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Review Article

Systematic Review on Predicting SVT Recurrence after Catheter Ablation Using Autonomic Markers

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Abstract: ***Purpose***: This systematic review's aim is to evaluate the role of autonomic markers in predicting supraventricular tachycardia (SVT) recurrence after catheter ablation. Understanding these markers can help to identify patients at higher risk of recurrence and improve post-procedural management. ***Methodology***: A full literature review has been conducted using 12 electronic databases, such as PubMed, ScienceDirect, Springer, MDPI and Oxford Academic. It has covered studies in English from 1999 to 2025. The PRISMA 2020 guidelines for systematic reviews have been followed in the review. Studies have been chosen using the PICO framework: adult patients with SVT who undergo catheter ablation (Population), evaluation of autonomic markers like heart rate variability (HRV), baroreflex sensitivity (BRS), skin sympathetic nerve activity (SKNA), and P-wave alternans (Intervention), comparison with normal or baseline values (Comparator), and recurrence or non-recurrence of SVT as the outcomes (Outcome). Both qualitative and quantitative data were extracted, including statistical measures such as odds ratios, hazard ratios and predictive accuracy metrics. ***Findings***: HRV is the most studied and widely applied autonomic marker. Early post-ablation HRV changes correlate with recurrence risk in AF studies, but evidence in SVT is limited and largely hypothetical. BRS, SKNA and PWA have showed potentiality but have been underexplored in SVT. Clinical and procedural factors, such as accessory pathway location and ablation strategy, is influencing the recurrence rates. In Bangladesh, HRV has been measured in tertiary centers, while other markers are not routinely applied due to resource constraints. ***Conclusion***: Autonomic markers have promising potential to predict SVT recurrence, but no robust SVT-specific studies are there. Future research should focus on multicenter prospective studies with standardized measurement protocols and integration of clinical factors to develop reliable predictive models.

Keywords: SVT, Catheter Ablation, Heart Rate Variability, Autonomic Markers, Recurrence Prediction, Baroreflex Sensitivity, P-wave Alternans.

INTRODUCTION

Supraventricular tachycardia (SVT) is a common cardiac arrhythmia affecting adults worldwide (American Heart Association, 2024). Catheter ablation has become the standard treatment to achieve rhythm control and prevent recurrence (Hopkins Medicine, 2024). Despite high procedural success, a subset of patients has been experienced of

SVT recurrence, which have impacted their quality of life and increased healthcare burden. So, identifying predictors of recurrence is crucial to optimize post-ablation monitoring and management (Mo *et al*., 2024).

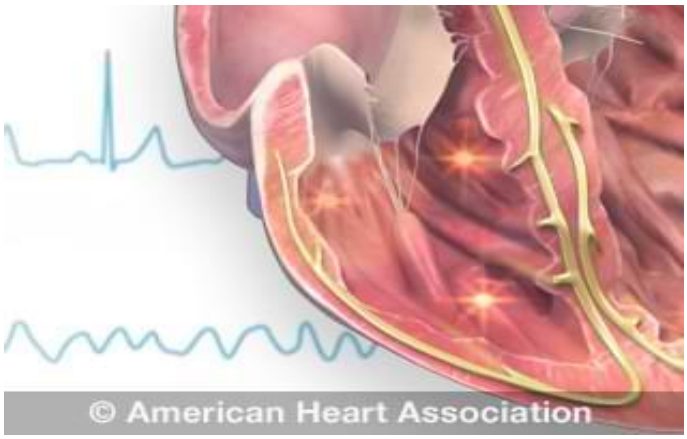

Fig. 1: SVT

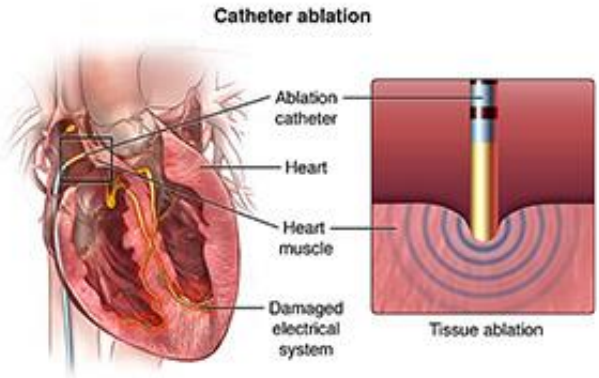

Fig. 2: Catheter Ablation

Autonomic markers, including heart rate variability (HRV), baroreflex sensitivity (BRS), skin sympathetic nerve activity (SKNA) and P-wave alternans (PWA), have been proposed as potential tools to predict arrhythmia recurrence. These markers reflect the balance between sympathetic and parasympathetic activity and the vulnerability of the cardiac substrate (Stavrakis *et al*., 2020a).

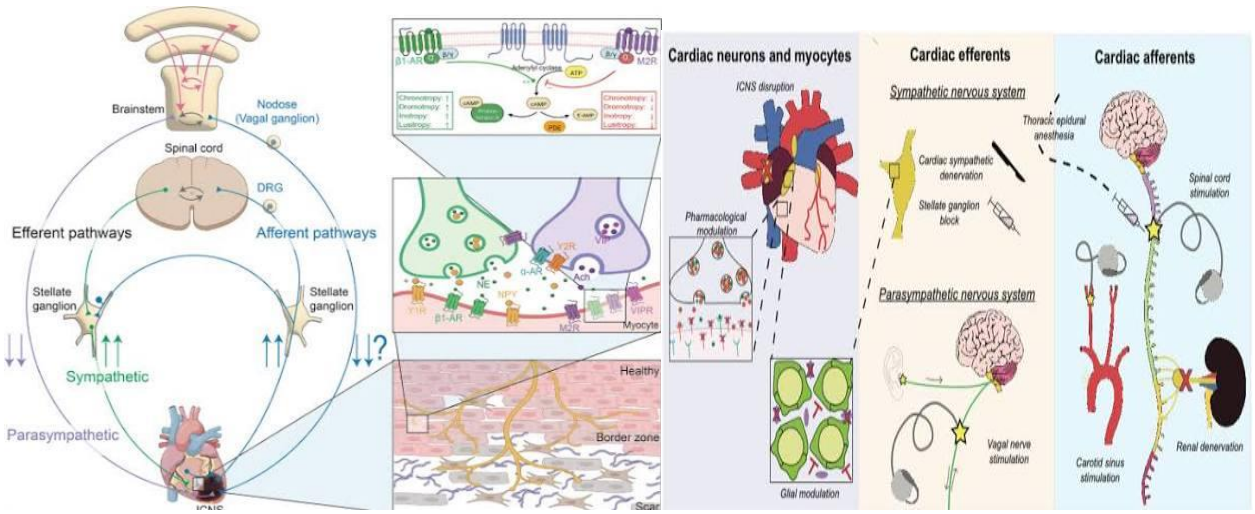

Fig. 3: Breakdown of how these markers provide insight into the delicate balance and vulnerabilities that contribute to arrhythmia recurrence

Evidence from atrial fibrillation (AF) studies suggests that early post-ablation changes in HRV may predict future recurrence (Andrade *et al*., 2025). However, the direct applicability of these findings to SVT is uncertain because SVT substrates are more focal, such as atrioventricular nodal re-entry or accessory pathways (Althoff & Mont, 2022).

Globally, many research have explored autonomic markers in SVT, but the evidence in Bangladesh is limited. Studies have focused mainly on HRV using ECG-based analysis (Park *et al*., 2022), while other markers like BRS, SKNA and PWA have not been routinely applied due to limited equipment and resource constraints (Uradu *et al*., 2017). Therefore, understanding the global and local evidence can guide clinicians and researchers in improving prediction strategies and personalized follow-up care.

So, this systematic review's aim is to synthesize existing evidence on the use of autonomic markers to predict SVT recurrence after catheter ablation. It'll explore the qualitative and quantitative measurements of these markers, their predictive value, the influence of clinical and procedural factors, and the potential for translation into routine clinical practice, both globally and in the Bangladeshi context.

Research Questions

1. What specific autonomic markers (HRV, BRS, SKNA, PWA) have been studied to predict SVT recurrence after catheter ablation?
2. How have these markers been measured in both qualitative and quantitative terms?
3. What evidence from AF studies can inform the potential link between pre-ablation HRV and SVT recurrence?
4. How do clinical and procedural factors interact with autonomic markers in influencing recurrence risk?
5. What are the immediate and long-term effects of catheter ablation on autonomic markers, and how might these apply to SVT?
6. What is the mechanism by which ganglionated plexi (GP) ablation influences SVT recurrence?
7. What is the potential predictive role of baroreflex sensitivity (BRS) in SVT recurrence after ablation?
8. What gaps remain in the literature, and what directions should future studies take?

METHODOLOGY

This systematic review has been conducted by following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher *et al.*, 2010).

Literature Search

A comprehensive literature search has been performed across 11 renowned electronic database sources. These were PubMed, ScienceDirect, Springer, Oxford Academic, Wiley, MDPI, AHAA Journals, CHIP Network, Lithuanian University of Health Sciences Research Management System (CRIS), US Department of Veterans Affairs and VIA Medica. The search has been limited to studies that have been published in English between 1999 and 2025, which has resulted in a total of 31 selected publications.

The following search keywords were used with Boolean operators for searching the literatures:

- Population/Intervention: "supraventricular tachycardia" OR "SVT" OR "atrial fibrillation" OR "atrial flutter" OR "atrial tachycardia" AND "catheter ablation" OR "radiofrequency ablation"
- Outcome: "recurrence" OR "relapse" OR "reappearance" AND "predict*" OR "determinant*" OR "prognosis"
- Autonomic markers: "autonomic nervous system" OR "heart rate variability" OR "HRV" OR "baroreflex sensitivity" OR "BRS" OR "ganglionated plexi" OR "inflammatory markers" OR "autonomic function"

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Studies those were investigated SVT recurrence after catheter ablation.
- Studies that assessing autonomic markers such as HRV, BRS, ganglionated plexi activity, or inflammatory markers.
- Adult patients (≥18 years) with post-ablation follow-up.
- Peer-reviewed original research, systematic reviews or meta-analyses.

Exclusion Criteria:

- Non-English publications.
- Pediatric populations (<18 years).
- Studies without recurrence outcomes or without autonomic marker assessment.
- Editorials, letters, conference abstracts or opinion papers.

Study Selection

The selection process has followed the PRISMA flow as summarized in Fig 1. A total of 115 records were initially identified across the 12 sources. After removing 22 duplicates and 3 non-English records, 90 studies were remained for title and abstract screening. In the following screening, total 35 studies were excluded.

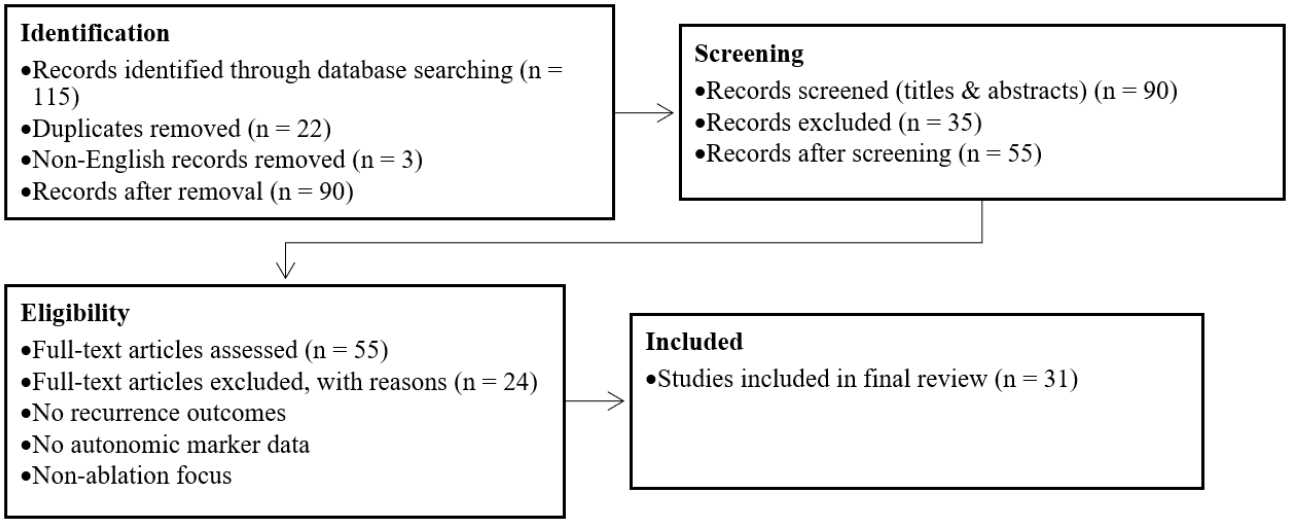

Fig. 4: PRISMA Flow Diagram

In this phase, a total number of 55 full-text articles were assessed for eligibility. Out of these, 24 articles were excluded for the reasons of absence of recurrence outcomes, lack of autonomic marker data or non-ablation focus. Ultimately, 31 studies were included in the final review process.

Table 1: Source-wise Distribution of Included Studies

AHAA Journals	4
CHIP Network	1
Lithuanian University of Health Sciences Research Management System (CRIS)	1
MDPI	1
Oxford Academic	1
Pubmed	13
Science Direct	5
Springer	1
US Department of Veterans Affairs	1
VIA MEDICA	2
Wiley	1
Total	31

Table 2: PICO Framework for SVT Recurrence Research Questions

Question	Population (P)	Intervention / Exposure (I)	Comparator (C)	Outcome (O)	Where to Input Evidence
1. Autonomic markers used to predict SVT recurrence	Adult patients with SVT undergoing catheter ablation	Assessment of autonomic markers (SDNN, rMSSD, HF, LF/HF ratio, BRS, SKNA, PWA)	Patients without measurement or normal values	List of markers with qualitative meaning and quantitative measurement	Findings & Discussion, Section 1
2. Predictive value of autonomic markers	Same as above	Predictive indices (OR, HR, AUC, p-values) from cohort studies and reviews	Baseline or reference values	Statistical significance of predictive capacity	Findings & Discussion, Section 2
3. Pre-ablation HRV and AF recurrence risk (translation to SVT)	Patients with AF undergoing ablation	HRV indices (rMSSD, SDNN, HF) before ablation	Patients with lower values	Association of recurrence vs. non-recurrence	Findings & Discussion, Section 2

4. Clinical and procedural factors influencing recurrence	Patients with AVNRT, AVRT, WPW/AP, and AF	Ablation strategies, pathway site, age, cryo vs. RF ablation	Other SVT subgroups or strategies	Recurrence rate differences	Findings & Discussion, Section 3
5. Timing of recurrence after ablation	Patients with successful ablation	Follow-up period (<6 months, 6–24 months, >2 years)	Patients without recurrence	% recurrence by time frame	Findings & Discussion, Section 3
6. Autonomic nervous system consequences post-ablation	Patients pre- and post-ablation	HRV parameters (SDNN, rMSSD, HF, LF/HF)	Pre-ablation baseline	Immediate vs. long-term changes in HRV	Findings & Discussion, Section 4
7. Inflammatory markers and SVT	Patients with SVT vs. healthy controls	NLR, RDW, NE, EO levels	Healthy/control groups	Diagnostic and predictive value (AUC, p-values)	Findings & Discussion, Section 1 (note on inflammatory markers)
8. Mechanism of GP ablation in recurrence	Patients undergoing GP ablation (with or without PVI)	Ganglionated plexi ablation	Ablation without GP	Impact on recurrence and vagal modulation	Findings & Discussion, Section 5
9. Baroreflex sensitivity as predictor	Patients with and without recurrence	BRS indices (Alpha LF, Alpha HF, H-LF, H-HF)	Patients without recurrence	Independent predictive value	Findings & Discussion, Section 6
10. Clinical implications and future research	Patients undergoing ablation	Integration of autonomic and inflammatory markers into management	Standard practice without marker-guided follow-up	Improved recurrence prediction and patient outcomes	Findings & Discussion, Final section + Conclusion

FINDINGS & DISCUSSION

1. Specific Autonomic Markers Used to Predict SVT Recurrence and Their Measurements

Heart Rate Variability (HRV):

Qualitative: HRV shows the balance between sympathetic and parasympathetic activity (Galin & Keren, 2024). High HRV means healthy cardiac function. Low HRV is linked with risk of arrhythmias and sudden death (*VA.Gov | Veterans Affairs*, n.d.).

Quantitative: HRV is measured in three ways:

- ✓ ***Time Domain:*** Based on RR intervals. SDNN shows long-term HRV. Root mean square of successive differences shows short-term HRV. The percentage of RR intervals differing by more than 50 ms also measures short-term HRV (Stavrakis *et al*., 2020b).
- ✓ ***Frequency Domain:*** Uses spectral analysis. LF band (0.04–0.15 Hz) reflects both sympathetic and parasympathetic activity. HF band (0.15–0.40 Hz) reflects parasympathetic activity. The LF/HF ratio shows autonomic balance (Stavrakis *et al*., 2020b).
- ✓ ***Nonlinear Measures:*** These show variability complexity. SD1 reflects parasympathetic input. SD2 reflects both sympathetic and parasympathetic input. The SD1/SD2 ratio indicates changes in autonomic tone. Rhythmocardiography (RCG) provides high-resolution analysis of RR intervals and spectral shares of VLF, LF, and HF bands (Stavrakis *et al*., 2020b).

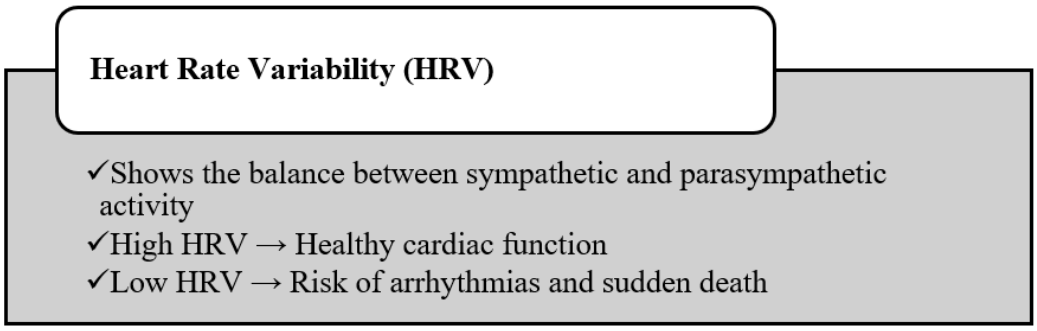

Fig. 5: HRV (Qualitative)

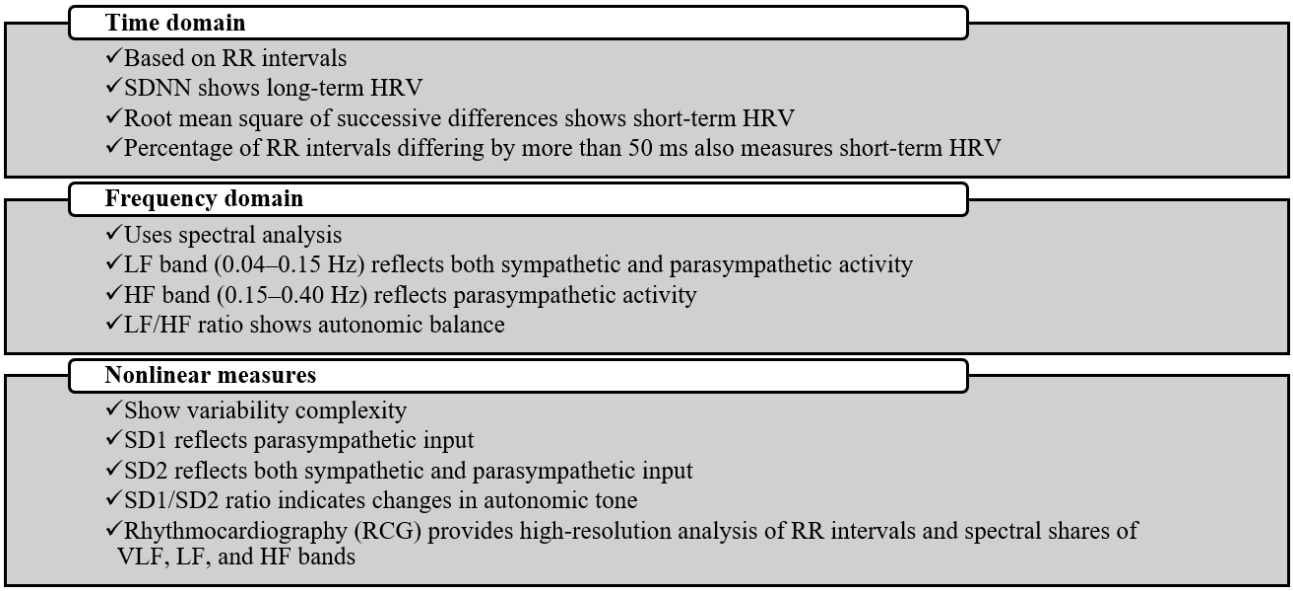

Fig. 6: HRV measuring (quantitative)

Baroreflex Sensitivity (BRS):

Qualitative

- ✓ Reflects parasympathetic activity (Stavrakis *et al*., 2020b).
- ✓ Shows a negative relation with maximum heart rate during posture changes (Vaičiulytė, 2004).

Quantitative

- ✓ Measured as the slope between heart rate and blood pressure changes (Stavrakis *et al.*, 2020b).
- ✓ Can be calculated using drugs like phenylephrine or by comparing supine and standing positions (Vaičiulytė, 2004).

Skin Sympathetic Nerve Activity (SKNA):

Qualitative: Reflects sympathetic drive. It often rises before atrial tachycardia and AF episodes. Sustained increases are linked with AF clustering and ventricular arrhythmia (Baghestani *et al*., 2024).

Quantitative: Measured from ECG recordings with special filters to capture sympathetic signals (Kusayama *et al*., 2020).

P-Wave Alternans (PWA):

Qualitative: Reflects the atrial substrate that can predispose to AF (Nearing *et al*., 2024).

Quantitative: Measured by voltage and K-score from ECG recordings (Siniorakis *et al*., 2017).

It should be noted that inflammatory markers, such as neutrophil-to-lymphocyte ratio (Lekkala *et al*., 2024) and red cell distribution width, are studied in SVT (Isik *et al*., 2012). However, they are inflammatory markers, not direct autonomic markers and are not primary tools for predicting recurrence after ablation.

2. Evidence from AF Studies on the Link between Pre-Ablation HRV and SVT Recurrence

Studies in AF have reported that early HRV has predicted later AF recurrence. Lower rMSSD in the first 1–2 days after ablation has predicted higher AF recurrence. One review has stated this clearly and has cited multicenter data (Drexler *et al*., 2024). A focused study has also tested HRV in the early period after ablation and has reported predictive value for recurrence (Zhu *et al*., 2020).

Mechanism has been proposed in AF. Ablation has reduced vagal input around pulmonary veins, HRV has fallen early, and partial recovery has followed over months. Larger early HRV fall has often tracked with better rhythm control (Drexler *et al*., 2024) (Ferreira *et al*., 2024) (Marinković *et al*., 2020). So, a cautious translation to SVT has been made. Typical AVNRT and AVRT lesions are focal and not wide atrial denervation. Therefore, autonomic shifts should be smaller. HRV before or soon after SVT ablation may have less predictive power than in AF, and it has remained a hypothesis (Hsieh *et al*., 1999b).

3. Impact of Clinical and Procedural Factors on SVT Recurrence

Accessory pathways (AP). Recurrence has been higher with septal or posteroseptal APs and with right-sided APs. These locations have been more difficult to ablate and have carried higher risk of recurrence or AV block *(Macedo et al*., 2010) (Enzhao Liu *et al*., 2012). In a contemporary cohort, AP ablation has shown initial success near 95% and long-term success near 93% over a median of ~2.5 years (Young *et al*., 2021). Yet recurrences have clustered by pathway site.

A 2020–2024 body of work has added details (Chang, 2021). Multiple APs and shorter consolidation after initial AP elimination (<90 seconds) have increased recurrence risk (Audrey Dionne, MD *et al.*, 2020).

AVNRT. Modern series have reported low recurrence after slow-pathway modification. One pooled analysis has suggested an AVNRT recurrence rate near 1.1%, and most redo cases have succeeded (Hirata *et al*., 2024).

Cryoablation has had a favorable safety profile (Zook *et al*., 2022). However, persistence of slow-pathway conduction or single echo beats after cryo has been linked to higher recurrence in several studies (Lau & Lee, 2020). Other studies have not confirmed this link, so centers have used practical endpoints (De Sisti *et al*., 2012).

WPW/AP in contemporary series. A 2024 analysis has reported cumulative AP recurrence of 6.5% at 6 months and 7.2% at 12 months (Burke *et al*., 2024). Most recurrences have occurred in the first 6 months. Under-ascertainment has been possible with short follow-up.

4. Immediate and Long-Term Autonomic (HRV) Effects of Catheter Ablation and Their Relevance to SVT

In AF ablation, immediate vagal withdrawal has been observed. HRV has dropped markedly in the first days and weeks, then has partially recovered over months. Several cohorts and reviews have reported this time course (Gottlieb *et al*., 2021).

Quantitatively, studies have shown the steepest HRV fall on day 1 after PVI, with gradual recovery by 6–12 months. Larger early falls have often tracked with lower AF recurrence (Marinković *et al*., 2020).

Applying this to SVT needs care. AVNRT and AVRT lesions have targeted the slow pathway or a discrete AP. Therefore, wide atrial denervation has not been expected. HRV changes after SVT ablation should be smaller and more localized, so any HRV-based prediction for SVT recurrence has remained uncertain (Hsieh *et al*., 1999a).

5. Mechanism of Ganglionated Plexi (GP) Ablation in Influencing SVT Recurrence

In AF, GP ablation has targeted intrinsic cardiac ganglia. The goal has been to reduce autonomic triggers and to modulate atrial remodeling. Reviews and trials have reported mixed benefit when GP ablation has been added to PVI (Stavrakis *et al*., 2015). For SVT, the re-entry substrate has been nodal dual-pathway physiology or a discrete AP. Autonomic tone has modulated cycle length but has not created the substrate. Therefore, routine GP ablation has had uncertain value for preventing SVT recurrence. Any benefit would be indirect, for example by reducing vagal facilitation of slow-pathway conduction. Trials in typical SVT have not established a role (Stavrakis *et al.*, 2015).

6. Potential Role of Baroreflex Sensitivity (BRS) as a Predictor of SVT Recurrence

AF studies have reported that depressed BRS has associated with higher AF recurrence after ablation. Peri-procedural ablation has also modified BRS (Miyoshi *et al*., 2020). These findings have suggested that global autonomic balance has mattered for AF outcomes (Zuk *et al*., 2024). A careful translation to SVT has been reasonable. BRS has measured systemic autonomic control and may track vagal-sympathetic balance. However, because SVT substrates are focal, BRS has remained an unproven predictor for SVT recurrence. It has been a hypothesis to test rather than a clinical tool today (Miyoshi *et al*., 2020).

Table 3: Global Comparison and Bangladesh Context on Autonomic Markers and SVT Recurrence

Area	Global Evidence	Bangladesh Context
Autonomic Markers (HRV, BRS, SKNA, PWA)	HRV, BRS, SKNA, and PWA have been used as predictors of arrhythmia recurrence. HRV is the most studied and widely applied marker. BRS and SKNA are more experimental. PWA shows atrial substrate vulnerability (Findings 1).	HRV has been studied in some tertiary hospitals (e.g., NICVD, BSMMU) using ECG-based analysis. BRS, SKNA and PWA have not yet been applied in clinical prediction due to lack of advanced equipment and cost constraints (Begum, 2016).
HRV Predictive Value (from AF to SVT)	AF studies show that lower pre- or early post-ablation HRV predicts higher recurrence. HRV drop after AF ablation has correlated with rhythm outcomes. Translation to SVT is cautious since ablation targets are focal (AVNRT/AP) (Findings 1).	In Bangladesh, HRV analysis has been mostly descriptive. Limited studies exist on SVT recurrence. Translation of AF findings to SVT has not yet been tested in a systematic way (Rahman *et al*., 2021).
Clinical & Procedural Factors	Recurrence is higher in difficult AP sites (septal, right-sided). AVNRT recurrence is low (~1%). Cryoablation is safe but can show higher recurrence if residual slow pathway conduction persists. WPW/AP recurrence ~6–7% in first year (Findings 3).	In Bangladesh, RF ablation is common, cryoablation is rare. Technical challenges and limited mapping tools make septal and right-sided pathways more prone to recurrence. Follow-up data is often incomplete, limiting recurrence tracking (Rahman *et al*., 2021).
Immediate Autonomic Effects of Ablation	AF ablation causes vagal withdrawal with HRV fall, then partial recovery over months. In SVT, HRV changes are smaller and localized. Predictive role of HRV in SVT recurrence is uncertain (Findings 4).	In Bangladesh, autonomic follow-up after ablation is rarely performed. HRV before and after ablation is not measured as routine. Clinical follow-up relies mainly on symptom recurrence, not autonomic monitoring (Frankel & Gerstenfeld, 2010).
Ganglionated Plexi (GP) Ablation	In AF, GP ablation has shown mixed results. In SVT, GP ablation has no established role, since substrates are focal (Findings 5).	In Bangladesh, GP ablation is not practiced. Centers follow standard AVNRT and AP ablation protocols (sami, 2024).
BRS as Predictor	Lower BRS has correlated with higher AF recurrence. Its role in SVT is still experimental and not proven (Findings 6).	No clinical studies on BRS exist in Bangladesh. Blood pressure and HR response are measured, but not BRS slope analysis (Haq *et al*., 2022).

Table 4: Gaps and Future Research Directions

Area	Current Gap	Future Research Direction
SVT-specific evidence	Most studies focus on AF; SVT evidence is scarce	Conduct SVT-focused studies to validate autonomic markers
Sample size	Small cohorts limit statistical power	Perform multicenter prospective studies with larger samples
Marker assessment	HRV is studied most; BRS, SKNA, PWA rarely applied	Include HRV, BRS, SKNA, PWA together to compare predictive value
Follow-up duration	Short-term recurrence reported; long-term outcomes underexplored	Conduct long-term follow-up studies to assess sustained predictive value
Standardization	Variable measurement and analysis methods	Develop uniform protocols for recording and analyzing markers
Integration with clinical factors	Few studies combine autonomic markers with patient or procedural factors	Combine autonomic markers with clinical variables to refine prediction models
Global representation	Minimal research in low- and middle-income countries	Conduct studies in Bangladesh and similar contexts to assess feasibility and applicability
Monitoring approaches	Conventional ECG or lab-based assessment only	Explore wearable devices and non-invasive continuous monitoring methods

CONCLUSION

Autonomic markers provide promising insights into the prediction of SVT recurrence after catheter ablation. HRV is the most widely studied and showing its potential for identifying patients at higher risk of recurrence, while BRS, SKNA, and PWA are remained experimental. Evidence from AF suggests that early autonomic changes may correlate with outcomes, but translation to SVT requires caution due to the focal nature of its substrates.

Clinical and procedural factors, including accessory pathway location, ablation technique and residual conduction, also influence recurrence risk. In Bangladesh, HRV analysis has been applied in tertiary centers, but systematic use of other autonomic markers is limited by technical and financial constraints. Integrating autonomic markers with clinical assessment could improve prediction of recurrence and guide follow-up strategies.

Future research should focus on prospective studies in SVT populations, testing multiple autonomic markers and their combinations with clinical parameters. This approach could help to develop personalized post-ablation monitoring, reduce recurrence rates and improve patient outcomes. Overall, autonomic markers hold its potential, but further validation is needed to establish their role in routine of SVT management.

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