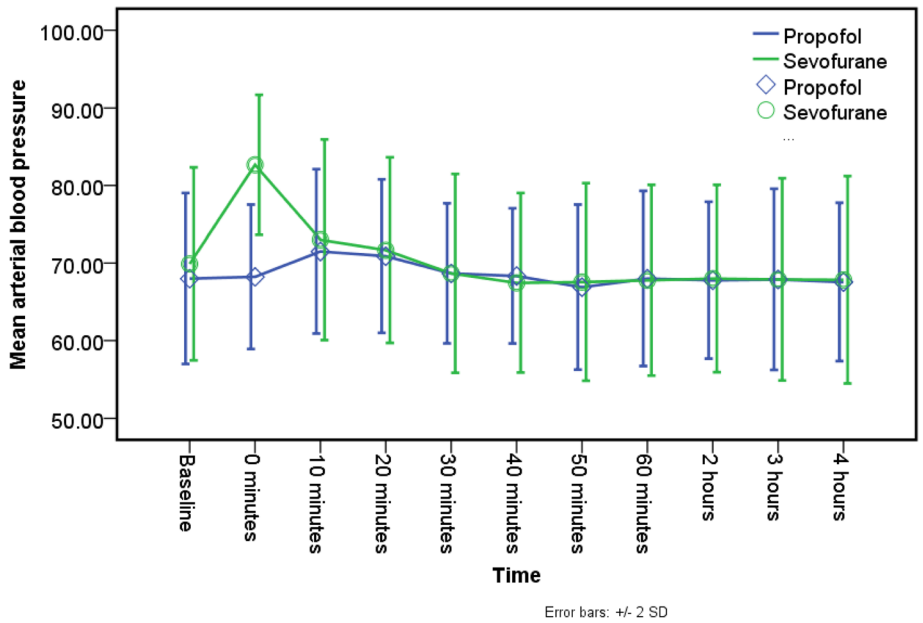

Fig. 3 Changes in mean arterial pressure from baseline up to 4 h in the two studied groups. A *P* value < 0.05 was considered significant

recovery room was lower in the sevoflurane group than in the propofol group (7.6 ± 2.1 and 13.5 ± 2.9 min, respectively; $P = 0.04$).

In agreement with our findings, Li et al. 2012 reported that the duration of stay in the PACU for the propofol group was shorter than that in the sevoflurane group and the combined propofol–sevoflurane group (21.8 ± 5.7, 26.2 ± 6.9, and 27.8 ± 8.9 min, respectively; $P = 0.005$).

In contrast, Pieters et al. 2010 reported in their study that there was no difference between the propofol and sevoflurane groups in the time spent in recovery room (46.5 ± 11.3 and 46.1 ± 13.7 min, respectively) and that difference in the findings may be because of their small sample size. In addition, there may be bias in their anesthetic technique as they induced anesthesia in both groups with sevoflurane and nitrous oxide 60%.

As regards postoperative complications, our study reported that there were no statistically significant differences between the two groups in the occurrence of laryngeal spasm and hypersalivation. However, as regards PONV, our study reported that the incidence of PONV was lower in the propofol group than in the sevoflurane group ($P = 0.03$).

Our findings coincide with those of Hassani and colleagues, who reported that two (4.3%) patients in group P and nine (21%) in group S developed postoperative nausea. These differences were significant ($P = 0.001$). The children under sevoflurane anesthesia had a higher rate of vomiting (31%) compared with the rest of the patients. These differences were significant with a *P* value of 0.001 (Hasani et al. 2003). Moreover, Pieters et al. (2010) reported that seven patients in the sevoflurane group reported PONV and only one patient in the propofol group had PONV ($P = 0.042$).

In contrast, Li and colleagues reported that the incidence of shivering and PONV within 24 h postoperatively was not different among the studied groups ($P = 0.095$). This difference could be attributed to the differences in the age of their target population and possible bias in their anesthetic technique, as anesthesia in all of their groups was induced with midazolam 0.03 mg/kg, fentanyl 3 μg/kg, and propofol 1.5–2 mg/kg. Moreover, there was a difference in the type of the operation, as Li et al. 2012 operated on women undergoing laparoscopic surgeries.

Conclusion

Our study revealed that the use of propofol is more advantageous compared with sevoflurane for the induction and maintenance of general anesthesia in children undergoing adenotonsillectomy. The use of propofol in the induction and maintenance of anesthesia decreases early postoperative pain and analgesic consumption, reduces the postoperative agitation, and decreases the PONV. However, the use of propofol in the induction and maintenance of anesthesia is associated with an increase the time for recovery.

Abbreviations

ASA: American Society of Anesthesiologists; $EtCO_2$: End tidal carbon dioxide; FiO_2: Fraction inspired of oxygen; FPS: Faces Pain Scale; HR: Heart rate;

PACU: Postanesthesia care unit; PONV: Postoperative nausea and vomiting; RE: Response entropy; SE: State entropy; TOF: Train of four

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Availability of data and materials
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions
SAI and HMA contributed to the conception and design of the study. Both organized the data collection, reviewed and greatly contributed to the interpretation of results, checked the statistical analysis, and revised the manuscript critically for important intellectual content. AA and SEAA performed the data collection and organized data preparation. All authors actively discussed the manuscript, critically reviewed its comprehensive content, and finally approved the version to be submitted for publication.

Ethics approval and consent to participate
The study protocol was approved by Suez Canal University Research Ethics Committee with reference no #2214. All procedures were in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The aim of the research was explained to the parents of the participants and signed written informed consents.

Consent for publication
A consent to publish has been obtained from the participant to report individual patient data.

Competing interests
The authors declare that they have no competing interests.

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