Original Article

Comparison of the Electrophysiological Effects of Inhalational Anesthesia with Sevoflurane Versus Total Intravenous Anesthesia with Propofol in Children Undergoing Radiofrequency Catheter Ablation for Tachyarrhythmias. A randomized-Controlled Study

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ABSTRACT

Background: Radiofrequency catheter ablation (RFCA) is performed under general anesthesia in children and is the preferable interventional therapy for tachyarrhythmia. Two commonly used anesthetic agents were studied: sevoflurane and propofol.

Method: In this study, 86 patients ranging from 1 to 14 years old undergoing ablation, were assessed for eligibility, 19 patients did not meet the criteria and 7 patients refused to participate in the study. Patients with contraindications to the use of sevoflurane or propofol including heart failure, uncontrolled asthma or malignant hyperthermia, also patients with previous ablation were excluded due to difficult cardiac mapping. The remaining patients were randomly allocated into two equal groups (30 patients in each) and assigned to receive either sevoflurane- or propofol-maintained anesthetic. The ability to induce sustained tachycardia (using a scoring system), procedural durations, effects on hemodynamic status and postoperative complications were compared between the two groups.

Results: Our study showed that the mapping time was significantly lower in the sevoflurane group than the propofol group (P=0.018). Radiofrequency procedure time, total anesthesia time and mapping/total anesthesia time were insignificantly different between both groups. Failed ablation, postoperative nausea and vomiting (PONV) and ventricular tachycardia were insignificantly different between both groups while excessive secretion was significantly lower in the sevoflurane group than the propofol group.

Conclusion: Sevoflurane and propofol-based anesthesia were equally suitable in children undergoing Radiofrequency catheter ablation in pediatrics regarding inducibility of arrythmias except that the mapping time was shorter with sevoflurane.

Key Words: Pediatrics, propofol, radiofrequency catheter ablation, sevoflurane, tachyarrhythmia

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INTRODUCTION

Catheter ablation is the preferable method of treatment in tachyarrhythmias, particularly in Pediatrics[1]. The used medications during general anesthesia affect the cardiac electrophysiology and conduction and alter the ability to induce the arrhythmia. This may have a negative impact on the mapping and ablation treatment [2]. Numerous anesthetic drugs have been observed in children with tachyarrhythmia with different results in regards to hemodynamics changes and the success of ablation[3]. Our objectives were to determine the effect of sevoflurane and propofol on electrophysiology of pediatric tachyarrhythmias in regards to the mapping time, to compare the time of mapping of both drugs with the total anesthesia time and compare the effects of sevoflurane and propofol on hemodynamic status.

We hypothesized that regarding cardiac ablation of tachyarrhythmia in children, sevoflurane is superior to propofol infusion in arrhythmia induction.

In some studies, the efficacy of isoflurane has been compared to propofol infusion[4]. Whereas limited studied are available comparing sevoflurane and propofol in this regard.

Pediatric cardiac tachyarrhythmias

Unlike adults, tachycardia in children can be defined as a heart rate that is greater than appropriate for age (Table 1).

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Table 1: Age specific normal range of the heart rate[5]:

Age	Mean (range) Heart Rate (beats/min)
0-4Weeks	145(95-180)
1-6months	145(110-180)
6-12months	135(110-170)
1-3Years	120(90-150)
4-5Years	110(65-135)
6-8Years	100(60-130)
9-11Years	85(60-110)
12-16Years	65(60-110)
>16Years	80(60-100)

Tachyarrhythmias can be classified anatomically as

- supraventricular tachycardia: originates from the tissue of the His bundle or above.
- ventricular tachycardia: originating below the bifurcation of the His bundle.

It can also be classified electrocardiographically as

- narrow QRS tachycardia: indicates those with a QRS duration≤120ms.
- wide QRS tachycardia: refers to one with a QRS duration>120ms[6].

PATIENTS AND METHODS

This study was conducted at Abo El Reesh Pediatric Hospital, Faculty of Medicine Cairo University from November 2022 to April 2023. It included children aged from 1 to 14 years old undergoing ablation for tachyarrhythmia. Exclusion criteria included subjects with contraindications to the use of sevoflurane or propofol including heart failure, uncontrolled asthma or malignant hyperthermia, also patients with previous ablation were excluded due to difficult cardiac mapping. Patients were randomly allocated to receive propofol (group pro) or sevoflurane (group sevo), and randomization was generated using a computer random number. After obtaining the institutional ethical committee's approval (code N-50-2022), written informed consents was obtained from the parents or guardians. Patients aged 1–14 years scheduled for cardiac catheterization procedures under general anesthesia were randomized digitally the day before.

We used a single blinded approach where the patient was blinded but the anesthesiologist and the electrophysiologist were not (double- blinded approach was unapplicable as propofol infusion is well known to the operators). After ensuring the patient met the eligibility criteria of the study, the patient was transferred to the holding area where standard monitoring in the form of electrocardiography, pulse oximetry and non-invasive arterial blood pressure was applied. Then baseline measurements of blood pressure, heart rate, and saturation were noted. Then, they were transferred from the holding area to the operating room where standard monitoring was re-applied.

General anesthesia was induced in the supine position after pre-oxygenation for 3 minutes.

In group (sevo)

Anesthesia was induced by inhaling Sevoflurane in 100% oxygen via a face mask. An IV access was secured by *a* 22-gauge peripheral cannula. Propofol (2–3mg/kg) was given in older children from 10 to 14 years, and atracurium (0.5mg/kg) were used to facilitate tracheal intubation. After tracheal intubation, the fresh gas flow was set to 1 l/min O_2 and 2 l/min air for the remainder of the procedure. Sevoflurane was continued with an inspiratory fraction of 1.5%.

In group (pro)

An IV access was secured by 22-gauge peripheral cannula. Propofol (2–3mg/kg), atracurium (0.5mg/kg) were used to facilitate tracheal intubation. After tracheal intubation, the fresh gas flow was set to 1 l/min O_2 and 2 l/min air for the remainder of the procedure. Propofol infusion started with 0.125mg/kg/min.

The change in blood pressure and heart rate were documented every 10 minutes from the time of intubation until the patient was extubated.

After stable anesthesia was established, femoral venous access was obtained under ultrasound guidance, using one of the femoral veins. Electrode catheters were positioned in the high lateral right atrium, right ventricular apex, Hiss bundle region, and within the coronary sinus, whenever possible.

Then the diagnostic electrophysiological study commenced using 3D electro- anatomical navigation system (CARTO3/NAVX systems) for mapping. The pulmonary veins were electrically isolated. Once the focus was identified, muscle relaxation was guaranteed before ablation was done using the heating system (radiofrequency ablation). Afterward, a pace test was done to detect whether we could induce arrhythmia, and isoprenaline was used to stress the heart and detect any abnormal rhythms.

The amount of sevoflurane consumed was measured by the Drager anesthesia machine. It uses an algorithm that measures gas consumption based on agent concentration in the circuit, which is measured via the sampling line continuously[7].

The time elapsed until the focus was found was detected and compared with the total anesthesia time. Also, the difference in the mapping time between both drugs and the ability to induce arrhythmia after radiofrequency ablation were evaluated.

Endotracheal extubation was performed after the reversal of the muscle relaxant's action and the patient had regained full muscle power. Then the patient remained in the post anesthesia care unit until they were hemodynamically stable, fully conscious, and capable of protecting their airway. Finally, when the pain was controlled and no nausea or vomiting was present, they were transferred to a ward room pending discharge from the hospital.

Data measured included; Type of arrhythmia, Total dosage of administrated drugs post intubation: (propofol, sevoflurane), Hemodynamics including blood pressure and heart rate at an interval of 10 minutes from the time of intubation until the patient was extubated.

Time analysis: mapping time, radiofrequency procedure time, total anesthesia time and mapping/anesthesia time ratio.

- Mapping time is calculated from the moment of induction of anesthesia until the detection of the focus.
- Radiofrequency-procedure time is measured from the start of the first diagnostic electrophysiological study until the end of the final diagnostic electrophysiological time.
- Total anesthesia time is calculated from the induction of anesthesia until the endotracheal extubation.
- Mapping/anesthesia time ratio: the ratio between mapping time over total anesthesia time.

Postoperative complications include postoperative nausea and vomiting, ventricular tachycardia or congestive heart failure, or failure of ablation or excessive secretion.

The primary outcome of the study was the successful identification and ablation of tachyarrhythmia focus in optimal time, (from the start of the first diagnostic electrophysiological study until the end of the final diagnostic electrophysiological time). Cardiac ablation will be successful, if after ablation of the focus, and prompting the heart to start beating quickly again (using pacing or isoprenaline) the heart rate remains regular and slow.

The secondary outcome was the changes in hemodynamic status and the detection of supraventricular tachycardia induction upon entry to the laboratory or upon catheter placement or on induction of anesthesia or after isoprenaline (stress-related or medically induced).

Statistical analysis

Sample size

The primary outcome is successful ablation in optimal time. A previous study had reported the total time of procedure in minutes 221±86.9. The sample size is calculated to detect a mean difference of 25% between groups. A minimum number of 21 patients is needed to have a study power of 80% and alpha error of 0.05 using G*Power program version 3.1.9.7. The number will be increased to 46 patients (23 patients per group) to compensate for possible dropouts.

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's *t*- test. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test or Fisher's exact test when appropriate. A two-tailed *P* value <0.05 was considered statistically significant.

RESULTS

In this study, 86 patients were assessed for eligibility, 19 patients did not meet the criteria and 7 patients refused to participate in the study. The remaining patients were randomly allocated into two equal groups (30 patients in each). All allocated patients were followed up and analyzed statistically (Figure 1).

Age, gender and weight were insignificantly different between both groups (Table 2).

Type of arrhythmia (atrial tachycardia, AVNRT, AVRT) and WPW were insignificantly different between both groups (Table 3).

Mapping time was significantly lower in sevoflurane group than propofol roup (*P* value= 0.018). Radiofrequency procedure time, total anaesthesia time and mapping/total anesthesia time were insignificantly different between both groups (Figures 1, 2).

The inducibility of the first SVT was insignificantly different between both groups (Figure 3).

The total dosage of sevoflurane ranged from 20–55ml with a mean value (±SD) of 37.17±10.56ml. Total dosage of propofol ranged from 183-1618.7 mg with a mean value (±SD) of 728.45±400.74mg (Table 4).

Systolic blood pressure measurements at baseline, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200 and 210min were insignificantly different between both groups.

Diastolic blood pressure measurements at 100 and 110min were significantly higher in the sevoflurane group than the propofol group (*P* value= 0.012 and 0.009 respectively) but insignificantly different in the rest of the study.

Heart rate measurements at baseline, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200 and 210min were insignificantly different between both groups.

Failed ablation, PONV and ventricular tachycardia were insignificantly different between both groups while excessive secretion was significantly lower in the sevoflurane group than the propofol group (*P* value <0.001) (Table 5).

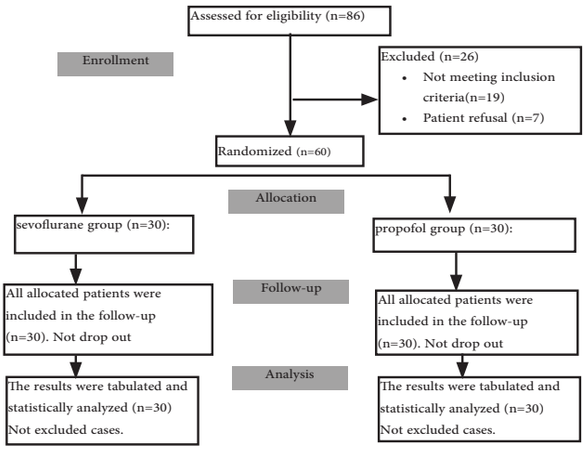

Fig. 1: CONSORT flowchart of the enrolled patients.

Table 2: Demographics of the studied groups:

		Sevofluranegroup (*n*=30)	Propofol group (*n*=30)	*P* value
Age (years)	Mean±SD	8.7±2.87	8.9±2.76	0.784
	Range	4-14	4-13	
Gender	Male	15(50%)	16(53.33%)	0.796
	Female	15(50%)	14(46.67%)	
Weight (kg)	Mean±SD	30.77±13.12	35.83±13.28	0.143
	Range	9 - 66	19 – 70	

Table 3: Type of arrhythmia of the studied groups:

	Sevoflurane group (*n*=30)	Propofol group (*n*=30)	*P* value
Atrial tachycardia	8(26.67%)	6(20%)	
AVNRT	10(33.33%)	9(30%)	0.715
AVRT	12(%)	15(%)	
WPW	8(26.67%)	11(36.67%)	0.405

AVNRT: Atrioventricular nodal re-entry tachycardia; AVRT: Atrioventricular reciprocating tachycardia; WPW: Wolf-Parkinson White syndrome.

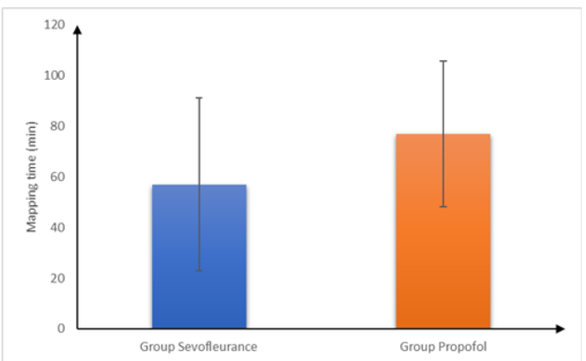

Fig. 1: Mapping time of the studied groups.

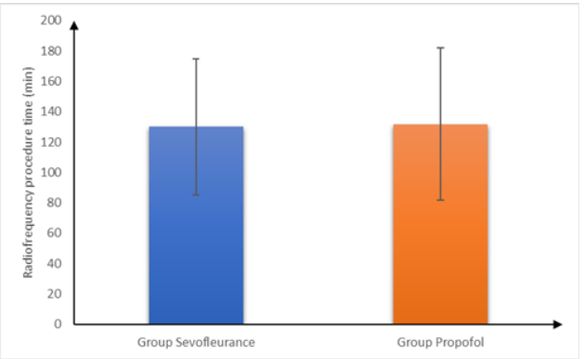

Fig. 2: Radiofrequency procedure time of the studied groups.

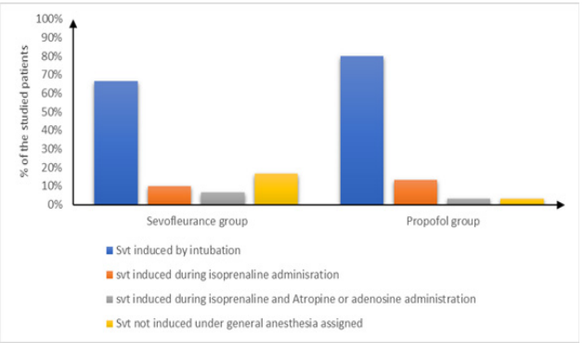

Fig. 3: Inducibility of first SVT of the studied groups.

Table 4: Total dosage of the studied groups:

		Total dosage
Sevoflurane group (*n*=30)	Mean±SD	37.17±10.56(ml)
	Range	20–55(ml)
Propofol group (*n*=30)	Mean±SD	728.45±400.74(mg)
	Range	183-1618.7(mg)

Table 5: Postoperative complications of the studied groups:

	Sevoflurane group (*n*=30)	Propofol group (*n*=30)	*P* value
Failed ablation	1(3.33%)	0(0%)	0.313
PONV	1(3.33%)	1(3.33%)	1.00
Excessive secretion	0(0%)	14(46.67%)	<0.001*
Ventricular tachycardia	0(0%)	1(3.33%)	0.313

DISCUSSION

This was a randomized controlled study, conducted on 60 children (1-14 years old) undergoing elective radiofrequency cardiac ablation of tachyarrhythmia. Patients were randomly allocated to receive propofol or sevoflurane using a computer random number. The purpose of this study was to investigate whether sevoflurane in anesthesia for cardiac ablation, is superior to propofol infusion in children with tachyarrhythmia in arrhythmia induction.

It showed that the mapping time was significantly lower in the sevoflurane group than the propofol group (*P* value= 0.018), which means less procedural time in a normally long procedure and reducing probability of recurrent mapping. Radiofrequency procedure time, total anesthesia time and mapping/total anesthesia time were insignificantly different between both groups. It also reported that types of arrhythmia (atrial tachycardia, Atrioventricular nodal reentrant tachycardia AVNRT, Atrioventricular reentrant tachycardia AVRT) and Wolf Parkinson white (WPW) were insignificantly different between both groups, and that the inducibility of first supraventricular tachycardia SVT was insignificantly different between both groups.

Supraventricular tachycardia (SVT) in children can be treated very effectively with Radiofrequency catheter ablation (RFCA). RFCA in pediatric patients has a good success rate with acceptable recurrence and complication rates when compared to adult patient results. Therefore, RFCA can be considered as the first line of therapy for arrhythmias with concealed and manifested accessory pathways (Aps) and Atrioventricular nodal reentrant tachycardia (AVNRT) in pediatric patients[8].

General anesthesia is necessary for this patient population to ensure comfort throughout the drawn-out procedure and immobility, the latter of which allows accurate mapping and subsequent ablation of the accessory pathway or arrhythmogenic focus, potentially increasing safety for pediatric patients undergoing RFCA[9].

In 2021, a multicenter retrospective cohort study using data from the Improving Pediatric and Adult Congenital Treatment (IMPACT) Registry, a national registry of catheterization and electrophysiology (EP) procedures in young patients, concluded that anesthesia strategy did not affect on inducibility of SVT or Ectopic atrial tachycardia (EAT), but general anesthesia was associated with premature ventricular complex/ventricular tachycardia (PVC/VT) non-inducibility and higher rates of non-ablation. There was no significant difference in ablation success or major adverse events between strategies. A MAC strategy should be considered for PVC/VT ablation in the pediatric population[10].

Erb *et al*., (2002) conducted a similar study where patients were randomly assigned to receive either an isoflurane- or propofol-maintained anesthetic. They reported that the RFCA procedure time, the onset of SVT time, the diagnostic electrophysiologic study time, the anesthesia time, and the time until ready for discharge from the PACU were not significantly different between the groups. However, drug administration was titrated according to the pharmacodynamic endpoint of thedepth of sedation using bispectral index score which wasn't available in our study.

Furthermore, Erb *et al*., (2002). reported that AVRT was higher in the propofol group than isoflurane group. However, similar to our study AVNRT was similar among both groups[11].

The effects of sevoflurane on the electrophysiological (EP) properties of the normal AV conduction system and the accessory pathways in patients with Wolff-Parkinson-White (WPW) syndrome have been evaluated in the past in combination with alfentanil and midazolam. Sharpe *et al*., concluded that sevoflurane had no effect on the EP nature of the normal AV or accessory pathway and had no clinically important effect on SA node activity[12].

The most widely used intravenous anesthetic in the world, propofol is preferred over volatile anesthetics because it causes less postoperative nausea and emergence delirium, especially in children. It is also frequently used for induction and maintenance of anesthesia during radiofrequency catheter ablation (RFCA) in pediatric patients as it has little or no significant effect on the cardiac conduction system according to contemporary investigators. The primary disadvantage of propofol is its hemodynamic depressive effect[12].

Matsushima *et al*., (2020). used a small sample (23 pediatric patients) and maintained the propofol infusion after the completion of RFCA for 10mins using a 5mg/kg/hr infusion of propofol then a bolus of 2mg/kg followed by another 10min of 10mg/kg/hr infusion. They showed that propofol significantly suppressed intrinsic cardiac Hiss-ventricular conduction, but did not affect the sinus node recovery time, sinoatrial conduction time or the atrial-Hiss interval[13].

Yildiz *et al*., (2018). also reported that Propofol is the primary medication for sedation and GA during ablation procedures, yet it has little impact on the conduction system and QT interval. Additionally, it suppresses catecholaminergic activity and blocks myocardial ion channels[14].

Lai *et al*., (2006). showed that intravenous propofol anesthesia is feasible during RFCA for most tachyarrhythmias except for ectopic atrial tachycardia in children. In four out of the seven patients with ectopic atrial tachycardia (AT), the tachycardia terminated after propofol infusion and couldn't be induced by isoproterenol infusion[15].

Kast *et al*., (2022). retrospectively analyzed anesthetic protocols of 166 children undergoing elective RFCA, including either inhalational anesthesia (sevoflurane and/or nitrous oxide) or intravenous anesthesia (propofol with/without remifentanil). They showed that AVNRT induction is not affected by a propofol infusion or inhalational anesthesia. However, in ectopic atrial

tachycardia (AT) patients, inhalational anesthesia seemed to be superior to intravenous anesthesia[16].

In this study, it was reported that failed ablation, postoperative nausea and vomiting PONV and ventricular tachycardia were insignificantly different between both groups while excessive secretion was significantly lower in the sevoflurane group than propofol group (*P* value <0.001).

Similar to our findings, Janson *et al*., (2021). reported that there was no statistically significant difference between both groups regarding occurrence of major adverse outcomes[10].

LIMITATIONS

Our study were that it was a single-center study, and the results may differ elsewhere. Bispectral index score (BIS) was not used for monitoring the level of sedation for sevoflurane and propofol. In patients undergoing RFCA, BIS monitoring may be especially useful because hemodynamic parameters such as heart rate and blood pressure, typically used to assess the depth of sedation in paralyzed patients, are altered because of the use of cardiac pacing and drugs, which have chronotropic effects. A double-blinded study is recommended to decrease bias in similar studies. Also the wide range of age of the patients makes a difference in their anesthetic requirements whether in sevoflurane or propofol, so a narrower range of age give more accurate results.

CONCLUSION

Sevoflurane and propofol-based anesthesia were equally suitable in children undergoing Radiofrequency catheter ablation in pediatrics regarding inducibility od arrythmias except that the mapping time was shorter with sevoflurane.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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