Original Article

To Study Effective Dosage of Intravenous Amiodarone to Prevent Junctional Ectopic Tachycardia After Paediatric Cardiac Surgery

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Abstract

Background: Junctional ectopic tachycardia (JET) is a frequent postoperative arrhythmia after paediatric congenital heart surgery, contributing to haemodynamic instability and prolonged hospital stay. Prophylactic strategies are limited; recent pharmacologic interest has focused on amiodarone, but its intra operative role during cardiopulmonary bypass (CPB) is not well defined. The aim of the study was to evaluate the effectiveness of intraoperative amiodarone supplementation during cardiopulmonary bypass in reducing the incidence and severity of junctional ectopic tachycardia (JET) after paediatric cardiac surgery. **Material and Methods:** Prospective, randomized controlled trial. Department of paediatric cardiac anesthesia, shri Sathya sai sanjeevani hospital Naya Raipur. 1 year duration, 100 paediatric patients undergoing cardiac surgery under cardiopulmonary bypass were enrolled in the study. **Results:** Intraoperative amiodarone significantly reduced the incidence of postoperative JET (8% vs. 30%, P=0.004) and sustained JET >1 hour (2% vs. 18%, P=0.01). It also lowered postoperative amiodarone bolus infusion (2% vs. 20%, P=0.005) and reduced heart rate (118 ± 12 vs. 132 ± 15 bpm, P<0.001) and VIS score (6 ± 3 vs. 9 ± 4, P=0.001). ICU (2 vs. 3 days, P=0.02) and hospital stays (7 vs. 9 days, P=0.01) were shorter. Multivariate analysis confirmed amiodarone as an independent protective factor against JET (aOR 5.6, P=0.004). **Conclusion:** Intraoperative Intravenous amiodarone is a safe and effective strategy to prevent postoperative JET in paediatric cardiac surgery. It significantly reduces JET incidence and postoperative amiodarone use. Improved haemodynamics, shorter ICU stay, and reduced hospital duration were observed. These findings support its routine prophylactic use.

Keywords: Junctional ectopic tachycardia; amiodarone; cardiopulmonary bypass; paediatric cardiac surgery; prophylaxis; arrhythmia prevention.

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Introduction

Congenital heart disease (CHD) is the most common congenital anomaly, affecting 8–12 per 1000 live births globally.[1] Despite major advancements in surgical techniques, cardiopulmonary bypass (CPB), and perioperative care, postoperative arrhythmias remain a significant cause of morbidity and mortality in paediatric cardiac surgery.[2] Among these, junctional ectopic tachycardia (JET) is particularly important in the early postoperative period. It arises from increased automaticity in the AV node or His bundle and is marked by AV dissociation with a faster ventricular rate.[3] JET occurs in 2%–11% of paediatric cardiac surgeries, especially following procedures involving the ventricular septum or AV node, such as tetralogy of Fallot repair, AV septal defect (AVSD) repair and VSD closure.[4,5] JET is multifactorial in origin, often associated with myocardial injury, catecholamine surge, hyperthermia, electrolyte imbalances (notably hypokalemia and hypomagnesemia), and systemic inflammatory responses from cardiopulmonary bypass CPB.[6] Though often transient, JET can impair cardiac output due to loss of AV synchrony, which is particularly harmful in neonates and infants.[7] Management involves normothermia, electrolyte correction, reduced inotropes, pacing, and pharmacotherapy. Amiodarone, a class III antiarrhythmic is highly effective for both treatment and prophylaxis of JET.[8,9] Prophylactic intraoperative amiodarone has shown promise in reducing JET incidence and improving haemodynamics.[10] Its effectiveness may be enhanced when administered during CPB due to increased myocardial penetration in the inflamed, perfused environment.[11] CPB itself contributes to arrhythmogenesis via ischemia-reperfusion injury, oxidative stress, cytokine release, and autonomic dysfunction.[12] Studies such as Talwar et al. report reduced JET with prophylactic amiodarone in AVSD and VSD repairs,[13] though others cite potential risks including

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bradycardia and hypotension.[14] A meta-analysis by Chrysostomou et al. supports its efficacy in reducing JET, ICU stay, and ECLS need.[15]

While postoperative intravenous administration is common, intraoperative use may provide superior protection due to increased bioavailability during cardiopulmonary bypass CPB.[16,17] Clinical decisions should consider patient-specific factors like age, surgery type and arrhythmia risk.

Given the limited large-scale trials, this study aims to assess the efficacy of intraoperative amiodarone in preventing JET in paediatric cardiac surgeries and to propose a standardized perioperative prophylaxis protocol.

Materials and Methods

Type of study: Prospective, interventional randomized controlled trial (single centre study).

Place of study: Department of paediatric cardiac anaesthesia, shri Sathya sai sanjeevani hospital Naya Raipur.

Study duration: 1 year

Sample size: 100 pediatric patients undergoing cardiac surgery with CPB were enrolled in the study. Randomisation was done with computer generated random number table from 1 to 100.

Inclusion Criteria

- Paediatric patients undergoing cardiac surgery, particularly those requiring cardiopulmonary bypass (CPB).
- Age range: Typically, from infancy to early childhood (e.g., 1 month to 5 years).
- Patients scheduled for elective or urgent cardiac procedures such as VSD repair, AVSD and TOF.

Exclusion Criteria

- Patients with known hypersensitivity to amiodarone or other contraindications to its use.
- Patients with preexisting arrhythmias or a history of significant cardiac disease.
- Patients with severe liver or renal dysfunction.
- Emergency surgery cases where amiodarone supplementation during CPB could not be feasibly administered.

Study variable:

- Baseline & Operative Characteristics
- Bolus dosage of amiodarone 5 mg per kg.
- Intra-op Medications, JET, Hemodynamics & Outcomes
- Adverse Events
- Predictors of JET

Statistical Analysis: Data were entered into Excel and analyzed using SPSS and GraphPad Prism. Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests were used to compare independent groups, while paired t-tests accounted for correlations in paired data. Chi-square tests (including Fisher's exact test for small sample sizes) were used for categorical data comparisons. P-values ≤ 0.05 were considered statistically significant.

Results

Table 1: Baseline & Operative Characteristics

Baseline Characteristics	Variable	Amiodarone (n = 50)	Control (n = 50)	P
	Age, months (mean ± SD)	26 ± 14	25 ± 13	0.78
	Weight, kg (mean ± SD)	8.7 ± 2.9	8.4 ± 2.6	0.63
	Male sex, n (%)	28 (56%)	27 (54)	0.84
	Pre-op β-blocker use, n (%)	6 (12)	7 (14)	0.76
Operative Details	Surgery type: VSD repair, n (%)	22 (44)	23 (46)	0.84
	Tetralogy of fallot, n (%)	6 (12)	5 (10)	0.75
	Total CPB time, min (median [IQR])	72 [60–90]	75 [63–92]	0.54
	Aortic cross-clamp, min (median [IQR])	48 [40–60]	50 [42–62]	0.48

Table 2: Intra-op Medications, JET, Hemodynamics & Outcomes

Category	Variable	Amiodarone	Control	P Value
CPB Prime Composition	Crystalloid volume (mL/kg)	28 ± 4	29 ± 5	0.1199
	Mannitol (g)	0.25 ± 0.05	0.25 ± 0.04	0
JET Incidence	Any JET episode, n (%)	4 (8%)	15 (30%)	0.004
	Sustained JET > 1 h, n (%)	1 (2%)	9 (18%)	0.01
	Post-op amiodarone needed, n (%)	1 (2%)	10 (20%)	0.005
Time to First JET	Time (median [IQR], h post CPB)	11	6 (4–9)	0.03
Post-op Hemodynamics (6h post ICU)	Heart rate (bpm)	118 ± 12	132 ± 15	<0.001
	MAP (mmHg)	62 ± 6	60 ± 7	0.08
	Vaso active inotropic score	6 ± 3	9 ± 4	0.001
ICU & Hospital Outcomes	Mech. ventilation duration (h)	10 [8–14]	16 [12–24]	0.001
	ICU stay (days)	2 [2–3]	3 [2–5]	0.02
	Hospital LOS (days)	7 [6–9]	9 [7–12]	0.01
	30-day mortality	0	1 (2%)	0.31

Table 3: Adverse Events

Category	Variable	Amiodarone	Control	P Value

Adverse Events	Hypotension needing ≥2 boluses (10 ML/ KG FOLLOWED BY 15 ML PER KG)	3 (6%)	4 (8%)	0.69
	AV block ≥2°	1 (2%)	0	0.31
	Elevated liver enzymes >3× ULN	2 (4%)	1 (2%)	0.56
	QTc >500 ms	0	0	–

Table 4: Predictors of JET

Category	Variable	Effect Estimate	P Value
JET Predictors (Univariate)	No intra-op amiodarone	OR 4.9 (1.6–15.3)	0.005
	CPB time >90 min	OR 2.3 (0.9–5.9)	0.09
	Age <1 yr	OR 1.8 (0.7–5.1)	0.23
JET Predictors (Multivariate)	No intra-op amiodarone	aOR 5.6 (1.7–18.1)	0.004
	CPB time >90 min	aOR 2.7 (1.0–7.4)	0.05

Baseline Characteristics and Operative Data: There were no significant differences in baseline demographic or operative characteristics between the amiodarone group (n=50) and the control group (n=50). Mean age was 26 ± 14 months in the amiodarone group vs. 25 ± 13 months in controls (P=0.78), and mean weight was 8.7 ± 2.9 kg vs. 8.4 ± 2.6 kg (P=0.63). The proportion of males, and preoperative β-blocker use were similar between groups. The most common procedure was VSD repair (44% vs. 46%, P=0.84), with comparable CPB and aortic cross-clamp times between groups.

Intraoperative Management: CPB prime composition was largely similar between groups, with comparable crystalloid volume (28 ± 4 mL/kg in the amiodarone group vs. 29 ± 5 mL/kg in controls, P=0.1199) and mannitol content (0.25 g in both groups). Despite the same mean mannitol dose, a statistically significant P value (<0.001) was observed, likely due to minimal variation (low SD) rather than a true difference. Amiodarone infusion connected to venous reservoir as compared to none in control group.

Incidence and Characteristics of JET: The incidence of any postoperative JET was significantly lower in the amiodarone group (8%) compared to the control group (30%) (P=0.004). Sustained JET lasting >1 hour occurred in only 2% of the amiodarone group vs. 18% in the control group (P=0.01). Similarly, postoperative need for amiodarone boluses was significantly lower (2% vs. 20%, P=0.005). The median time to onset of the first JET episode was delayed in the amiodarone group (11 hours vs. 6 hours post-CPB; P=0.03).

Postoperative Haemodynamics: At 6 hours post-ICU arrival, the amiodarone group had a significantly lower heart rate (118 ± 12 bpm vs. 132 ± 15 bpm, P<0.001) and lower inotropic requirement (VIS score: 6 ± 3 vs. 9 ± 4, P=0.001). Mean arterial pressure was comparable (P=0.08).

ICU and Hospital Outcomes: Patients receiving intraoperative amiodarone had shorter durations of mechanical ventilation (median 10 [8–14] hours vs. 16 [12–24] hours, P=0.001), ICU stay (2 [2–3] vs. 3 [2–5] days, P=0.02), and total hospital stay (7 [6–9] vs. 9 [7–12] days, P=0.01). There was one death (2%) in the control group; no mortality occurred in the amiodarone group (P=0.31).

Adverse Events: Adverse events potentially attributable to amiodarone were rare and not statistically different between groups. Hypotension requiring ≥2 boluses fluids 10ml per kg followed by 15 ml per kg normal saline occurred in 6% vs. 8% (P=0.69), AV block in 2% vs. 0% (P=0.31), and elevated liver enzymes in 4% vs. 2% (P=0.56). No cases of QTc prolongation were observed.

Predictors of JET: On univariate analysis, the absence of intraoperative amiodarone was significantly associated with increased JET risk (OR 4.9, 95% CI: 1.6–15.3; P=0.005). On multivariate logistic regression, intraoperative amiodarone remained a significant independent protective factor against JET (aOR 5.6, 95% CI: 1.7–18.1; P=0.004), along with prolonged CPB time >90 minutes (aOR 2.7, 95% CI: 1.0–7.4; P=0.05).

Discussion

Comparison with Previous Studies: Our results are consistent with El Amrousy et al (2016),[18] who reported a significant reduction in postoperative JET with prophylactic amiodarone in children undergoing cardiac surgery. In their study, the incidence of JET was comparable to our findings, with a markedly lower occurrence in the amiodarone group compared to controls, along with reduced need for rescue antiarrhythmic therapy.

Similarly, Wadile et al,[21] (2023) conducted a randomized controlled trial comparing prophylactic amiodarone with dexmedetomidine and found that amiodarone significantly reduced the incidence of postoperative JET. Their findings strongly support the superiority of amiodarone in preventing arrhythmias in paediatric open heart surgery, which is in agreement with our results.

Imamura et al,[22] (2012) also demonstrated that prophylactic amiodarone after tetralogy of Fallot repair significantly reduced the occurrence of JET, particularly in the early postoperative period. This supports the concept that early intraoperative or perioperative administration of amiodarone provides protective electrophysiological stabilization, similar to what was observed in our study.

Furthermore, Arshad et al,[23] (2023) compared prophylactic amiodarone with dexmedetomidine and reported a lower frequency of postoperative JET in the amiodarone group. This reinforces our findings and highlights the consistent benefit of amiodarone across different paediatric cardiac surgical settings.

In contrast, Laird et al,[19] (2008), who evaluated therapeutic rather than prophylactic amiodarone use, reported higher incidence and later control of JET. This difference suggests that prophylactic intraoperative administration, as used in our study, may be more effective in preventing arrhythmia onset than post-onset treatment.

Additionally, our findings of improved hemodynamics—lower heart rate, better central venous oxygen saturation, and reduced

inotropic requirement—are consistent with Yamamoto et al,[20] (2010), who also demonstrated improved cardiovascular stability with amiodarone use after pediatric cardiac surgery. Our study further extends these findings by showing reduced mechanical ventilation duration and shorter ICU and hospital stay.

Mechanisms of Action: The antiarrhythmic effect of amiodarone is attributed to its class III properties, primarily potassium channel blockade, leading to prolonged myocardial repolarization and refractory period. This prevents re-entry circuits responsible for JET, which commonly occur after cardiopulmonary bypass due to ischaemia-reperfusion injury, inflammation, and myocardial irritation.

In addition, amiodarone exhibits multi-channel effects including sodium and calcium channel inhibition and mild beta-adrenergic blocking activity, contributing to suppression of ectopic automaticity in the atrioventricular junction. This multimodal action may explain its superior efficacy compared to single-mechanism agents such as dexmedetomidine, as also suggested by comparative studies.[21,23]

Adverse Events: In the present study, amiodarone was well tolerated, with no significant increase in hypotension, atrioventricular block, or liver enzyme abnormalities compared to the control group. No cases of QTc prolongation or life-threatening complications were observed.

These findings are consistent with El Amrousy et al,[18] (2016), Wadile et al,[21] and Arshad et al,[23] all of whom reported a favorable safety profile of prophylactic amiodarone in pediatric patients undergoing cardiac surgery. Overall, the evidence suggests that short-term intraoperative use is safe and does not increase clinically significant adverse effects.

Predictors of JET: Our analysis identified absence of intraoperative amiodarone and prolonged cardiopulmonary bypass (CPB) time (>90 minutes) as significant predictors of JET. The protective role of amiodarone (aOR 5.6, P=0.004) highlights its importance in reducing postoperative arrhythmic risk.

This is supported by El Amrousy et al,[18] and Imamura et al,[22] who similarly reported a lower incidence of JET with prophylactic administration, especially in complex congenital repairs. Prolonged CPB time likely increases myocardial injury and inflammatory response, thereby increasing susceptibility to arrhythmias, which can be mitigated by early amiodarone administration.

Conclusion

In conclusion, our study demonstrates that the administration of amiodarone during cardiopulmonary bypass is an effective and safe strategy to prevent postoperative JET in pediatric patients undergoing cardiac surgery. This intervention significantly reduces the incidence of JET, the need for postoperative amiodarone boluses, and improves postoperative hemodynamic parameters, ICU recovery time, and hospital stay. These findings provide strong evidence for the use of prophylactic amiodarone as a routine practice in pediatric cardiac surgery to improve outcomes and reduce arrhythmic morbidity.

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Conflicts of interest

There are no conflicts of interest.

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