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Comparative study: evaluation of the effect of sevoflurane versus isoflurane in general anesthesia for pediatric patients undergoing cardiac catheterization

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ABSTRACT

Background: Anesthesiologists have had a difficult time managing infants with congenital heart disease, particularly at cardiac catheterization.

Aim and objectives: The investigation goal was to examine hemodynamic parameters and recovery profiles using Sevoflurane or isoflurane for anaesthesia in children scheduled for elective cardiac catheterization.

Setting: University educational hospital.

Design: A single-center, prospective clinical trial

Materials and Methods: Sixty juvenile patients having optional cardiac catheterization were randomised and assigned to one of two groups: isoflurane (group I) or sevoflurane (group S). Midazolam 0.5 mg/kg was given orally to all patients, 30 minutes prior to the surgical procedure. The initiation of anaesthesia was initiated with 5 mg/kg intramuscular ketamine in both groups. Maintenance of anaesthesia throughout the procedure was either by One MAC 2 ug/kg was given to all patients to provide analgesia and 1% xylocaine infiltration at the site of catheter insertion. Isoflurane (1.2%) (Group I) or sevoflurane (2%) (Group S) in an oxygen-air mixture of 1:1. All drugs were given by anaesthesiologists not involved in the study.

Results: Hemodynamic changes at and after the procedure: Mean arterial blood pressure (MAP), O2 saturation, ejection fraction (EF), and fraction shortening (FS) showed statistically substantial differences (P 0.05). The S group had a considerably greater steward score (recovery score) than the I group.

Conclusion: Sevoflurane in paediatric patients having cardiac catheterization provides good preservation of hemodynamic stability, rapid recovery, better sedation, and minimal side effects.

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Isoflurane; sevoflurane; hemodynamic; recovery; sedation; congenital heart disease

1. Introduction

Although volatile anaesthetics have cardio-protective qualities, it is uncertain whether these benefits are shared by all members of the class [1].

Despite the fact that sevoflurane is a more recent anaesthesia than isoflurane, it was not introduced into practise in the absence of a clinically meaningful head-to-head comparison with isoflurane [2].

Although there may be no clinically substantial variations in sevoflurane and isoflurane when using anaesthesia as maintenance in heart surgeries, this conclusion should be based on further research. If the clinical effects of sevoflurane and isoflurane are identical, other functional concerns (such as availability, preferences, or expense) may influence the choice of anaesthetic [3].

When used as a maintenance anaesthetic in cardiac procedures, there may be no clinically significant differences between seroflurane and isoflurane. This conclusion should be based on further research. If the clinical effects of sevoflurane and isoflurane are identical, other functional concerns (such as availability, preferences, or expense) may influence the choice of anaesthetic [3].

If one medicine performs better clinically than the other, clinicians should be aware of this and use the superior anaesthesia [4].

However, volatile anaesthetics remain one of the most valuable pharmaceutical options for cardiac anaesthesia upkeep in cardiac anesthesia. This is due to the fact that this form of anaesthesia has better relevance (neuro and cardiac protection) than nonvolatile anaesthesia [5].

Cardiac catheterization has steadily gained popularity as the primary and most frequent treatment for children with congenital heart disease (CHD). However, the best anaesthetic approach for cardiac catheterization in children with CHD is still up for debate [6].

Halogenated agents, for example, sevoflurane, isoflurane, desflurane, and halothane, lower median arterial pressure while raising the anaesthetic gas in a dose-dependent way by a decrease in systemic vascular

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resistance [7]. Sevoflurane has been shown to have less of an effect on the heart and blood vessels than isoflurane, which means that it causes less illness and death [8].

As a result, the goal of this research was to examine hemodynamic parameters and recovery profiles after sevoflurane or isoflurane maintenance anaesthesia in children scheduled for elective cardiac catheterization.

2. Patient and methods

Following the medical ethics committee's acceptance of the research plan, 60 patients aged 5–9 years old with non-cyanotic congenital heart disease with ASA II–III who presented for elective diagnostic cardiac catheterization were enrolled in this study following their parents' agreement and gave written informed consent.

2.1. Exclusion criteria

Mechanical ventilation, multiple congenital anomalies, chromosomal abnormalities, organ dysfunction (liver or renal), neurological or endocrine disease, musculoskeletal disorder, or pulmonary disease, e.g., recent chest infection, airway abnormalities

All patients were assessed the day before the procedure by medical history, physical examination, and laboratory investigation, and according to fasting guidelines for pediatrics, informed the parents that the patients must be fasting for 6 hours for solid food and 2 hours for clear fluids before the procedure.

Patients were randomised and allocated to one of two groups (30 patients each), employing a computer-generated randomised list: Isoflurane was given to **group I**, while sevoflurane was given to **group S**.

All patients were administered midazolam 0.5 mg/kg orally 30 minutes before to surgery. At the cardiac catheterization lab, standard monitoring comprised a five-lead electrocardiogram (ECG), non-invasive blood pressure, and pulse oximetry. Every 5 min, the heart rate (HR), blood pressure (BP), and oxygen saturation (SpO2) were measured during the procedure.

Both groups received 5 mg/kg intramuscular ketamine to begin anaesthesia induction. An intravenous line was inserted when the eyelid reflex had vanished, and an adequate-sized endotracheal tube was used to intubate the patient with spontaneous ventilation throughout the procedure. The patients were randomised and allocated to take either one MAC Isoflurane (1.2%) or sevoflurane (2%) in an oxygen–air combination 1:1 for anaesthesia maintenance throughout the operation utilising sealed envelopes. To provide analgesia, all patients were administered 2 ug/kg fentanyl and 1% xylocaine infiltration at the catheter insertion site, and crystalloid solution was used to replenish fluid according to the "4/2/1-rule" (mL/kg/h) (lactated ringer).

During the procedure, ejection fraction (EF), fraction shortening (FS), cardiac index (CI), and vascular resistance index (VRI) were assessed by the cardiologist who was performing cardiac catheterization and was not involved in our study.

After bandaging the groin area at the end of the procedure, the vaporizer was switched off and the patients were given 100% oxygen. When the patients were completely aware, they were extubated and moved to the post-anaesthesia care unit (PACU). Hypotension (a drop in blood pressure of more than 20% from baseline) was treated with intravenous ephedrine 0.2 mg/kg and an intravenous bolus of crystalloid (10 ml/kg), bradycardia (a drop in heart rate of more than 20% from baseline) was treated with intravenous atropine 0.01 mg/kg, and desaturation (a drop in peripheral oxygen saturation of more than 5% from baseline) necessitated jaw support with an O2 Intravenous granisetron 40 ug/kg was used to treat vomiting, while intravenous paracetamol 15 mg/kg was used to address postoperative pain.

A modified steward recovery score [9] of > or = 6 indicates that the patient is conscious or reacts to verbal stimulation, has intentional motor movement, and coughs on order after inhalation anesthesia.

The following sedation scores [10] were used to evaluate postoperative sedation: 1 = totally awake; 2 = awake but sleepy; 3 = asleep but receptive to verbal orders; 4 = sleeping but responsive to tactile input; and 5 = asleep and not responsive to any stimulation.

All drugs were given by anesthesiologists blind to our study, and all data observed and recorded were done by other blinded anesthesiologists to the study.

2.2. Outcomes

The primary outcome is hemodynamic stability throughout the procedure. Secondary outcomes include recovery time, other complications (arrhythmia, hypotension, bradycardia, desaturation, nausea, vomiting, and postoperative sedation).

2.3. Statistical analysis

The following assumptions were utilised to compute the sample size in this research based on Kim et al's [11] study Epi-info STATCAL: −95% two-sided confidence level, with 80% power and 5% error. The highest sample size calculated from Epi-info data was 56. Thus, the sample size was increased to 60 subjects to assume any dropout cases during follow-up.

$$\left(\frac{Z_{\frac{a}{2}} + Z_B}{P_1 - P_2}\right)^2 (p_1q_1 + P_2q_2)$$

2.4. Takazawa & Morita [12]

n = sample size
Z a/2 (The key number that splits the Z distribution's central 95%)
ZB (The critical value that divides the central 20% of the Z distribution)
p1 = Value in group 1.
p2 = Value in group 2.

Summary statistics were computed using the baseline demographic data. First, histograms for continuous data were visually examined to check if they were generally evenly distributed. The Student's *t*-test was performed to see if they were. The variance in means across groups, its associated 95% confidence interval, and the null hypothesis test of no difference in averages were estimated using 0.5 quantile (median) regression, group assignment conditioning, and bootstrapping with 10,000 replications if the data was skewed. 19,20 To evaluate categorical data, such as the primary result, a two-sided Fisher's exact test was used. The Kaplan–Meier technique was used to show time-to-event data; average regression with bootstrapped standard errors was used to assess variations in median times-to-event; and the log-rank test was used to do hypothesis testing.

3. Results

In October 2021, 60 children's patients with ASA II and III who had cardiac catheterization at six university hospitals were split into two equal groups. The trial was completed by all 60 participants who were recruited.

The groups were matched based on their age in years, weight (Kg), sex, operation length (min), and ASA II & III (Table 1), and between them, there was no statistically substantial variation (P > 0.05) Table 1.

Table 1. Patient characteristics between the two groups.

	Group I (n = 30)	Group S (n = 30)	P value
Age (years)	6.9 ± 1.52	7.81 ± 1.34	.115
Mean ±SD			
Sex, n (%)			.793
Male	13 (43.3%)	12 (40%)	
Female	17 (56.7%)	18 (60%)	
Weight (kg)	27.41 ± 7.45	24.63 ± 6.21	.122
Mean ±SD			
Duration of procedure (min)	68.45 ± 1.511	67.15 ± 2.011	0.01
Mean ±SD			
ASA, n (%)			
II	22 (73.3%)	21 (70%)	0.853
III	8 (26.7%)	9 (30%)	

Table 2. Hemodynamics changes parameters.

Hemodynamic	Group I (n = 30) Mean ± SD	Group S (n = 30) Mean ± SD	P value
Heart rate (beat/min)			
During	114 ± 11.81	119 ± 9.35	0.003
After	123 ± 13.29	131.1 ± 10.76	0.004
MAP (mmHg)			
During	83.45 ± 3.62	86 ± 3.45	0.002
After	72.31 ± 7.78	88 ± 4.73	0.004
O2 saturation (%)			
During	91 ± 5.24	98 ± 1.38	0.001
After	90 ± 9.52	99. ± 1.34	0.001
Ejection fraction EF (%)			0.003
During	65.3 ± 7.34	68.4 ± 10.87	0.004
After	61.9 ± 8.17	70.6 ± 9.35	0.007
Fraction shortening SF (%)			
During	46.56 ± 6.32	48.15 ± 7.46	0.003
After	43.08 ± 5.14	47.73 ± 9.22	0.001
Cardiac index (L/min/m^2)			
During	3.18 ± 2.93	3.79 ± 3.05	0.238
After	3.01 ± 2.15	3.67 ± 2.99	0.304
Vascular resistance index (dyne s cm^{-5}m^2)			
During	1.1 ± 0.708	1.1 ± 0.950	0.007
After	0.759 ± 0.315	0.783 ± 0.391	0.001

Table 2 shows hemodynamic changes at and after the procedure. MAP, O2 saturation, ejection fraction (EF), and fraction shortening (FS) showed statistically significant differences as they decreased in I more than in the S group during and after the procedure (P 0.05). However, regarding heart rate for group S compared to group I, there is a significant increase regarding heart rate for group S compared to group I (P 0.05).

The groups were matched on age, weight (Kg), sex, operation length (min), and ASA II & III (Table 1), and there was no statistically significant difference between them (P > 0.05). Table of contents [1]

Hemodynamic alterations before and after the surgery are shown in Table 2. MAP, O2 saturation, ejection fraction (EF), and fraction shortening (FS) all fell in the I group more than the S group before and after the surgery, indicating statistically significant differences (P 0.05). However, when group S is compared to group I, there is a considerable rise in heart rate for group S. (P 0.05).

A modified Steward score was used to assess recovery from inhalation anaesthesia after stopping it; a score of > or = 6 indicates that the patient is awake or reacts to verbal stimuli, shows intentional physical activity, and coughs on command. The Modified Steward Score of > or = 6 was greater in the (S)

Table 3. Postoperative evaluation between the two groups.

Parameters	Group I (n = 30)	Group S (n = 30)	P
Recovery time (min)	37.85 ± 7.35	29.51 ± 6.42	<0.001
Mean ±SD			
Sedation Score	4.56 ± 0.705	3.24 ± 0.812	<0.001
Mean ±SD			
Modified steward recovery score (%)			
> 6	14 (46.7%)	8 (26.7%)	<0.001
6	16 (53.3%)	22 (73.3%)	

Table 4. Postoperative side effects.

	Group I (n = 30)		Group S (n = 30)		
Adverse effect	N	%	N	%	P
Arrhythmia	1	3.3%	0	–	0.315
Hypotension	7	23.3%	2	6.7%	0.071
Bradycardia	6	20%	3	10%	0.417
Desaturation	5	16.7%	2	6.7%	0.228
Nausea and vomiting	8	26.7%	5	16.7%	0.347

group compared to the (I) group, and the variation was statistically relevant (p 0.05). After full recovery from inhalational anesthesia, the sedation score was used to measure the degree of sedation. The S group had a greater sedation score than the I group (Table 3), and the variation was statistically substantial (p 0.05) (Table 3).

Table 4 shows that postoperative complications were less and prevented among group S compared to group I but without a statistically significant difference.

4. Discussion

Children with congenital heart disease (CHD) who have diagnostic and/or intervention cardiac catheterization are at a higher risk of hemodynamic instability due to the underlying disease, catheter-related arrhythmia, intra-procedural complications up to cardiac arrest [13].

In these situations, the goals of anaesthesia would be to keep the blood pressure stable and the heart's ability to contract as little as possible, stop arrhythmias, and keep the systemic and pulmonary circulations in balance [14].

In this study, we compared the two commonly used inhalational agents, sevoflurane and isoflurane, when used for maintenance of anaesthesia in children with congenital heart disease during cardiac catheterization, and their effects on hemodynamics, recovery, and complications.

In terms of hemodynamics MAP, EF, FS, and CI intra and post procedure, there was statistically significant variation between the two groups, with the I group being more affected than the S group. In agreement with our study, Rivenes et al [15], in juvenile cardiac surgery, researchers evaluated the cardiovascular effects of sevoflurane, isoflurane, and halothane, as well as the midazolam–fentanyl combination. The cardiac index was well maintained in sevoflurane at 1 and 1.5 MAC, whereas median arterial pressure was considerably lower than the baseline value at the same concentrations.

Another study done by Eldeen & Messeha [16] concluded that sevoflurane maintains hemodynamic stability of heart rate, mean arterial pressure, and cardiac index when used during induction and maintenance of anaesthesia for interventional paediatric cardiac catheterization –

Russell et al [17] performed a prior report on 182 paediatric patients for elective correction or palliation of congenital heart disease, comparing sevoflurane and halothane for anaesthesia upkeep, and indicated that sevoflurane may have hemodynamic benefits due to fewer hypotensive episodes and dysrhythmias in heart disease patients.

A prospective multicenter study done by Lin et al [18] Children of congenital cardiac disease have sensitive hemodynamics, and fluctuation in pulmonary and systemic vascular resistance with inhalational anaesthetics and mechanical ventilation, and EF was decreased by 10% by using sevoflurane and not affected by using isoflurane, while MAP was decreased by 9 mmHg and 19 mmHg, respectively.

Also, Dala et al [19] compared the cardiovascular effects of isoflurane and sevoflurane in children with congenital heart disease. They observed a significantly decreased MAP from baseline and stroke volume of 21.5 (9.2) versus 19.6 (6.2), CI 4.1 (1.2) versus 3.7 (0.87) and EF 64.2 (14.5) versus 62.5 (13.8), respectively. The previous two studies agree with our results regarding MAP and CI but disagree with us regarding EF. This might be because they used different techniques in anaesthesia than ours.

Previous investigations done by Duptont et al [20] and Umbrain et al [21] compared the hemodynamic effects of isoflurane and sevoflurane and found no significant difference between the two inhalational agents. Their results vary from ours as their study was on adult cardiac patients.

In addition to the above findings, we observed that sevoflurane had fewer postoperative complications than isoflurane but without a statistically significant difference. As regards sedation, we found that the S group had a greater sedation score than the I group and recovery time was longer in the I group as isoflurane has elevated blood gases levels, resulting in delayed recovery from anesthesia.

In agreement with our findings, Gupta et al [22] discovered drowsiness is significantly more common in the isoflurane group when compared to the sevoflurane group in their systematic review study comparing the recovery profiles after isoflurane and sevoflurane anaesthesia in ambulatory anesthesia, although other complications, such as shivering, headache, and postoperative nausea and vomiting were fewer in the sevoflurane group without significant difference.

Maheshwari et al [23] In their study, they discovered that the isoflurane group had a longer emergence time than the sevoflurane group, with no difference in the duration of the post-anesthesia care unit.

Research done by Kopyeva et al [24] showed that elevated hospital stays in isoflurane when compared to sevoflurane and desflurane groups. These studies agree with ours regarding recovery time.

Kurhekar et al [25] conducted a study comparing isoflurane, sevoflurane, and desflurane in ambulatory anaesthesia and found no difference in the recovery picture between sevoflurane and isoflurane. This is because their study was on adult patients performing day-case operations.

In contrast to our study [Pradeep et al [26]] randomised controlled study, comparing the recovery profiles between sevoflurane and isoflurane maintenance anaesthesia in paediatric patients, they observed an increased incidence of emergence agitation with sevoflurane, especially in the first 20 min of the postoperative period as it was linked with pre-induction agitation, and that is why their result does not go with ours. Also, the age of children in their study was younger than ours.

The research of Ulke et al [14], they used sevoflurane in the induction of anaesthesia in children with congenital heart disease, and they reported that sevoflurane reduced coughing, breath retention, and laryngospasm, and the researchers concluded that it might be the preferred agent for paediatric anaesthesia treatment.

5. Study limitations

There are certain limitations to the present research. It was a one-center experiment. Furthermore, since we did not recruit critically sick patients and most of the patients were stabilized clinically, the results may be limited in their relevance to clinically unstable patients with comorbidities. Because of the tiny sample size, it's possible that adverse events that occur rarely were missed. In addition, the economic implications of the pharmaceuticals used should be taken into account.

6. Conclusion

Sevoflurane is preferable to isoflurane as an anesthetic for juvenile cardiac catheterization because it causes less myocardial damage and improves hemodynamic stability.

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Availability of data and material

Available.

Consent for publication

I certify that all authors agree to submit the work.

Disclosure statement

No Conflicts of Interest.

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