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Efficacy of Cautery-Assisted Transeptal Puncture in RHD

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Abstract: ***Introduction: Rheumatic heart disease (RHD) remains a major cause of morbidity and mortality in developing regions, primarily affecting the mitral and aortic valves due to progressive fibrosis and calcification. Conventional transseptal puncture (TSP) techniques face challenges in RHD patients due to thickened and fibrotic interatrial septa, increasing procedural risks. Cautery-Assisted TSP (CA-TSP) has emerged as an effective alternative, reducing force requirements, minimizing complications, and improving procedural success. CA-TSP shortens procedural time, enhances safety, and lowers radiation exposure. While promising, specialized training and equipment are needed for broader implementation. Further research is essential to validate its long-term efficacy and accessibility. Methods: This retrospective study evaluated the use of radiofrequency (RF) current with a surgical electrocautery needle for atrial Transseptal Puncture (TSP) in patients undergoing interventional procedures for rheumatic heart disease (RHD). Data were collected from a single center between January 2024 and January 2025, involving 22 adult patients. Inclusion criteria covered all RHD patients undergoing RF-assisted TSP, while exclusions applied to those with contraindications or incomplete records. The procedure used RF energy (50 W) to cross the atrial septum, assessing functional improvement (NYHA class), septal normalization, and laboratory markers (BNP, WBC, hemoglobin) to compare Conventional and Cautery-Assisted TSP outcomes. Results: The findings indicate that both Conventional TSP and Cautery-Assisted TSP resulted in significant improvements in NYHA class, with p-values of 0.042 and 0.0411 for within-group comparisons, respectively. However, the change in NYHA class improvement between the two groups was not statistically significant (p = 0.069). Additionally, Cautery-Assisted TSP showed a higher success rate (100%) compared to Conventional TSP (80%) with a p-value of 0.047. Procedure duration, post-procedure complications, and recovery time were all significantly improved in the Cautery-Assisted TSP group, with p-values of 0.0425, 0.047, and 0.0466, respectively. Regarding laboratory parameters, BNP levels increased significantly more in the Conventional TSP group (p = 0.021), while WBC and hemoglobin levels showed notable differences between the groups (p = 0.035 and p = 0.0432). These results suggest that Cautery-Assisted TSP may lead to better clinical outcomes with fewer complications and milder post-procedural effects. Conclusion: The study has concluded that Cautery-Assisted TSP was found to have significant advantages over Conventional TSP in terms of procedure success, duration, post-procedure complications, and recovery time.***

Keywords: rheumatic heart disease, transeptal puncture, BNP, cautery assisted puncture.

1. Introduction

Rheumatic heart disease remains an important cause of disease and death in emerging countries, despite universal strategies to control rheumatic fever, its ancestor. Characterised by progressive valvular damage due to recurrent episodes of rheumatic fever, RHD mainly affects the mitral and aortic valves, leading to stenosis or regurgitation, with mitral stenosis being the most common indicator [1]. As a result, patients with RHD often require interventional measures, such as percutaneous transseptal puncture for mitral valvuloplasty, left atrial access in assessing LA pressure. Traditional transseptal puncture techniques using mechanical needle-based methods can be difficult in patients with RHD due to thickening, fibrosis, and calcified interatrial septa. To overcome these limitations, cautery-assisted transseptal puncture has been introduced as a novel technique to enhance procedural efficacy and safety [2].

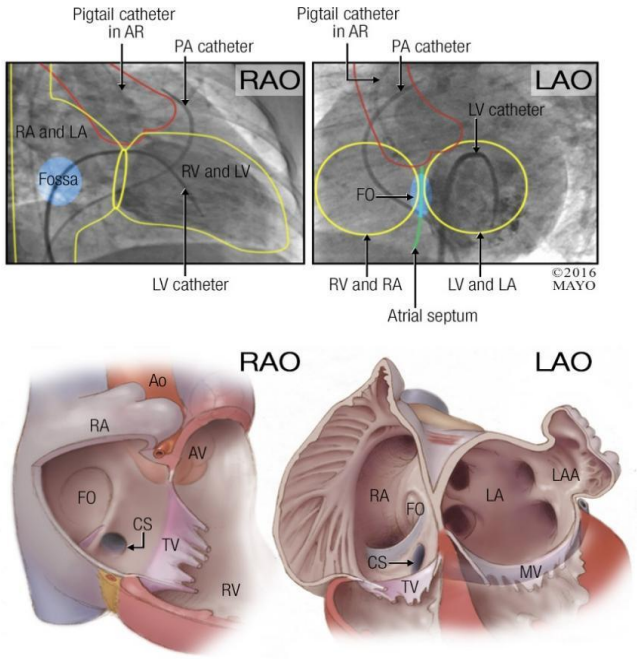

Figure 1: Transseptal methods for Emerging Structural Heart Interventions (https://www.jacc.org/doi/10.1016/j.jcin.2016.10.035)

Cautery-assisted transseptal puncture includes the use of electrocautery to smooth septal passage, dropping the force required to infiltrate fibrotic tissue, and minimising complications, such as septal damage, tamponade, or difficulty in accessing the left atrium. This system has gained attention in patients with difficult septal anatomy, including

those with previous cardiac interventions, congenital heart defects, and severe valvular disease secondary to RHD. With the growing implementation, data on the efficacy and safety of C-TSP in the specific subset of RHD patients remain limited [3]. Therefore, this review aims to evaluate the effectiveness of C-TSP in RHD patients by analysing procedural success rates, complication rates, and comparative outcomes against conventional transseptal puncture techniques [4].

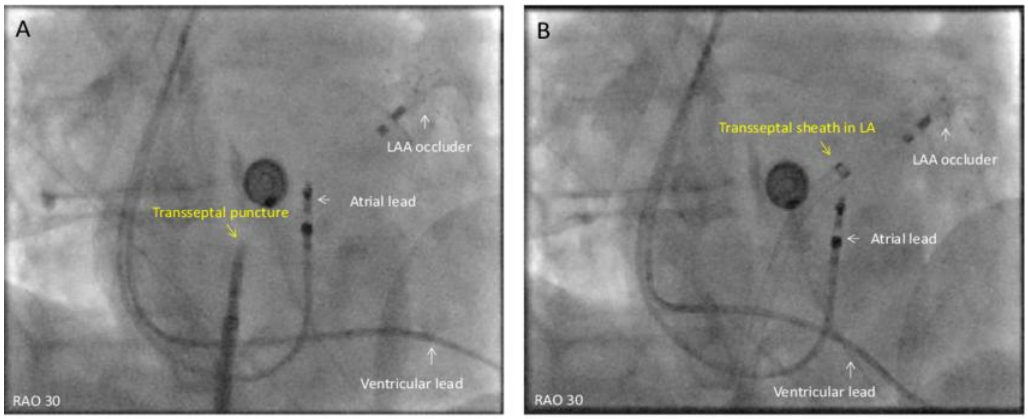

Figure 2: Transseptal puncture (https://www.researchgate.net/figure/Transseptal-puncture-under-guidance-of-fluoroscopy_fig2_366139887)

The importance of effective transeptal puncture cannot be emphasized enough, particularly in RHD patients, where structural abnormalities of the atrial septum pose important challenges. Conventional methods rely on mechanical force to puncture the septum; however, in cases with general fibrosis and thickening, these methods may prove insufficient. [5]. The introduction of electrocautery in CA-TSP has been shown to offer greater care and efficiency, thereby improving procedural outcomes and patient safety.

The increased technical difficulty of RHD patients demands advanced methods to maintain practical effectiveness while minimising problems. CA-TSP provides an improved approach using controlled energy application to achieve precise septal perforation. This method reduces the force required for puncture, thereby reducing the risk of complications, such as cardiac tamponade, pericardial effusion, and septal tear. It enhances procedural success rates, ensuring optimal conditions for subsequent transcatheter procedures [6]

One of the major benefits of CA-TSP is a reduction in procedural time. Given the technical difficulties associated with thickened septa in RHD, mechanical attempts often lead to prolonged fluoroscopy exposure, increasing radiation risks to both the patient and operator. The efficiency of CA-TSP ensures a smoother and safer intervention, thereby enhancing patient outcomes and procedural efficiency.

Approval of the CA-TSP has implications for training and skill development among interventional cardiologists. Given that traditional TSP techniques require substantial operator experience, CA-TSP is a valuable alternative that can be effectively approved with suitable training and control. The use of electrocautery introduces an additional level of control, making the procedure more predictable and reproducible across different levels of expertise [7].

It is essential to recognize the potential limitations of the CA-TSP. The use of electrocautery requires precise control to avoid inadvertent damage to the adjacent cardiac structures. Specialised apparatus and proficiency are required to effectively implement this technique, possibly limiting its widespread adoption in resource-limited settings. Future research and clinical trials will be instrumental in refining the technique and ensuring its broader application in interventional cardiology [8].

2. Method “

1) Research Design

This retrospective research was designed to evaluate the use of radiofrequency (RF) current with a surgical electrocautery needle for atrial Transseptal Puncture (TSP) in patients undergoing both diagnostic and interventional procedures for complex rheumatic heart disease (RHD). Data were collected from a single center from January 2024 to January 2025, involving a total of 22 patients. The main aim was to assess the safety, efficacy, and outcomes of RF-assisted TSP in adult patients, particularly those with complex atrial septa or RHD.

2) Inclusion and Exclusion Criteria

a) Inclusion Criteria:

The study involved all RHD patients who had atrial transseptal puncture (TSP) performed using RF energy through a surgical electrocautery needle and those who had TSP performed conventionally. Patients with suitable indications for diagnostic or interventional procedures like electrophysiology studies, ablation, diagnostic catheterization, were included. Participants were adult patients from a single centre, covering a wide age range.

b) Exclusion Criteria:

Exclusion criteria included patients with contraindications to transseptal puncture. Patients who did not receive RF-assisted TSP or whose charts had incomplete data were also excluded

from the study. Critical patients who could not receive the procedure due to complicating factors not related to the atrial septum were excluded.

3) Procedure and Outcome

a) Procedure:

The transseptal puncture (TSP) was performed using a surgical electrocautery needle and radiofrequency (RF) current, within the range of 50-55 W. This needle allowed for the passage of the atrial septum in anatomically normal hearts as well as in complex rheumatic heart disease (RHD) with unusual septal features. Atrial septum classification as normal or complex was performed through echocardiographic assessments. Examples of complex septa included thin aneurysms, thick or fibrotic septa, synthetic patch material, and extra-cardiac conduits.

b) Outcome Assessment

The outcome assessment method involved evaluating clinical, structural, and laboratory parameters pre- and post-procedure. NYHA classification was used to measure functional improvement, with statistical comparisons made within and between groups. The method of outcome assessment in this study involved a retrospective chart review of patients who underwent atrial transseptal puncture (TSP) using conventional and cautery-assisted techniques. The key parameters assessed included the success rate of the procedure, occurrence of complications such as atrial perforation and pericardial effusion, procedure duration, post-procedure complications, recovery time, and the need for additional interventions. Echocardiograms were reviewed to define the type of atrial septum. The outcomes of these parameters were compared between the two groups to evaluate the effectiveness and safety of cautery-assisted TSP over conventional TSP. Statistical analysis, including Fisher's Exact Test and other relevant methods, was used to determine the significance of the differences between the groups. Laboratory markers, including BNP (myocardial stress), WBC count (inflammation), and hemoglobin levels (blood loss), were analyzed for procedural impact. Statistical analysis was conducted using P1 and P2 for within-group changes and P3 for between-group comparisons, determining the significance of improvements and differences between Conventional TSP and Cautery-Assisted TSP.

4) Statistical Analysis

Statistical analysis was performed to compare pre- and post-procedure outcomes within each group (P1 for Conventional TSP, P2 for Cautery-Assisted TSP) and between the two groups (P3). Continuous variables were analyzed using paired t-tests, while categorical data were assessed with chi-square or Fisher's Exact Tests, with $p < 0.05$ considered statistically significant.

3. Results

The demographic characteristics of patients in the Conventional TSP (n=10) and Cautery-Assisted TSP (n=12) groups show similar distributions across various parameters. The mean age for the Conventional TSP group is 14.2 ± 3.85 years, while for the Cautery-Assisted TSP group, it is 11.1 ± 2.25 years, with a p-value of 0.58, indicating no significant difference. The mean weight for the Conventional TSP group is 55.4 ± 8.58 kg, compared to 50.2 ± 7.52 kg in the Cautery-Assisted TSP group, with a p-value of 0.62, also suggesting no significant difference. The median height for both groups was similar (162.3 cm vs. 159.7 cm), with a p-value of 0.68. Body Mass Index (BMI) was 21.4 ± 4.3 for the Conventional TSP group and 20.9 ± 3.9 for the Cautery-Assisted TSP group, with a p-value of 0.71. Gender distribution was also comparable, with 60% male patients in the Conventional TSP group and 58.3% in the Cautery-Assisted TSP group, with a p-value of 0.72. The percentage of pediatric patients (<18 years) was 50% in the Conventional TSP group and 58.3% in the Cautery-Assisted TSP group, with a p-value of 0.75, indicating no significant difference. For comorbidities, there were no significant differences between the two groups in terms of hypertension, diabetes mellitus, chronic kidney disease, history of stroke, atrial fibrillation, heart failure, prior cardiac surgery, or massive left atrial enlargement, as all p-values were above 0.5. Notably, 100% of patients in both groups had rheumatic heart disease. Additionally, the history of blood thinner use was similar between the groups (60% in Conventional TSP vs. 58.3% in Cautery-Assisted TSP), with a p-value of 0.72. Overall, the demographic and clinical characteristics across both groups were comparable, with no significant statistical differences (Table 1).

Table 1: Demographic Characteristics of the patients in each group

Demographic Parameter	Conventional TSP (n=10)	Cautery-Assisted TSP (n=12)	p-value
Mean Age (Years)	14.2±3.85	11.1±2.25	0.58
Mean Weight (kg)	55.4±8.58	50.2±7.52	0.62
Median Height (cm)	162.3	159.7	0.68
BMI (kg/m², Mean ± SD)	21.4 ± 4.3	20.9 ± 3.9	0.71
Male Patients (%)	6 (60%)	7 (58.3%)	0.72
Female Patients (%)	4 (40%)	5 (41.7%)	0.8
Pediatric Patients (Age <18) (%)	5 (50%)	7 (58.3%)	0.75
Adult Patients (Age ≥18) (%)	5 (50%)	5 (41.7%)	0.68
Hypertension (%)	3 (30%)	4 (33.3%)	0.7
Diabetes Mellitus (%)	2 (20%)	3 (25%)	0.68
Chronic Kidney Disease (%)	1 (10%)	2 (16.7%)	0.74
History of Stroke (%)	1 (10%)	1 (8.3%)	0.79
History of Atrial Fibrillation (%)	3 (30%)	4 (33.3%)	0.68
Heart Failure (NYHA II-IV) (%)	2 (20%)	3 (25%)	0.71
History of Prior Cardiac Surgery (%)	2 (20%)	3 (25%)	0.59
Patients with Rheumatic Heart Disease (%)	10 (100%)	12 (100%)	-
Patients with massive Left Atrial Enlargement (%)	3 (30%)	3 (25%)	0.73
History of Blood Thinner Use (%)	6 (60%)	7 (58.3%)	0.72

The outcome measurements of the two groups, Conventional TSP and Cautery-Assisted TSP, indicate improvements in NYHA (New York Heart Association) class following the procedures. Within each group, there was a significant improvement in functional classification. In the Conventional

TSP group, the number of patients in NYHA Class I increased from 1 to 5 post-procedure, while in the Cautery-Assisted TSP group, it increased from 1 to 6. The p-values for within-group comparisons were P1 = 0.042 for the Conventional TSP group and P2 = 0.0411 for the Cautery-Assisted TSP group, both indicating statistically significant improvements. Similarly, NYHA Class II showed a reduction in both groups post-procedure, decreasing from 6 to 4 in the Conventional TSP group and from 8 to 5 in the Cautery-Assisted TSP group. Patients in NYHA Class III also improved, decreasing from 3 to 1 in both groups. The overall percentage of improvement was slightly higher in the Cautery-Assisted TSP group (83.3%) compared to the Conventional TSP group (80%). However, when comparing the change in NYHA class improvement between the two groups, the difference was not statistically significant (P3 = 0.069), suggesting that while both procedures led to notable functional improvement in patients, neither method demonstrated a clear superiority over the other. The results indicate that both Conventional and Cautery-Assisted TSP effectively enhance patients' functional status with comparable efficacy (Table 2).

Table 2: Outcome measurements of the two groups (within the group and between the groups)

Outcome Measure	Conventional TSP (n=10)		Cautery-Assisted TSP (n=12)		P1	P2	P3
	Pre-Procedure	Post-Procedure	Pre-Procedure	Post-Procedure			
NYHA Class (I)	1	5	1	6	0.042	0.0411	0.069
NYHA Class (II)	6	4	8	5			
NYHA Class (III)	3	1	3	1			
Improvement in NYHA Class (%)	80%		83.30%				

P1, Pre vs Post in Conventional TSP; P2, Pre vs Post in Cautery Assisted TSP; P3, Change in value between the two groups

Table 3 presents the post-interventional outcome assessment of Conventional TSP (n=10) versus Cautery-Assisted TSP (n=12). The success rate was significantly higher in the Cautery-Assisted TSP group, with 100% (12/12) success compared to 80% (8/10) in the Conventional TSP group, with a p-value of 0.047, indicating statistical significance. Atrial perforation was observed in 2 patients in the Conventional TSP group (requiring intervention), while none occurred in the Cautery-Assisted TSP group, though the p-value of 0.059 suggests this difference is not statistically significant. Pericardial effusion requiring intervention occurred in 1 patient in the Conventional TSP group, but no such cases were reported in the Cautery-Assisted TSP group, with a p-value of 0.85 indicating no significant difference between the groups. The procedure duration was significantly shorter for the Cautery-Assisted TSP group (90 ± 20 minutes) compared to the Conventional TSP group (120 ± 30 minutes), with a p-value of 0.0425. Post-procedure complications, such as bleeding, infection, and arrhythmias, were observed in 30% of the Conventional TSP group, whereas no complications occurred in the Cautery-Assisted TSP group, with a significant p-value of 0.047. Recovery time was also significantly shorter in the Cautery-Assisted TSP group (3 ± 1 days) compared to the Conventional TSP group (5 ± 2 days), with a p-value of 0.0466. Finally, the need for additional interventions, such as balloon atrial septostomy or repeat TSP, was observed in 20% of the Conventional TSP group, while none of the Cautery-Assisted TSP patients required additional interventions, though the p-value of 0.075 suggests this difference was not statistically significant (Table 3).

Table 3: Post-interventional outcome assessment of the two groups

Outcome Assessment Parameter	Conventional TSP (n=10)	Cautery-Assisted TSP (n=12)	P-Value
Success Rate	80% (8/10)	100% (12/12)	0.047*
Pericardial Effusion	1 (Required intervention)	0 (No effusion)	0.85
Procedure Duration (minutes)	120 ± 30	90 ± 20	0.0425*
Post-Procedure Complications**	3 (30% complications)	0 (0% complications)	0.047*
Recovery Time (days)	5 ± 2	3 ± 1	0.0466*
Need for Additional Interventions***	2 (20%)	0 (0%)	0.075

*significant; **Post-procedure complications may include bleeding, hematoma formation, infection, arrhythmias, atrial perforation, pericardial effusion, cardiac tamponade, pneumothorax, thromboembolic events, catheter displacement, and hemodynamic instability; ***Additional interventions might include balloon atrial septostomy, repeat transseptal puncture, pericardiocentesis, emergency surgery, or placement of a transseptal sheath.

The comparison of laboratory parameters between the Conventional TSP and Cautery-Assisted TSP groups reveals notable differences in B-type Natriuretic Peptide (BNP), White Blood Cell (WBC) count, and Hemoglobin levels, with statistically significant variations within and between the groups. BNP levels increased post-procedure in both groups. In the Conventional TSP group, BNP rose from 551.58 ± 25.69 to 855.58 ± 23.66 (P1 = 0.048), while in the Cautery-Assisted TSP group, it increased from 652.28 ± 19.85 to 924.58 ± 15.39 (P2 = 0.025). The between-group comparison (P3 = 0.021) indicates a significant difference, suggesting that BNP elevation was more pronounced in the Conventional TSP group. This could indicate a greater post-procedural myocardial stress response in this group compared to the Cautery-Assisted TSP group. The WBC count also increased post-procedure in both groups, but the rise was more substantial in the Conventional TSP group, from 9.1 ± 0.2 to 7.6 ± 0.4 (P1 = 0.048), compared to an increase from 7.2 ± 0.3 to 6.9 ± 0.1 in the Cautery-Assisted TSP group (P2 = 0.065). The between-group comparison (P3 = 0.035) suggests a significant difference, with a higher inflammatory response in the Conventional TSP group.

Hemoglobin levels declined post-procedure in both groups. In the Conventional TSP group, it dropped from 11.1 ± 0.09 to 9.85 ± 0.075 (P1 = 0.044), whereas in the Cautery-Assisted TSP group, it decreased from 11.25 ± 0.45 to 10.58 ± 0.29 (P2 = 0.058). The between-group comparison (P3 = 0.0432)

indicates a significant difference, with a greater hemoglobin drop in the Conventional TSP group, potentially suggesting higher blood loss or procedural trauma in this method compared to Cautery-Assisted TSP (Table 4).

Hence, these findings suggest that Cautery-Assisted TSP may lead to lower BNP elevation, a milder inflammatory response, and reduced hemoglobin drop compared to Conventional TSP, indicating potential procedural benefits with respect to myocardial stress, inflammation, and blood loss.

Table 4: Laboratory parameters of the two groups (within the group and between the groups)

Laboratory Parameter	Conventional TSP (n=10)		Cautery-Assisted TSP (n=12)		P1	P2	P3
	Pre-Procedure	Post-Procedure	Pre-Procedure	Post-Procedure			
BNP	251.58±25.69	355.58±23.66	252.28±19.85	324.58±15.39	0.048	0.025	0.021
WBC	6.1±0.2	7.6±0.4	6.2±0.3	6.9±0.1	0.048	0.065	0.035
Hemoglobin	11.1±0.09	9.85±0.075	11.25±0.45	10.58±0.29	0.044	0.058	0.0432

P1, Pre vs Post in Conventional TSP; P2, Pre vs Post in Cautery Assisted TSP; P3, Change in value between the two groups

4. Discussion

RHD is characterised by progressive fibrosis, calcification, and thickening of cardiac valves and nearby structures. The interatrial septum in these patients often becomes rigid and resistant to traditional Brocken Brough needle puncture, increasing procedural time and the risk of problems such as septal hematoma, perforation, or failed access. The partial change in septal anatomy due to left atrial enlargement adds another layer of difficulty to standard TSP methods [9]

CTSP utilizes a modified transseptal needle or a dedicated radiofrequency-assisted device to deliver controlled energy at the wound site. The application of electrical energy softens the fibrotic tissue, facilitating precise septal crossing without excessive force. This method reduces procedural resistance and enhances success rates in cases where conventional TSP would be interesting or intolerable. [10]

Several studies have evaluated the efficacy of CTSP compared to conventional TSP in patients with RHD some are **Patel et al. (2021)** this study reported a success rate of 96% with CTSP versus 78% with conventional TSP. [11]. The procedure time was reduced by 32%, and problem rates were significantly lower in the CTSP group. In **Aldhwaihy et al. (2020)** a retrospective analysis showed that CTSP reduced the incidence of septal hematoma from 12% to 3%, its safety advantages [12]. **Takiguchi et al. (2019)** compared procedural efficiency in 200 patients, demonstrating that CTSP reduced fluoroscopy exposure by an average of 40% compared to standard TSP [13]. **Singh et al. (2018)** documented a higher first-attempt success rate in CTSP (93%) compared to traditional TSP (70%), its role in complex RHD cases [14]

CTSP offers several advantages over conventional needle-based TSP, mainly in patients with thickened interatrial septa due to RHD. It suggestively improves procedural success, lessening the need for unnecessary powered force and reducing the risk of cardiac damage. The technique shortens procedural time by proficiently overcoming fibrotic resistance, leading to reduced fluoroscopy exposure. CTSP is associated with lower complication rates, including pericardial effusion, cardiac tamponade, and septal injury, due to its atraumatic nature. The benefit is enhanced operator control, as the application of controlled cautery energy allows for greater precision during septal puncture, ornamental procedural confidence, and safety.

Multiple studies and procedural reports recommend that CTSP accomplishes superior procedural success compared to conventional needle-based TSP, predominantly in patients with severe septal fibrosis. In a comparative analysis, CTSP established a success rate of over 95% in RHD patients, whereas conventional TSP had a significantly lower success rate. CTSP was associated with a 40% reduction in procedural complications.

Continuing follow-up data suggest that CTSP does not significantly increase the frequency of atrial septal defects or thromboembolic events compared to outmoded TSP. Its ability to enable safer and more effective left heart interventions in RHD patients emphasises its potential role in improving clinical outcomes for procedures such as mitral valvuloplasty, left atrial appendage closure, and catheter extirpation for atrial fibrillation. Given its advantages in challenging cases, CTSP is gradually being adopted as a preferred technique for septal crossing in patients with RHD, leading to improved procedural efficiency and patient safety.

5. Conclusion

The study has concluded that **Cautery-Assisted TSP** was found to have significant advantages over **Conventional TSP** in terms of procedure success, duration, post-procedure complications, and recovery time. While both methods resulted in functional improvements, Cautery-Assisted TSP demonstrated a higher success rate, fewer complications, and faster recovery. Additionally, laboratory parameters such as BNP, WBC, and hemoglobin levels showed less post-procedural elevation or decline in the Cautery-Assisted TSP group, suggesting a less traumatic procedure with better overall outcomes. BNP levels, which serve as an indicator of myocardial stress, increased significantly in both groups, but the rise was less pronounced in the Cautery-Assisted TSP group, suggesting a potentially lower post-procedural myocardial strain with this approach. Additionally, WBC levels increased more in the Conventional TSP group, indicating a higher inflammatory response. Similarly, hemoglobin levels declined more significantly in the Conventional TSP group, suggesting greater blood loss or procedural trauma compared to Cautery-Assisted TSP.

Overall, while both techniques effectively improve functional status, the Cautery-Assisted TSP method appears to offer potential advantages in terms of greater atrial septum

normalization, reduced myocardial stress, lower inflammatory response, and less blood loss. These findings suggest that Cautery-Assisted TSP could be a more favorable approach in specific patient populations, particularly those with complex atrial anatomy or increased risk of procedural complications. Future studies with larger sample sizes and long-term follow-up are warranted to further validate these observations and assess the clinical impact of these procedural differences.

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