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Original Article

Temporary Epicardial Pacing Post Congenital Cardiac Surgery; Frequency and its Associated Outcomes

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ABSTRACT

Objective: To determine the frequency and outcomes of Temporary Epicardial Pacing (TEP) after congenital cardiac surgery in pediatric patients.

Study Design: Analytical Cross Sectional study.

Place and Duration of Study: Armed Forces Institute of Cardiology/ National Institute of Heart Diseases, Rawalpindi Pakistan, from Jan to Jun 2024.

Methodology: Total one hundred and ten patients having the age of <12 years who underwent cardiac surgery for congenital heart diseases were recruited. Frequency of patients requiring TEP was calculated and the pacing duration was noted for intervals of less than 12 hours, 12-24 hours, 25-48 hours, 49-72 hours and >3-15 days respectively. Patients were monitored post operatively to assess outcomes, including mortality and infection rate.

Results: Overall, 110 patients (27.7%) required TEP, including 62(56.4%) males and 48(43.6%) females. Out of total, 31(28.2%) patients required pacing for <12 hours, 51(46.4%) for 12-24 hours, 20(18.2%) for 25-48 hours, 6(5.5%) for 49-72 hours and 2(1.8%) patients were shifted to permanent pacing later on. Statistically significant difference was observed between pacing in terms of duration (p=0.02) with mortality. Statistically significant association was found between mortality and post procedural infections (p<0.001).

Conclusion: This study demonstrated that TEP was a common intervention following congenital cardiac surgery in pediatric patients with VSD and ASD, whereas majority required short-term pacing. Though most of the patients recovered without major complications, a small percentage may require permanent pacemakers due to prolonged pacing needs.

Keywords: Congenital Heart block, Congenital heart disease, Temporary epicardial pacing, Pediatric cardiology, Permanent pacemaker.

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INTRODUCTION

Temporary Epicardial Pacing (TEP) provides electrical cardiac stimulation to manage reversible bradyarrhythmias like high-grade AV block or severe hemodynamic impairment. It is used when permanent pacing is not immediately feasible or poses higher risks than benefits.[1] A Pakistani study found that during the perioperative period, TEP is commonly used to diagnose and treat symptomatic bradycardia, atrial fibrillation, and AV conduction abnormalities—typical indications for permanent pacing.[2]

TEP was required in 17% of pediatric patients post congenital heart surgery and it effectively managed immediate postoperative arrhythmias. Long-term monitoring was essential to prevent complications.[3] Previous study reported that early complete heart block (CHB) post-cardiac surgery occurred in 5.6% of cases, necessitating TEP. Identified risk factors included younger age and complex surgical procedures.[4] The frequency of TEP in children after surgical closure of ventricular septal defect (VSD) was reported to be 7.14%.[5]

CHB is a significant complication that arises postoperatively, with a global incidence reported between 1-4%.[4] VSD, accounting for approximately 20% of all Congenital Heart Disease (CHD) cases, is one of the most common forms of CHD.[5] The use of epicardial leads, which typically remain in place for 3 to 5 days postoperatively, is essential until the risk of dysrhythmia subsides. However, the removal of these leads can result in life-threatening complications like cardiac tamponade.[6] Despite, these risks, asynchronous to synchronous pacing, which has been in use for the past 20 years in pediatric cardiac surgery, has significantly improved both hemodynamics and the quality of life for affected children.[7]

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Despite previous studies emphasizing the role of TEP in managing arrhythmias following cardiac surgery, a significant gap exists in the literature regarding its application in pediatric congenital heart surgery. Our study seeks to address this gap by evaluating the frequency and outcomes of TEP use in pediatric patients at a tertiary care hospital, particularly focusing on in-hospital outcomes such as infection and mortality. Additionally, this study aimed to assess whether TEP use serves as a predictor of short-term clinical outcomes, offering insights that could inform future clinical management and improve outcomes in pediatric congenital heart surgery patients.

METHODOLOGY

This study was an Analytical cross sectional study conducted in children who underwent congenital cardiac surgery from Jan to Jun 2024 at Armed Forces Institute of Cardiology/ National Institute of Heart Diseases, Rawalpindi Pakistan. The study was conducted after taking ethical approval from the Institutional Ethical Review Board (IERB) (letter no: 9/2/R&D /2024/297;10th Jan 2024) and there were no ethical issues.

With reference to 7.14% frequency of TEP in children after surgical closure of VSD5, calculated sample size was 102 by WHO sample size calculator at confidence level=95% and margin of error 5%. However data was collected from a total of 110 patients through non probability consecutive sampling.

Inclusion Criteria: Patients with age less than 12 years, irrespective of gender undergoing cardiac surgery for any congenital heart diseases including those requiring TEP due to post-operative conduction problems, Arrhythmias (Atrial Fibrillation, Atrial Flutter, Atrioventricular Blocks, Bradycardia) and post op Heart Block / high grade heart blocks (1st degree, 2nd degree, 3rd degree and Complete Heart Block). These diseases may include Atrial septal defect(ASD), Ventricular septal defect (VSD), Partial atrioventricular septal defect (PAVSD), Complete atrioventricular septal defect (CAVSD), Tetralogy of Fallot (TOF), Univentricular heart physiologies, Patent ductus arteriosus (PDA), Transposition of great arteries (TGA), Pulmonary atresia (PA), Pulmonary stenosis (PS), Double outlet right ventricle(DORV) and others. The procedures for these diseases included and not limited to septal defects closure, Corrective surgeries such as TOF repair, Bidirectional Glenn Shunt (BDG), Pulmonary Artery (PA) Banding and PDA Ligation or interruption, ROSS and Senning.

Exclusion Criteria: Patients with preoperative or congenital heart blocks, those requiring temporary or permanent pacing before surgery, and those with no indication of pacing after surgery were excluded.

Patients/ legal guardians were informed and consent was taken before filling the data forms. The frequency of epicardial pacing was documented, and patients were monitored to assess outcomes, including mortality and infection rate. During the study period, 110 needed temporary epicardial pacing, which was our target group for the study. Patients were monitored until discharge. A pre designed questionnaire was utilized to record patients demographics (including name, age, gender, weight, height, BMI), pre procedural parameters (temperature, heart rate, urine output, ejection fraction), Intraoperative (Cardiopulmonary Bypass Time, Indications for TEP such as brady/tachy arrythmias, heart blocks and others were noted). Post procedural parameters were also included which comprised of pacing type, pacing mode, and duration of pacing (<12 hours, 13-24 hours, 25-48hours, 49-72 hours, >3-15 days). In hospital Outcomes such as post procedural infections and mortality were also recorded. Post-procedural infection at the pacing wire site was defined by the presence of erythema, swelling, and purulent discharge. Patient flow for evaluating temporary epicardial pacing (TEP) outcomes after congenital cardiac surgery in pediatric patients, from initial presentation to postoperative analysis is illustrated in Figure-1.

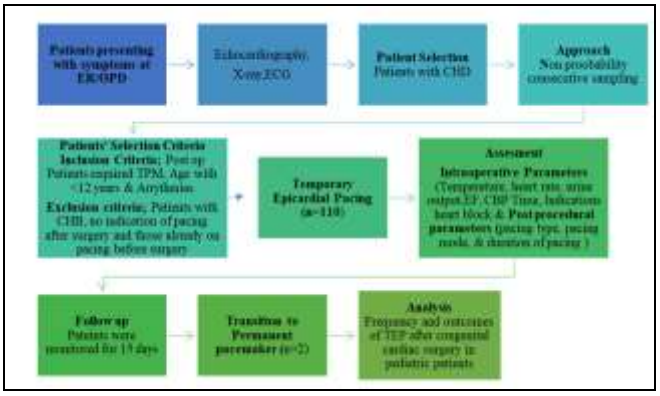

Figure-1 Patient Flow Diagram for Evaluating TEP Outcomes After Cardiac Surgery

Data were entered and analyzed by using Statistical Package of Social Science (SPSS) version -

23:00. The normality of continuous variables (age, weight, height, BMI, temperature, heart rate, urine output and ejection fraction due to non-homogeneity) was evaluated using the Kolmogorov-Smirnov test. Median and interquartile ranges were computed for quantitative variable like age, weight, height, BMI, temperature, heart rate, urine output and ejection fraction due to non-homogeneity. Percentage and frequencies were reported for qualitative variables like gender, indications, pacing, and pacing mode, duration of pacing, post procedural infections and mortality. Chi-square test/Fischer Exact test was applied to find the association of gender, indications, pacing, duration of pacing, infections with mortality and Mann Whitney U test was performed to compare the median of BMI, temperature, heart rate, urine output and ejection fraction among survivors and non survivors. A *p*-value of ≤0.05 was considered statistically significant.

RESULTS

Out of 110 patients, 62(56.40%) were males and 48(43.60%) were females. The median age and BMI of participants were 2(1.00-3.10) years and 12.50(12.00-14.00) (kg/m^2) respectively as shown in Table-I.

Table-I Demographic Characteristic of Participants (n=110)

Variables		Frequency (%)
Demographics		
Gender	Male	62(56.40%)
	Female	48(43.60%)
		Median(IQR)
Age(years)		2.00(1.00-3.10)
Weight(kg)		9.00(6.00-12.20)
Height(cm)		86.50(67.00-111.50)
BMI (kg/m2)		12.50(12.00-14.00)

BMI=Body mass index

A total of 108(98.1%) patients required TEP for duration of less than 15 days and their heart rate and rhythm reverted back, while 2(1.81%) patients were later shifted to permanent pacemaker as their duration of pacing exceeded the 15 days waiting period for resumption of normal heart rate and rhythm. Median ejection fraction among participants was 50.00(45.00-55.00%). The primary indication for TEP was bradycardia in 99(90.0%) patients and post procedural infection was observed in 10(9.10) patients as depicted in Table-II.

The most common CHD was VSD observed in 28(25.5%) patients, followed by ASD at 23(20.9%), and TOF at 19(17.3%) (Figure-2).

The most frequently performed procedure was septal defects closure, accounting for 58(52.7%) patients while ROSS was performed in <1% patients to correct CHDS respectively (Figure-3).

Table- II Perioperative Parameters of Participants (n=110)

Variables		Median(IQR)
Pre-procedural Parameters		
Temperature(˚F)		98.00(98.00-98.30)
Heart Rate(bpm)		50.00(44.00-64.00)
Urine Output(ml)		1.00(1.00-2.00)
Ejection Fraction (%)		50.00(45.00-55.00)
Intra Operative Parameters		
Cardiopulmonary Bypass Time (minutes)		67.00(44.00-88.50)
		Frequency (%)
Indications For Temporary Pacing	Bradycardia	99(90.00%)
	Heart block	11(10.00%)
Post-Procedural Parameters		
Pacing	TEP	108(98.10%)
	PPM	2(1.81%)
Pacing Mode	VVI	33(30.00%)
	AAI	43(39.10%)
	DDD	34(30.90%)
Duration of Pacing (hours/days)	<12 hours	31(28.20%)
	13-24 hours	51(46.40%)
	26-48 hours	20(18.20%)
	49-72 hours	6(5.50%)
	>3-15 days	2(1.80%)
Outcomes		
Post procedural Infection	Yes	10(9.10%)
	No	100(90.90%)
Mortality	Yes	17(15.50%)
	No	93(84.50%)

TEP- Temporary Epicardial Pacing ; PPM-Permanent Pace Maker ; Pacing Modes Sequence shows letter1-Chamber Paced, letter2-Chamber sensed , Letter3-Chamber Inhibited A- Atria V-Ventricle D or DDD-Dual I-Inhibited

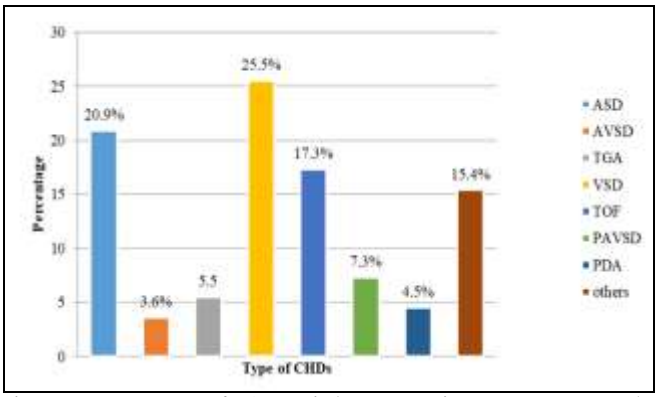

Figure-2: Percentage of Congenital Heart Diseases Among study Participants (n=110)

Pre-procedural urine output (p<0.001), and ejection fraction was significantly associated with mortality. Intra-operatively, non survivors had prolonged CPB time, 112.00(40.00-177.00) minutes compared to 66.00(44.00-80.00) minutes in survivors (p=0.02). Bradycardia was the predominant indication

in non-survivor patients (70.6% vs. 93.5%; *p*=0.01). Survived patients less frequently required extended pacing duration (49-72 hours in 2.2% vs. 23.5%; *p*=0.02), and post-procedural infections were significantly less prevalent among survivors (3.2% vs. 41.2%; *p*<0.001) (Table-III).)

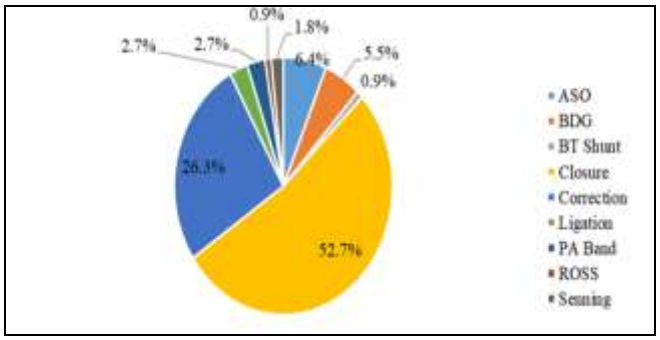

Figure-3: Distribution of Performed Procedures Among study Participants (n=110)

DISCUSSION

In our study, 27.7% of patients required TEP, with the vast majority 98.1% needing pacing for less than 15 days before successfully returning to a normal heart rate and rhythm. Only a small percentage 2(1.81%) required PPM due to prolonged pacing needs. A previous study reported that PPM used in around 3(1.91%) children following congenital heart surgery which is slightly higher than our findings.[8]

While TEP was generally a temporary measure, the length of pacing was strongly associated with mortality (*p*=0.02). Postoperative infections were noted in 9.1% of cases, and the overall mortality rate was 15.5%. Mikulski.*et al*., reported mortality rate of 36.2% in children requiring temporary pacing wires.[9] This finding contrasts with our results, in which all non survivors had undergone TEP. Current findings indicated that TEP yields positive short-term outcomes, with most patients recovering without major complications. However, patients with prolonged pacing requirements warrant closer monitoring to prevent adverse outcomes primarily due to complications associated with congenital heart surgery.

Current study found that only 2(1.81%) patients required pacing for over 15 days. Adil MD *et al*., also reported that 2(12.5%) patients with a pacing duration of more than 10 days had expired, whereas our study found no mortality in patients with a pacing duration exceeding 10 days.[2] They also reported a mortality rate of 16%, while this study observed mortality in

Table-III Comparison of Demographics and Perioperative Parameters with Mortality (n=110)

Variables		Mortality		*p*-value
		Yes Frequency (%) (n=17)	No Frequency (%) (n=93)	
Demographics				
Gender	Male	8(47.1%)	54(58.1%)	0.43
	Female	9(52.9%)	39(41.9%)	
		[Median(IQR)]		
Age(years)		1.00(0.50-2.00)	2.00(1.00-3.40)	0.01
BMI (kg/m2)		12.00(11.00-12.80)	12.90(12.00-14.00)	0.02
Pre-procedural Parameters				
Temperature(F˚)		98(98.00-98.20)	98.6(98.00-98.30)	0.53
Heart Rate(bpm)		50.00(44.00-60.00)	54.00(44.00-64.00)	0.39
Urine Output(ml)		1.00(0.80-1.00)	1.00(1.00-2.00)	<0.001
Ejection Fraction (%)		50.00(45.00-50.00)	50.00(45.00-55.00)	0.02
		Frequency (%)		
CHDs	ASD	1(5.90%)	22(23.7%)	0.08
	AVSD	1(5.90%)	3(3.20%)	
	PAVSD	2(11.8%)	6(6.50%)	
	PDA	1(5.90%)	4(4.30%)	
	TGA	3(17.6%)	3(3.20%)	
	TOF	1(5.9%)	18(19.4%)	
	VSD	4(25.5%)	24(25.8%)	
	Other	4(25.5%)	13(14.0%)	
Intra Operative Parameters		[Median(IQR)]		
Cardiopulmonary Bypass Time (minutes)		112(40.00-177.00)	66.00(44.00-80.00)	0.02
		Frequency (%)		
Indications	Bradycardia	12(70.6%)	87(93.5%)	0.01
	Heart Block	5(29.4%)	6(6.5%)	
Pacing	TEP	17(100.0%)	91(97.8%)	1.00
	PPM	-	2(2.2%)	
Post-Procedural Parameters		Frequency (%)		
Pacing Mode	VVI	3(17.6%)	30(32.3%)	0.42
	AAI	7(41.2%)	36(38.7%)	
	DDD	7(41.2%)	27(29.0%)	
Duration of Pacing	<12 hours	3(17.6%)	28(30.1%)	0.02
	12-24 hours	6(35.3%)	45(48.4%)	
	25-48 hours	4(23.5%)	16(17.2%)	
	49-72 hours	4(23.5%)	2(2.20%)	
	>3-15 days	0	2(2.20%)	
Complication		Frequency (%)		
Infection	Yes	7(41.2%)	3(3.2%)	<0.001
	No	10(58.8%)	90(96.8%)	

TEP=Temporary Epicardial Pacing ; PPM-Permanent Pace Maker ; Pacing Modes Sequence shows letter1-Chamber Paced, letter2-Chamber sensed , Letter3-Chamber Inhibited A- Atria V-Ventricle D or DDD-Dual I-Inhibited; CHD=Congenital Heart Disease; ASD=Artrial Septal Defect ;AVSD=Atrioventricular Septal Defect; PAVSD=Partial Atrioventricular Septal Defect; ,PDA=Patent Ductus Arteriosus; TOF=Tetrology of Fallot; TGA=Transposition of the Great Arteries other includes=Pulmonary artesia, Pulmonary stenosis, Double Outlet Right Ventricle

17(15.4%) patients. Ibrahim *et al*., reported that in our patients, the most common CHD associated with permanent CHB was TOF (50%), followed by VSD 25.5%. In contrast, our study found that 19(17.35%)

patients were diagnosed with TOF, while 28(25.5%) patients had VSD.[4]

In our study, TEP was required in 110(27.7%) patients out of them, 28(25.5%) of the cases were VSD. This was approximately in parallel with literature where VSD accounts for approximately 20% of all CHD cases, and was one of the most common form of CHDs.[5] In a previous study, 4 out of 13 children 30.0% underwent TEP, with 2(15.3%) later requiring PPM. However, our study showed slightly different results, with only 2 patients (1.81%) were being shifted to PPM.[10]

In current study, 99(90.0%) patients requiring TEP had bradyarrhythmias, while 11(10.00%) patients had post-procedural heart blocks. A previous study reported different findings, with 23 patients requiring pacing, of whom 10(30.0%) had sinus bradycardia and 6(18.0%) had atrioventricular block.[11] TEP was primarily indicated for managing perioperative arrhythmias, including CHB, symptomatic brady-cardias, and atrial fibrillation. According to previous studies, CHB was a significant complication post-cardiac surgery, necessitating the use of TEP to maintain hemodynamic stability.[12-15]

In other studies as well, the outcomes of TEP are generally favorable, with a low rate of complications. However, certain risks were associated with the procedure, including infection, bleeding from the pacing wire site, and dislodgement of pacing wires.[13,16] A study by Risk and Benefits of Temporary Pacemaker Electrodes in Adult Open-Heart Surgery (2022) highlighted that while TEP was effective in managing arrhythmias, careful monitoring is essential to mitigate these risks.[17-19]

TEP is a critical intervention in managing perioperative arrhythmias following congenital cardiac surgery. The literature highlighted several key aspects of TEP, including its frequency, indications, and associated outcomes.[20,21] The frequency of TEP varies significantly across different studies. For instance, a study by Cronin *et al.*, (2022) reported that approximately 30-40% of pediatric patients undergoing congenital cardiac surgery required TEP. This variation was influenced by factors such as the type of congenital heart defect, the complexity of the surgery, and the patient's preoperative condition.[12,18] According to the previous literature, complications such as cardiac tamponade, although rare, can occur following the removal of epicardial leads and therefore the importance of timely intervention and appropriate management strategies to address these complications must be emphasized.[3,6,18]

The literature underscores the critical role of TEP in managing perioperative arrhythmias in pediatric patients undergoing congenital cardiac surgery. While the procedure was generally safe and effective, careful monitoring and management were essential to mitigate associated risks. Our study contributed new insights by establishing the clinical patterns of TEP use in pediatric congenital heart surgeries within a local tertiary care setting. Additionally, the low frequency of rare complications offered a reassuring reflection on local surgical protocols.

This study highlighted that pacing duration showed a significant association with the likelihood of transitioning to PPM. VSD and ASD were identified as most common CHDs. Lower frequency of post-operative infection and mortality was observed which highlighted the generally positive outcomes of TEP in the short term, with most patients recovering without major complications, though continued vigilance was warranted for those at risk of prolonged pacing requirements.

LIMITATIONS OF STUDY

The study only assessed short-term outcomes such as in-hospital mortality and infections, without follow-up beyond the immediate postoperative period. As a result, long-term outcomes, including outcomes after the initial 60-day follow up and six-month mortality rates, were not evaluated. The cross-sectional nature of the study also prevents establishing causal relationships between TEP use and patient outcomes and limiting our ability to evaluate more extended outcomes. Future studies should include larger, multicenter cohorts with extended follow-up periods to validate these findings and offer more comprehensive insights into the prognostic implications of TEP in pediatric congenital heart surgery patients.

CONCLUSION

This study demonstrated that TEP was a common intervention following congenital cardiac surgery in pediatric patients with VSD and ASD, whereas majority requiring short-term pacing. Though most of the patients recovered without major complications, a small percentage may require permanent pacemakers due to prolonged pacing needs.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SN & KA: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

MN & HM: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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