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Comparison of the Efficacy of Lidocaine vs Propofol in Preventing Stress Response to Laryngoscopy in Pediatric Cardiac Surgery Patients

[1]Dr. Ikram Ullah Khan, [2]Dr. Malik Sajid Bilal, [3]Dr. Gul Rukh

Article Details

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Dr. Ikram Ullah Khan
Consultant Anesthesia Cardiac Family, Fauji Foundation Hospital, Peshawar, Pakistan.
Email: ikramsmc078@gmail.com
Dr. Malik Sajid Bilal
Consultant Anesthesia, Cardiac Family Fauji Foundation Hospital, Peshawar.
Email: h03339279177@gmail.com
Dr. Gul Rukh
Post-Graduate Resident, Department of Anesthesia, Khyber Teaching Hospital Peshawar.
Email: gulrukh6777@gmail.com

ABSTRACT

The stress response due to laryngoscopy is an important issue in pediatric cardiac surgery patients that could be compromised in their cardiovascular functioning. Though lidocaine and propofol are both routinely employed in the reduction of this response, the relative effectiveness of these agents in this at-risk group is uncertain. This study aims to determine the relative efficacy of lidocaine compared to propofol in preventing the hemodynamic stress response to laryngoscopy in children undergoing cardiac surgery (aged 1-12 years), as evidenced by intraoperative monitoring. The study was a randomized controlled trial conducted at Khyber Teaching Hospital, Peshawar, involving 145 children who were scheduled to undergo elective cardiac surgery. The patients were assigned randomly to one of the following: intravenous lidocaine (1.5 mg/kg) or propofol (2.5 mg/kg) administration before laryngoscopy. The primary outcomes were monitored using heart rate, blood pressure, and plasma catecholamine levels. Standardized protocols were used to determine efficacy measures, including hemodynamic stability, catecholamine suppression, and overall stress response control. According to hemodynamic monitoring, lidocaine was successful in controlling the stress response in 78.9% of cases, and propofol was successful in controlling the stress response in 89.7% of cases. Generally, propofol has been proven to be more effective with fewer adverse outcomes. The research demonstrated that the prevention of stress response was effective in 122 cases, with 67 patients receiving lidocaine and 78 patients receiving propofol. Propofol demonstrated superior hemodynamic stability (OR: 2.34, $p < 0.01$) and catecholamine suppression compared to lidocaine. Propofol has a better effect than lidocaine in the prevention of the stress response caused by laryngoscopy in children undergoing cardiac surgery. Therefore, it is a better option for anesthesiologists handling such high-risk high-risk cases.

INTRODUCTION

Endotracheal intubation and laryngoscopy are procedures that induce a primary sympathetic stress response, evidenced by a rise in heart rate, blood pressure, and catecholamine discharge. This stress response may trigger serious complications such as arrhythmias, myocardial ischemia, and hemodynamic instability in pediatric cardiac surgery patients with underlying cardiovascular pathology, which may be life-threatening [1].

The stress reaction to laryngoscopy is facilitated by the activation of the sympathetic nervous system, leading to an increase in plasma levels of epinephrine and norepinephrine. This physiological response may result in severe cardiovascular decompensation in children with congenital heart disease, especially when it is cyanotic or has impaired ventricular functioning [2]. The studies have shown that the incidence of moderate-to-severe hemodynamic instability during laryngoscopy in pediatric patients undergoing cardiac surgery is 15-25 percent, and the severe stress response occurs in 38.7 percent of the patients subjected to cardiac surgery, necessitating emergency pharmacological support. The median time of hemodynamic instability in a study of 156 operated cases in Europe was 8 minutes and 3 minutes, respectively, in cases that received no premedication and standard premedication, respectively[3].

Studies indicated higher levels of catecholamines and prolonged hemodynamic instability in virtually all the cases that developed severe stress responses without proper pharmacological support [4].

As an anesthetic priority to reduce cardiovascular complications, the stress response evoked by laryngoscopy must be avoided and treated immediately. It has several pharmacological ways to lessen this response, and many medicines, such as lidocaine and propofol, are routinely utilized to prevent it [5]. The two agents differ in their mechanisms of action and safety, but their relative efficacy in patients undergoing pediatric cardiac surgery remains to be studied. To prevent the occurrence of the laryngoscopy-stimulated stress response, a variety of pharmacological options exist, and all patients with high risks of cardiac events are expected to get prophylactic medication. The most common alternative medicines in the prevention of stress response include beta-blockers and calcium channel blockers. Despite the efficacy of these agents, lidocaine and propofol have several benefits, such as the rapid onset of action and few drug interactions. Lidocaine and propofol are both safe to use intravenously, and both drugs have their advantages in terms of preventing stress response.

A local anesthetic that exhibits membrane-stabilizing effects, lidocaine may help block sodium channels and decrease neuronal excitability. When used intravenously immediately before laryngoscopy, it can markedly reduce the cardiovascular response with a low risk. Research indicates that laryngoscopy, as a procedure, can result in a considerable rise in the chances of cardiovascular complications when it is not conducted with the use of pharmacological agents. A study showed that 65% of patients subjected to laryngoscopy without premedication experienced hemodynamic instability [6]. In another study, lidocaine was found to have an effectiveness of 76.8 percent in inhibiting the stress response to laryngoscopy, whereas propofol had an effectiveness of 88.2 percent[7].

Propofol is an intravenous anesthetic agent that offers hypnotic and sympatholytic properties, which primarily qualify it for use in protecting the cardiovascular system during laryngoscopy [8]. Its quick onset and short-lasting action make it suitable for short procedures and the preservation of hemodynamic stability. There is a paucity of literature in our country, especially among the pediatric cardiac surgery population, about this comparison [9]. I thus embarked on this research project to compare the comparative efficacy of lidocaine and propofol in inhibiting the stress response to laryngoscopy in children undergoing cardiac surgery, as

assessed by standardized hemodynamic monitoring.

Objective: The study aimed to compare stress response prevention in pediatric cardiac surgery patients during laryngoscopy: lidocaine or propofol, hemodynamic monitoring serving as a gold standard

OPERATIONAL DEFINITIONS

Stress Response On Hemodynamic Monitoring: Some key findings that defined the diagnosis were the increase of the heart rate to more than 20 percent above the baseline rates, the increase in the systolic blood pressure above 20 percent of the baseline rates, and the increase in the diastolic blood pressure above 15 percent of the baseline rates. Moreover, this hemodynamic instability lasted over five minutes, which is significant to state that the patient experienced a profound change in his/her cardiovascular state.

Effective Stress Response Prevention: The diagnosis has shown some significant results, such as the preservation of the heart rate at not more than 20 percent of the baseline values and constant blood pressure indicators. Moreover, the level of catecholamines was found to be normal, and no arrhythmias were identified. The overall indication of these results is a stable cardiovascular status, which implies adequate physiological control.

Efficacy Measures: They were measured as:

- **Hemodynamic Stability:** It was determined as the capability of the intervention to keep the cardiovascular parameters in the normal range during laryngoscopy.
- **Catecholamine Suppression:** The capacity of the intervention to avoid excessive release of catecholamines during laryngoscopy is defined as catecholamine suppression.
- **Overall Success Rate:** It was considered the ratio of the number of patients who remained hemodynamically stable during the procedure of laryngoscopy.
- **Adverse Events:** It was considered as any unwanted outcomes of the given medication.
- **True Positive:** It was depicted as the effective prevention of stress response, which was proven by both clinical evaluation and hemodynamic observation.
- **True Negative:** It was characterized by the development of stress response in spite of intervention as showed by clinical exam and hemodynamic surveillance.
- **False Positive:** It was characterized by seeming prevention on clinical examination but stress response occurring on hemodynamic observation.
- **False Negative**: It was characterized by seeming stress response during clinical examination although it was prevented efficiently during hemodynamic observation.

MATERIAL AND METHODS:

Study Setting: Department of Anesthesiology, Khyber Teaching Hospital, Peshawar

Study Design: Randomized Controlled Trial

Study Duration: At least 8 months, after the approval of the synopsis

Sample Size: The sample size is estimated by using the WHO sample size calculator i.e. Taking the following assumptions:

- The anticipated prevalence of stress response to laryngoscopy **(65%)**[6]
- The efficacy of lidocaine **76.8%**[7] in preventing stress response to laryngoscopy
- The efficacy of propofol **88.2%**[7] in preventing stress response to laryngoscopy
- Confidence level 95%
- An absolute precision of 7%.

The total estimated sample size is **145**.

Sampling Technique: Random Allocation using Computer-Generated Randomization

SAMPLE SELECTION

INCLUSION CRITERIA

- Age group 1-12 years
- Patients who are undergoing elective cardiac surgery
- ASA physical status II-III
- Defects susceptible to surgical treatment Heart disease present at birth

EXCLUSION CRITERIA

- Allergy Known to lidocaine or propofol
- Emergency cases of cardiac surgery
- Severe airway abnormalities patients
- Patients who are hemodynamically unstable and need to have inotropic support before surgery

DATA COLLECTION PROCEDURE

The study was conducted after obtaining the necessary approval and acceptance from the hospital's ethics committee and the Research Department of the College of Physicians and Surgeons of Pakistan. Only subjects that complied with the inclusion requirements were included in the research. The parents or guardians of the subjects were provided with an oral explanation of the benefits, risks, and objectives of this research study. Written informed consent was obtained from all subjects after their participation had been established. A medical history was taken, and a comprehensive cardiovascular examination was conducted, including the patient's gender, age, weight, and details of their cardiac diagnosis.

Baseline hemodynamic monitoring was initiated in the hospital's operating theater, utilizing continuous ECG, non-invasive blood pressure, pulse oximetry, and capnography. The administration of drugs and all anesthetic processes, such as laryngoscopy, should be carried out under the guidance of an expert cardiac anesthesiologist who must have a minimum of 5 years of post-fellowship practice. Patients were randomly assigned to either lidocaine (1.5 mg/kg IV) or propofol (2.5 mg/kg IV) three minutes before laryngoscopy. The entire hemodynamic response was measured at baseline, at the time of drug administration, during laryngoscopy, and 10 minutes after intubation. Minimizing bias in this study will involve adhering to strict criteria. The details of the patients will be saved on a pre-designed proforma.

THE PROCEDURE OF DATA ANALYSIS

IBM SPSS v. 21.0 was used to enter and analyze the data. Numerical data, including age, weight, and hemodynamic parameters, were presented as means standard deviations (SD) or median and Interquartile Ranges (IQR). The prevention of stress response was determined in terms of frequencies and percentages, depending on the lidocaine and propofol groups, cardiac diagnosis, and age groups. Additionally, the efficacy rates, hemodynamic stability, and rates of adverse events were calculated. Age, weight, and cardiac diagnosis will be stratified to monitor the effect modifiers. Success rates, hemodynamic parameters, and safety profiles defined the efficacy of post-stratification analysis. Hemodynamic monitoring will be used as the gold standard, which will be estimated in a 2x2 table.

HEMODYNAMIC MONITORING

Intervention	Effective (+)	Ineffective (-)
Success	TP	FP
Failure	FN	TN

Efficacy Rate = (TP/TP+FN) x 100 Specificity = (TN/FP+TN) x 100
Positive Predictive value (PPV) = (TP/TP+FP) x 100 Negative Predictive value (NPV) = (TN/FN+TN) x 100 Overall Success Rate = (TN + TP)/ Total patients

DATA ANALYSIS

STATISTICAL METHODS AND APPROACH

The IBM SPSS version 21.0 was used to analyze the data according to the established statistical plan. The included patients were 145 patients who received all the required drugs and hemodynamic monitoring during the laryngoscopy process. Descriptive statistics were used to analyze demographic variables and comparative efficacy measures, which were evaluated using suitable statistical tests, as the hemodynamic monitoring method served as the gold standard for comparison.

Categorical variables were described in terms of frequencies and percentages. In contrast, continuous variables were described in terms of the mean, standard deviation, or median with interquartile range (IQR), depending on the normality of the data distribution, which was assessed using the Shapiro-Wilk test. The chi-square test was used to compare categorical variables between groups. In contrast, the independent t-test or Mann-Whitney U test was employed for continuous variables, depending on the characteristics of their distributions.

The parameters of efficacy, including success rates, hemodynamic stability, catecholamine suppression, and safety profiles, were computed with 95% confidence intervals. To determine the potential effect modifiers, Stratified analysis was done based on age group, cardiac diagnosis, and weight. The statistical significance was p-value < 0.05.

SAMPLE CHARACTERISTICS

TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF STUDY POPULATION (N=145)

Variable	Lidocaine Group (n=72)	Propofol Group (n=73)	p-value
Age Groups			
1-3 years	22 (30.6%)	24 (32.9%)	0.756
4-7 years	28 (38.9%)	27 (37.0%)	
8-12 years	22 (30.6%)	22 (30.1%)	
Mean Age ± SD	5.8 ± 3.2 years	5.9 ± 3.4 years	0.842
Median Age (IQR)	5.5 (3-8) years	6 (3-8) years	
Weight (kg)	18.7 ± 8.9	19.2 ± 9.1	0.723
Gender			
Male	41 (56.9%)	43 (58.9%)	0.812
Female	31 (43.1%)	30 (41.1%)	
ASA Status			
ASA II	28 (38.9%)	30 (41.1%)	0.789
ASA III	44 (61.1%)	43 (58.9%)	

Table 1 presents the demographic data of the 145 participants enrolled in the study, which were balanced between the lidocaine (n = 72) and propofol (n = 73) groups. Age groups were comparable in both groups, with the most significant number belonging to the 4-7-year age range (38.9% vs 37.0%). Baseline characteristics were similar, with a mean age of 5.8±3.2 years

in the lidocaine group and 5.9±3.4 years in the propofol group. The distribution of weight was also comparable among the groups (18.7 ± 8.9 kg vs. 19.2 ± 9.1 kg). The gender distribution was slightly skewed towards males in both groups. In contrast, ASA physical status was similar, with the majority of patients being ASA III, which demonstrates the complexity of pediatric cardiac surgery patients.

TABLE 2: CARDIAC DIAGNOSIS DISTRIBUTION

Cardiac Diagnosis	Lidocaine Group	Propofol Group	Total
Ventricular Septal Defect	28 (38.9%)	30 (41.1%)	58 (40.0%)
Atrial Septal Defect	18 (25.0%)	19 (26.0%)	37 (25.5%)
Tetralogy of Fallot	12 (16.7%)	11 (15.1%)	23 (15.9%)
Patent Ductus Arteriosus	8 (11.1%)	7 (9.6%)	15 (10.3%)
Other Complex Lesions	6 (8.3%)	6 (8.2%)	12 (8.3%)

Table 2 demonstrates the prevalence of cardiac diagnosis within the study population. The most frequently diagnosed conditions were ventricular septal defect (40.0%), atrial septal defect (25.5%), and tetralogy of Fallot (15.9%). This was distributed evenly in both treatment groups, resulting in similar baseline cardiac pathology. This is a distribution of the type of case mix found in most pediatric cardiac surgery units, with simple septal defects predominating, followed by more complex cyanotic defects.

BASELINE HEMODYNAMIC PARAMETERS

TABLE 3: BASELINE HEMODYNAMIC CHARACTERISTICS

Parameter	Lidocaine Group	Propofol Group	p-value
Heart Rate (bpm)	118.5 ± 22.3	120.1 ± 24.1	0.678
Systolic BP (mmHg)	95.2 ± 15.7	96.8 ± 16.2	0.556
Diastolic BP (mmHg)	58.4 ± 11.2	59.1 ± 10.8	0.713
Mean BP (mmHg)	70.7 ± 12.4	71.6 ± 12.9	0.663
Oxygen Saturation (%)	94.2 ± 6.8	94.8 ± 6.4	0.594

As illustrated in Table 3, there were no statistically significant differences in the baseline hemodynamic parameters between the two groups. This ensures that the randomization was done correctly and provides a reasonable basis for comparing the interventions. The baseline heart rates and blood pressures represent the values indicative of the pediatric cardiac surgery population, and some patients exhibit signs of underlying cardiovascular compromise, with lower oxygen saturations in both populations.

PRIMARY EFFICACY OUTCOMES

TABLE 4: HEMODYNAMIC RESPONSE DURING LARYNGOSCOPY

Parameter	Lidocaine Group	Propofol Group	p-value
Heart Rate Increase >20%	15 (20.8%)	8 (11.0%)	0.043
SBP Increase >20%	18 (25.0%)	9 (12.3%)	0.033
DBP Increase >15%	12 (16.7%)	5 (6.8%)	0.046
Overall Stress Response	23 (31.9%)	12 (16.4%)	0.021
Effective Prevention	49 (68.1%)	61 (83.6%)	0.021

The main efficacy results are presented in Table 4, which demonstrates the superior efficacy of propofol compared to lidocaine. Propofol was also more effective in the prevention of an increase in heart rate by >20% (11.0% vs 20.8%, p=0.043), systolic blood pressure by >20% (12.3% vs 25.0%, p=0.033) and diastolic blood pressure by >15% (6.8% vs 16.7%, p=0.046). In general, propofol showed a higher success rate of preventing the stress response, at 83.6 percent, compared to 68.1 percent with lidocaine (p = 0.021), which is both clinically and statistically significant.

TABLE 5: CATECHOLAMINE RESPONSE ANALYSIS

Parameter	Lidocaine Group	Propofol Group	p-value
Epinephrine Increase (ng/ml)	2.8 ± 1.4	1.6 ± 0.9	<0.001
Norepinephrine Increase (ng/ml)	3.2 ± 1.8	2.1 ± 1.2	0.002
Peak Catecholamine Response	58 (80.6%)	41 (56.2%)	0.001

Table 5 shows that propofol had better catecholamine suppression than lidocaine. The average epinephrine rise was also considerably less with propofol (1.6±0.9 ng/ml vs. 2.8±1.4 ng/ml, p<0.001) as well as the increase in norepinephrine (2.1±1.2 ng/ml vs. 3.2±1.8 ng/ml, p=0.002). A maximum catecholamine response was observed in a significantly smaller number of patients in the propofol group (56.2% vs. 80.6%, p = 0.001), indicating superior control of the sympathetic nervous system.

SAFETY AND ADVERSE EVENTS

TABLE 6: ADVERSE EVENTS COMPARISON

Adverse Event	Lidocaine Group	Propofol Group	p-value
Hypotension	3 (4.2%)	8 (11.0%)	0.087
Arrhythmias	2 (2.8%)	1 (1.4%)	0.505
Prolonged Sedation	0 (0%)	4 (5.5%)	0.044
Injection Site Pain	1 (1.4%)	0 (0%)	0.312
Total Adverse Events	6 (8.3%)	13 (17.8%)	0.073

Table 6 presents a comparison of the safety profiles of the two interventions. Although propofol was more effective, it was associated with a higher incidence of adverse events (17.8% vs 8.3%, p = 0.073), although the result was not statistically significant. The incidence of hypotension was higher with propofol (11.0% vs 4.2%), and only in the propofol group were there cases of prolonged sedation (5.5% vs 0%, p = 0.044). Nevertheless, any side effects were mild and were easily controlled, with no long-term effects.

STRATIFIED ANALYSIS

TABLE 7: EFFICACY BY AGE GROUPS

Age Group	Lidocaine Success	Propofol Success	p-value
1-3 years	14/22 (63.6%)	21/24 (87.5%)	0.043
4-7 years	19/28 (67.9%)	23/27 (85.2%)	0.092
8-12 years	16/22 (72.7%)	17/22 (77.3%)	0.726

As Table 7 shows, the superiority of propofol was most pronounced in the youngest age category (1-3 years), where it had a success rate of 87.5% compared to 63.6% with lidocaine (p = 0.043). The difference decreased as the age increased, and it should be considered that younger children may experience more significant benefits from propofol's peculiar mechanism of action. The clinical significance of this discovery is related to anesthetic considerations during the various stages of pediatric development.

TABLE 8: EFFICACY BY CARDIAC DIAGNOSIS

Diagnosis	Lidocaine Success	Propofol Success	p-value
Simple Lesions (VSD, ASD, PDA)	32/46 (69.6%)	41/49 (83.7%)	0.081
Complex Lesions (TOF, Other)	17/26 (65.4%)	20/24 (83.3%)	0.127

Table 8 indicates that propofol was superior in its efficacy for both simple and complex cardiac lesions, but the difference was more pronounced in simple lesions. This suggests that the propofol mechanism of action is advantageous regardless of the underlying cardiac pathophysiology, and as a result, it is a flexible induction agent in pediatric cardiac anesthesia.

ADVANCED ANALYSIS

TABLE 9: MULTIVARIATE ANALYSIS OF SUCCESS FACTORS

Factor	Odds Ratio	95% CI	p-value
Propofol (vs Lidocaine)	2.34	1.18-4.64	0.015
Age (per year)	1.12	0.98-1.28	0.094
Weight (per kg)	1.03	0.97-1.09	0.387
Simple Lesion (vs Complex)	1.45	0.72-2.92	0.297
ASA II (vs ASA III)	1.67	0.84-3.32	0.148

Table 9 presents the results of multivariate analysis, which identified independent predictors of successful stress response prevention. The only statistically significant factor that predicted the success was the propofol use (OR: 2.34, 95% CI: 1.18-4.64, p=0.015), meaning that patients using propofol were more likely to have their stress response prevention succeeded more than twice as compared to lidocaine-using patients, even after other factors were taken into consideration.

TABLE 10: TIME COURSE ANALYSIS

Time Point	Lidocaine Group	Propofol Group	p-value
Baseline	Stable	Stable	-
Post-drug (3 min)	Stable	Mild Sedation	0.023
During Laryngoscopy	23/72 Stress	12/73 Stress	0.021
Post-intubation (5 min)	18/72 Ongoing	8/73 Ongoing	0.032
Post-intubation (10	12/72 Ongoing	4/73 Ongoing	0.041

min)

Table 10 shows the time course of drug actions and stress reaction. Propofol offered protection that lasted longer, as fewer patients showed a continued stress response at 5 and 10 minutes after intubation. This long-lasting effect could be particularly beneficial during the perioperative period when maintaining hemodynamic stability is crucial.

DISCUSSION AND ANALYSIS

OVERVIEW OF KEY FINDINGS

The superiority of propofol over lidocaine in the prevention of laryngoscopy-induced stress response in children undergoing cardiac surgery is well evidenced in this randomized controlled trial. The study demonstrates that propofol achieved a 15.5 percent improvement in stress response prevention success compared to lidocaine, with 83.6 percent versus 68.1 percent ($p = 0.021$), representing a clinically relevant increase in success rates. The importance of this discovery is especially relevant for patients undergoing pediatric cardiac surgery, as hemodynamic stability during laryngoscopy may be a key factor in avoiding complications that could lead to life-threatening situations.

Propofol was also superior in terms of numerous hemodynamic parameters, with considerably lower incidences of heart rate rises of over 20% (11.0% vs. 20.8%, $p = 0.043$) and systolic blood pressure increases of over 20% (12.3% vs. 25.0%, $p = 0.033$). Diastolic blood pressure increases by over 15% (6.8% vs 16.7%, $p = 0.046$). These findings suggest that propofol may provide more comprehensive cardiovascular protection during the high-risk period of laryngoscopy and intubation.

MECHANISTIC CONSIDERATIONS

The outstanding excellence of propofol can be discussed in terms of its pharmacological peculiarities and mechanism of action. Propofol has several actions through which it exerts its effects, unlike lidocaine, which is a local anesthetic with primary action as a sodium channel blocker. Propofol potentiates the activity of gamma-aminobutyric acid (GABA) receptors, resulting in depression of the central nervous system and a decrease in sympathetic outflow. Propofol also exhibits a direct myocardial depressant effect and a peripheral vasodilatory effect, which helps in achieving hemodynamic stability.

The multifactorial stress response to laryngoscopy is likely the reason why propofol, with its dual mechanism of action—central sympathetic inhibition and direct cardiovascular effects—performs better than other drugs tested. Although lidocaine is effective in blocking sodium channels and thereby decreasing neuronal excitability, it mainly exerts its effect on membrane stabilization as opposed to the extensive sympatholytic effect of propofol. This mechanistic disparity is especially relevant in pediatric cardiac surgical patients, in whom the stress reaction involves intricate interactions between the central nervous system and the cardiovascular system.

The catecholamine suppression data very strongly support this mechanistic interpretation. Propofol produced significantly better inhibition of epinephrine (1.6 ± 0.9 ng/ml vs. 2.8 ± 1.4 ng/ml, $p < 0.001$) and norepinephrine (2.1 ± 1.2 ng/ml vs. 3.2 ± 1.8 ng/ml, $p = 0.002$) responses compared to lidocaine. This superior control of catecholamines indicates that propofol can disrupt the stress response cascade at multiple levels, including central sympathetic stimulation and peripheral catecholamine secretion.

CLINICAL IMPLICATIONS AND SIGNIFICANCE

These findings have broader clinical implications that go past the direct perioperative period. Laryngoscopy-induced stress response in a pediatric cardiac surgery patient may trigger a sequence of events such as arrhythmias, myocardial ischemia, raised oxygen use, and

hemodynamic instability. The increase in success rates with propofol (15.5%) corresponds to approximately one additional patient out of 6 achieving optimal hemodynamic stability during this critical time.

This is due to the sustained protection evident in the time course analysis, which is especially valuable in pediatric cardiac anesthesia with propofol. Inhibition of stress response at 5 and 10 minutes after intubation indicates that the effects of propofol last longer than the time of immediate laryngoscopy, and it may have continued cardiovascular protection in the early stages of anesthetic induction. This long-lasting effect can be beneficial in patients with complex cardiac lesions that require a prolonged period of hemodynamic stability.

The age-based analysis provides valuable clinical data on how these agents should be utilized in various pediatric groups. The most significant effect of propofol was observed in the youngest age group (1-3 years), with success rates of 87.5% compared to 63.6% with lidocaine ($p = 0.043$). This observation could be explained by the hypothesis that younger children are more sensitive to the mechanism of action of propofol, which may be associated with the maturation of cardiovascular physiology, the sympathetic nervous system, or the pattern of drug metabolism in younger children.

SAFETY PROFILE AND RISKBENEFIT ANALYSIS

Although propofol has been proven to be more effective, a safety analysis presents some crucial points to note in clinical practice. The greater overall adverse event rate with propofol (17.8% vs 8.3%, $p = 0.073$) needs to be weighed against its better efficacy. The safety issue that needs to be noted most is the more frequent occurrence of hypotension with propofol (11.0% vs 4.2%), which is explainable by its vasodilatory and myocardial depressant properties.

However, the clinical importance of these adverse events should be put into perspective. All the observed side effects were mild and could be managed comfortably without any long-term implications. The hypotension caused by propofol was generally brief and was treated with the usual measures, which include fluids or vasopressor support. The incidence of prolonged sedation in the propofol group (5.5% vs 0%, $p = 0.044$) is representative of the sedative effect of the drug but did not correlate with clinically relevant complications.

Risk-benefit Profile The profile favors propofol, especially when one takes into consideration the life-threatening effects of uncontrolled stress response in children undergoing cardiac surgery. The 15.5% reduction in efficacy with propofol is more than offset by the avoidance of the manageable excess of mild adverse events, and all the more so given that the stress responses avoided would have caused more significant complications in some patients, including arrhythmias or myocardial ischemia.

COMPARISON WITH EXISTING LITERATURE

The results of the present study align with and extend the findings of previous studies regarding the prevention of stress responses during laryngoscopy. The expressed lidocaine efficacy of 68.1% is consistent with past research, which reported a lidocaine efficacy rate of 76.8%. The propofol efficacy rate of 83.6% is comparable to the earlier mentioned 88.2% efficacy rate. The minor differences in efficacy rates compared to those of the prior studies could represent variations in any of the patient groups, dose schedules, or outcome criteria.

A greater catecholamine suppressive effect is observed with propofol compared to other agents, confirming earlier studies that demonstrated its sympatholytic effect. The extent of catecholamine depression observed in the present study (approximately a 43% decrease in epinephrine and a 34% decrease in norepinephrine compared to lidocaine) can be explained by the known mechanism of action of propofol and previous pharmacological reports.

The safety picture in this trial is also consistent with known information regarding the

two drugs. An apparent increase in the rate of hypotension associated with propofol is reported in the literature, which is attributed to its cardiovascular depressant properties. The absence of serious adverse events in either group supports the safety of these interventions when used appropriately in patients undergoing pediatric cardiac surgery.

PEDIATRIC-SPECIFIC CONSIDERATIONS

The pediatric population has special needs and issues that complicate the application of the study's findings and make them particularly applicable. Children affected by congenital heart disease usually experience disturbed cardiovascular physiology, i.e., they have distorted hemodynamics, limited cardiac reserve, and are highly vulnerable to stress-related complications. Propofol excelled in this vulnerable group because its fully understood mechanism of action is highly tailored to meet the complicated physiological demands of pediatric cardiac surgery patients.

The age-stratified analysis has given significant indications of the developmental nature of both stress response and drug actions in children. The most significant advantage of propofol in the youngest age group (1-3 years) can be attributed to several factors, including the underdevelopment of the sympathetic nervous system, the distinct distribution of receptors, or changes in the pharmacokinetics of very young children. This is a significant revelation to the current anesthetic management practice protocols, and propofol could be the drug of choice to prevent stress response in very young children undergoing cardiac surgery.

The prevalence of various cardiac diagnoses in this study is similar to that of a typical case mix in pediatric cardiac surgery, with simple septal defects being the most common (65.5% of cases) and complex cyanotic lesions comprising the second most common diagnoses (24.2% of cases). The uniform superiority of propofol in both complex and straightforward lesions suggests that its advantages are not confined to particular types of cardiac pathology but rather represent fundamental benefits in preventing the stress response that would apply across the board to children undergoing cardiac surgery.

CONCLUSION

PRINCIPAL FINDINGS, SUMMARY

This randomized control trial demonstrates the better effect of propofol over lidocaine in the prevention of stress response caused by laryngoscopy in children undergoing cardiac surgery. The primary objective of the study was achieved, demonstrating that propofol is significantly more effective in terms of hemodynamic stability and stress response prevention in this at-risk population. Propofol was the more successful intervention, with an overall success rate of 83.6% compared to 68.1% with lidocaine ($p = 0.021$), corresponding to a clinically relevant increase of 15.5 percentage points in treatment success.

Propofol superiority was observed in all measured hemodynamic variables. There were also significant differences in the incidences of heart rate rise >20 percent (11.0% vs 20.8%, p=0.043), systolic blood pressure rise >20 percent (12.3% vs. 25.0%, p=0.033), and diastolic blood pressure rise >15 percent (6.8% vs. 16.7%, p=0.046) in patients given propofol. All the above findings suggest that propofol provides greater cardiovascular protection during the high-risk phase of laryngoscopy and endotracheal intubation.

This is also supported by the biochemical evidence provided by stemcellsharbor.com, which highlights the superiority of propofol due to its more substantial catecholamine suppression effects. The virtually equal decrease in epinephrine (1.6±0.9 vs. 2.8±1.4 ng/mL, $p < 0.001$) and norepinephrine (2.1±1.2 vs. 3.2±1.8 ng/mL, $p = 0.002$) responses indicates that propofol can disrupt the stress response cascade at the most basic level, that of sympathetic nervous system activation. This biochemical benefit directly correlates with the clinical benefits

observed with improved hemodynamic stability.

CLINICAL SIGNIFICANCE AND IMPACT

The clinical implications of these findings extend well beyond statistical significance to encompass clinically important changes in patient care and safety. The greater effectiveness of propofol in such patients (pediatric cardiac surgery patients) where hemodynamic instability during laryngoscopy may trigger life-threatening complications such as arrhythmias, myocardial ischemia, and cardiovascular decompensation constitutes a significant improvement in the management of perioperative care.

The time course analysis, which indicated the benefit of propofol at 5 and 10 minutes after intubation, is especially valuable in the perioperative environment due to the lasting protection that propofol affords. This longer duration effect provides hemodynamic stability not only during the actual laryngoscopy procedure itself but also during the most crucial periods of anesthetic maintenance when continuity of cardiovascular stability is needed to provide optimal surgical conditions and ensure patient safety.

The age-adjusted analysis reveals that the beneficial effect of propofol is most pronounced in the youngest patients (1-3 years), with success rates of 87.5% compared to 63.6% in lidocaine ($p = 0.043$). The implication of this finding on clinical practice is profound since very young children with congenital heart disease are the most vulnerable group of children undergoing cardiac surgery. This improvement in efficacy in such a high-risk population makes propofol the ideal agent for preventing stress responses in the most demanding clinical situations.

PROFILE OF SAFETY AND CLINICAL ACCEPTABILITY

Although propofol was associated with a higher overall adverse event rate (17.8% vs 8.3%, $p = 0.073$), this increase should be considered within the context of event severity and management in the clinical setting. All the observed adverse events were of mild level and could be controlled by standard clinical measures. The majority of adverse events were transient and resolved with standard hemodynamic support interventions; the most frequent one, hypotension (11.0% vs. 4.2%), was no exception.

The incidence of excessive sedation only in the propofol group (5.5% vs 0%, $p=0.044$) is indicative of the pharmacological effect of the drug but did not translate to any clinically relevant complications or delayed recoveries. This safety profile is reflected in the known pharmacology of propofol and does not constitute safety signals for unexpected and concerning incidences.

The benefits-harm analysis points toward the use of propofol, especially given the potentially disastrous effects of uncontrolled stress response in children undergoing cardiac surgery. The acceptable rise in mild adverse events is easily offset by the considerable benefit of preventing possible life-threatening hemodynamic instability. The multivariate analysis supports the use of propofol as an independent predictor of successful stress response prevention (OR: 2.34, 95% CI: 1.18-4.64, $p = 0.015$), and it is also the most significant factor determining the treatment outcome.

MEDICAL CONTRIBUTIONS TO KNOWLEDGE

The present research makes several significant contributions to the existing body of medical literature. This is the first attempt to compare canine and propofol in detail in pediatric cardiac surgery patients, seeking to address a crucial and essential area of knowledge. The strictly performed methodology, which incorporates objective hemodynamic monitoring and biochemical confirmation with measurements of catecholamines, provides strong evidence that cannot be extrapolated from past research studies, which are mainly based on clinical

assessments.

The age-stratified analysis will provide novel insights into developmental variations in the response to stress and drug performance across pediatric age groups. The finding that propofol is superior in younger children provides valuable age-specific, age-specific clinical insight in pediatric cardiac anesthesia.

The thorough safety analysis, in which all adverse events are documented, and their severity and management are carefully characterized, provides valuable safety data that can be useful in clinical practice. The information is especially crucial where there is a dearth of safety information on these interventions among pediatric cardiac surgery patients.

CLINICAL PRACTICE IMPLICATIONS

The study's results are expected to have a direct impact on clinical practice guidelines and protocols in pediatric cardiac anesthesia. Based on the evidence listed, propofol ought to be regarded as the intervention of first choice in the prevention of laryngoscopy-stimulated stress reaction in children undergoing cardiac surgery, and propofol deserves to be used in younger children exclusively where the advantage is the most spectacular.

The dosing protocol of propofol, 2.5 mg/kg administered intravenously 3 minutes before laryngoscopy, is recommended as a practical, evidence-based dose protocol that can be implemented in clinical practice. Anesthesiologists are advised to be prepared to handle any propofol-associated adverse outcomes, especially hypotension, by ensuring proper monitoring of the outcomes and having vasopressor assistance readily available.

The research findings justify the formulation of institutional guidelines that would promote the use of propofol in the prevention of stress response in pediatric cardiac surgery, but with lidocaine as an alternative in patients with specific contraindications to propofol or in cases where the adverse effect profile of the latter would be a particular cause of concern in the clinical context.

LIMITATIONS AND FUTURE DIRECTIONS

Although this study has yielded strong results in favor of propofol's superiority, several limitations should be noted. The single-center single-center nature might reduce its applicability in other institutions with diverse patient populations or practices. Multi-center trials in the future would help confirm the generalizability of these results in different clinical practices.

Another limitation is the relatively short duration of the follow-up (10 minutes after intubation), as the long-term outcomes and their correlation with the prevention of the stress response were not studied. The association between the prevention of immediate stress responses and postoperative complications, recovery times, and overall patient outcomes warrants further exploration in future research.

Exclusion of emergency cases, as well as hemodynamically unstable patients, is methodologically appropriate but narrows the applicability of results to the most severely ill patients who could benefit most due to the successful prevention of the stress response. These high-risk populations should be considered in future studies, accompanied by proper safety monitoring measures.

WIDER HEALTHCARE IMPLICATIONS

The results of this research can be applied not only to direct clinical use but also to broader healthcare thinking. The excellent ability of propofol to prevent the occurrence of complications may save healthcare costs to deal with complications related to stress response, longer monitoring needs, and prolonged hospitalization.

The body of evidence presented in favor of using propofol could impact medication

formulary lists, staff training needs, and quality improvement programs aimed at optimizing perioperative care following pediatric cardiac surgery. This research is part of the growing body of literature that supports and ensures the validity of personalized medicine practices in pediatric anesthesia, where patient-centered variables, including age and cardiac diagnosis, further refine treatment choices.

FINAL RECOMMENDATIONS

Due to the total evidence provided in this paper, propofol should become the agent of choice in the prevention of laryngoscopy-induced stress response in children undergoing cardiac surgery. Its overwhelming superiority in effectiveness, especially in younger children, and acceptable safety record make propofol the ideal drug for this most important clinical use.

These evidence-based recommendations should be considered by healthcare institutions when revising clinical protocols and guidelines. Education and training protocols must focus on promoting the appropriate use of propofol to prevent stress responses by using suitable doses and timing and managing adverse events effectively.

Ongoing research should aim to optimize propofol by conducting dose-response studies, exploring combination therapy, and evaluating long-term outcomes. The platform established by this research provides a solid foundation for further research aimed at enhancing perioperative care for pediatric cardiac surgery patients.

CLOSING STATEMENT

This randomized controlled trial shows conclusive results that the use of propofol is better than lidocaine in the prevention of stress response caused by laryngoscopy in children undergoing cardiac surgery. The results will represent a significant development in the practice of pediatric cardiac anesthesia, providing evidence-based guidance on enhancing perioperative care for this high-risk group. The high methodological quality of the study, its thorough analysis, and clinically meaningful findings make it set a new standard of care that is to be introduced to enhance patient safety and outcomes in pediatric cardiac surgery.

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