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Original Article

# Assessing safety of leadless pacemaker (MICRA) at various implantation sites and its impact on paced QRS in Indian population

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ABSTRACT

*Background:* In this study we report our experience in implanting MICRA TPS (transcatheter pacing system) at various RV sites; observing its safety, and impact on paced QRS in Indian population.
*Material & methods:* 35 patients with MICRA TPS deployed from March 2017 to December 2019 at Army Hospital Research and Referral, New Delhi, at RVOT, apical septum and mid septum of RV were enrolled in the study. These patents were followed up and impact of implantation site, procedure related complications, change in pacing parameters, left ventricular ejection fraction and duration of paced QRS were monitored.
*Results:* Sick sinus syndrome was the commonest indication of pacing in this study (51.5%), followed by high degree AV block (34.2%). Mean follow up of 1.4 years showed no change in left ventricular ejection fraction, electrical parameters or change in pacing thresholds after implantation. Mean pQRS was broadest (166.60 ms) in apically implanted MICRA TPS and narrowest in mid septum group 139.33 ms. Among 35 cases, in our study one patient developed pericardial effusion, and other had intermittent diaphragmatic pacing.
*Conclusion:* Among these three implantation sites mid septum deployment is associated with narrowest paced QRS in Indian population.


## 1. Introduction

Pacemaker technology with transvenous lead was developed in 1959 and thereafter implantable pacemakers were introduced in 1960s. These pacemakers revolutionised the field of cardiology for decades. However conventional transvenous pacemaker implantation is associated with a risk of procedure related complications, ranging up to 10%.[1]

To overcome this, MICRA™ (Medtronic USA), transcatheter leadless pacing system received FDA approval in April 2016. Micra transcatheter pacing system (TPS) implantation is associated with a risk of 4% including cardiac perforation, tamponade, embolization. Studies have compared leadless pacemakers with conventional transvenous ones and have documented a 50% reduction in early major complications with leadless pacemakers.[2,3]

MICRA TPS implantation was initially implanted at apical septum sites. However, as in conventional pacing, non apical pacing sites were gradually preferred because of narrower QRS and risk of long term left ventricular dysfunction. However, not many studies have reported safety and feasibility of Micra deployment at various implantation sites in RV and its effect on paced QRS. In this study we report our experience in implanting MICRA TPS at various RV sites; observing its safety, and impact on paced QRS.

## 2. Material and methods

Prospective, single centre, non randomized, observational study for establishing safety, and feasibility of leadless pacing at different implantation sites in RV and studying its impact on paced QRS duration. All consecutive 35 patients with MICRA transcatheter pacing system (TPS) deployed, from March 2017 to December 2019, at Army Hospital Research and Referral New Delhi, at three different pacing sites in RV were enrolled in the study. MICRA was deployed for the following indications: recurrent pocket site infection, recurrent lead dislodgement or lead fracture, twiddler

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**Table 1**
Patient characteristics CAD - Coronary artery disease, COPD - Chronic obstructive pulmonary disease, CKD – Chronic kidney disease, AF- Atrial fibrillation, LVEDD, Left Ventricular end diastolic diameter; LVEF, left ventricular ejection fraction.

| | Total | APICAL | MID SEPTUM | RVOT |
|---|---|---|---|---|
| Patients | 35 | 10 | 18 | 7 |
| Age | 80 (71–92) | 80 (76–88) | 84 (71–92) | 78 (75–85) |
| Male | 57% (20) | 60% (6) | 55.5% (10) | 57.1% (4) |
| Hypertension | 22 | 5 | 13 | 4 |
| Diabetes mellitus | 9 | 2 | 6 | 1 |
| Copd | 5 | 1 | 3 | 1 |
| Ckd | 3 | 1 | 1 | 1 |
| Indication pacing | | | | |
| High degree av block | 34.2% (12) | 30% (3) | 33.3 (6) | 42.8 (3) |
| Sick sinus syndrome | 51.5% (18) | 60% (6) | 44.4% (8) | 57.1 (4) |
| Af with bradycardia | 14.3% (5) | 10% (1) | 22.2% (4) | – |
| Cad | 20% (7) | 20% (2) | 22.2% (4) | 14.2% (1) |
| H/o heart failure | 4 (11.4) | 10% (1) | 11.1% (2) | 14.2% (1) |
| Lvedd | 45.6 (41–50) | 45 (41–47) | 46 (43–50) | 45.8 (42–49) |
| Lvef at implantation | 55% (45–60) | 55% (45–60) | 55% (45–60) | 55% (45–60) |
| Lvef follow up | 55% (45–60) | 55% (45–60) | 55% (45–60) | 55% (45–60) |
| Implantation Duration (minutes) | | 12 (7–15) | 13 (9–17) | 15 (10–21) |
| Fluoroscopy TIME(minutes) | | 7 (5–8) | 8 (6–11) | 12 (10–15) |
| Pericardial effusion | 1 | – | – | 1 |
| Dislodgement | – | – | – | – |
| Diaphragmatic pacing | 1 | 1 | – | – |
| Groin hematoma | – | – | – | – |

syndrome, radiation/tumour or other causes of venous obstruction, and frailty (in which paucity of tissue precludes pocket formation).

To differentiate between septal and free wall position of MICRA TPS LAO 40 projection was used; while right ventricular outflow tract (RVOT), mid septum and apical septum position was judged in RAO 30 cine views. In RAO 30, cardiac silhouette[4] was divided into thirds from external border of heart to left lateral border of spinal column, resulting in 9 segments (Fig A). Central most square depicted mid-septum, middle square of top most row indicated RVOT septum, outermost square in bottom row indicated right ventricular apex. Depending upon the position of MICRA TPS in RAO and LAO views patients were divided into three categories.

1. Apical septum
2. Mid Septum
3. RVOT

The protocol was approved by the Ethics Committee of the hospital. All the Micra TPS were implanted according to the manufacturer's protocol.[5] After cannulating the Femoral vein, loaded device was implanted in the right ventricle where it was deployed with the help of 4 flexible nitinol tines. The Micra TPS is a single-chamber ventricular pacemaker. Compared to traditional transvenous pacemakers it is 93% smaller with a total volume of 0.8 mL.

All events including procedure related complications, device malfunction, hospitalisation for more than 48 h post procedure were noted. Thereafter these patients were followed up. The average time for follow-up was 1.4 ± 0.3 years.

Fig. A. In the RAO 30 view, the cardiac Silhouette was sub divided into 9 quadrants, lateral boundaries being the external border of the heart and the spinal column using an imaginary grid. APEX-apical septum of right ventricle (RV), MID - middle septum of RV, RVOT- Right ventricular outflow tract.

## 3. Results

A total of 35 patients underwent leadless pacemaker implantation from March 2017 to December 2019 at Army Hospital Research and Referral, New Delhi and were enrolled in this study.

Patients were on average 80 ± 8.5 years of age, males constituting 57% (20) and females constituting 43% (15).

Patients in this study group had multiple comorbidities (Table 1), 63% (22) of the patients were hypertensive, 25% (9) patients were diabetic, 20% (3) had a history of coronary artery disease out of which 4 were post CABG (coronary artery bypass grafting), 15% (5) patients had Chronic obstructive pulmonary disease and 8% (3) patients had chronic kidney disease with one on maintenance haemodialysis, through right subclavian catheter.

The most common primary indication of pacing in this study was Sick sinus syndrome (51.5%), followed by high degree AV block (34.2%). In 66% (23) cases MICRA TPS was deployed because of recurrent pocket site infections. One patient had Twiddler syndrome and 2 patients had lead fracture (Table 2).

About 28.6% (10) patients, had up front MICRA TPS implantation. Out of these 22.8% (8) patients were elderly/frail with BMI <20 kg/m$^2$ and hardly any pectoral muscle mass. One patient was on maintenance haemodialysis with a subclavian catheter on right site and pocket site infection on the left side. Another patient had bilateral subclavian vein stenosis.

Average time for follow-up was 1.4 ± 0.3 years. Pacing threshold at 0.25 V, R-wave amplitude and impedance were measured in all patients and compared to the values at the time of implantation. No significant difference was found in pacing threshold, R-wave amplitude and impedance on follow up.

MICRA implantation was successful in all patients at initially targeted site. Depending upon the site of MICRA TPS implantation, patients were divided into three groups and their electrocardiograms were analysed for paced QRS (pQRS) duration (Table 3).

**Table 2**
Indications of leadless pacemaker implantation and distribution of patients.

| | | Number of patients | Percentage |
|---|---|---|---|
| 1 | Recurrent pocket site infection | 23 | 66% |
| 2 | Fraility | 8 | 22.8% |
| 3 | Twiddler Syndrome | 1 | 2.8% |
| 4 | Lead fracture | 1 | 2.8% |
| 5 | No subclavian access | 2 | 5.6% |

**Table 3**
Procedure related complications and mean native QRS durations of three groups.

| | Site of leadless pacemaker implant | Number of patients | Percentage | Procedure related complication | Native QRS duration before implant, ms | Mean pqrs (post implant) | Standard deviation | 95% CI |
|---|---|---|---|---|---|---|---|---|
| 1 | Apical Septum | 10 | 28.6% | Diaphragmatic pacing | 110 ± 20 ms | 166.60 ms | 7.66 | (162.58, 170.62) |
| 2 | Mid Septum | 18 | 51.4% | – | 112 ± 16 ms | 139.33 ms | 5.53 | (136.34, 142.33) |
| 3 | RVOT | 7 | 20% | Pericardial effusion | 116 ± 18 ms | 151.14 ms | 5.76 | (146.34, 155.95) |

In 28.6% (10) patients as shown in Fig. 1a and b MICRA TPS was deployed at apical septum and position was confirmed in RAO 30 and LAO views. ECG of this group of patients showed widest pQRS with a LBBB pattern (left bundle branch block) and a negative R in leads II, III and aVF; typical of RV apical septum pacing.

In this study maximum number of MICRA TPS, 51.4% (18) of total patients, were deployed in mid septum (Fig. 2a and b). ECG of this group of patients showed relatively narrow pQRS with a LBBB pattern (left bundle branch block) and biphasic QRS morphology in lead I suggestive of pacing site exactly at mid septum(Fig. 2c).

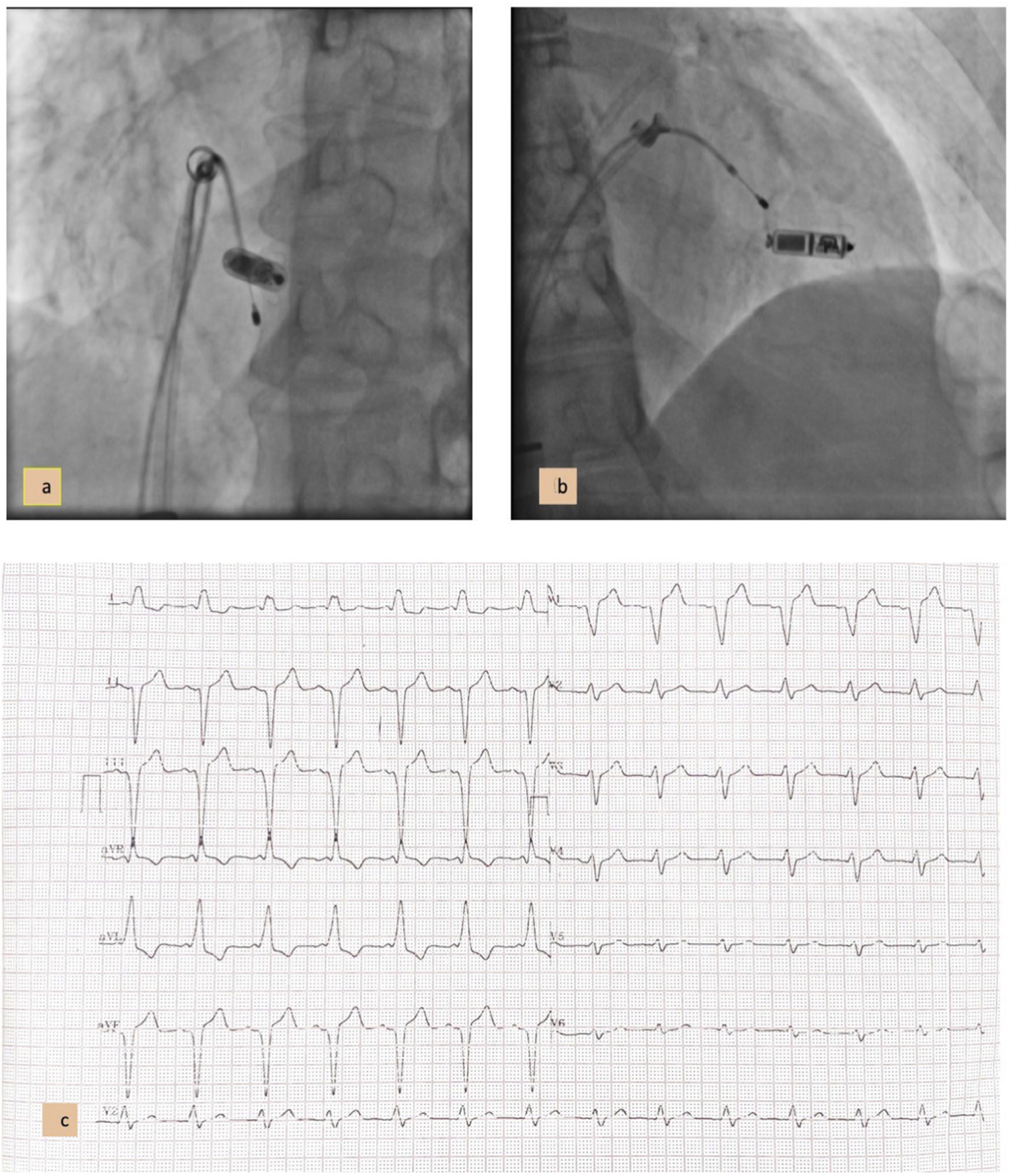


**Fig. 1.** 1a and 1b depict the deployment of MICRA TPS at apical septum and position being confirmed in LAO and RAO 30 views respectively. ECG (1c) of his patient shows pQRS of 160 ms with a LBBB (left bundle branch block pattern) and a negative R in leads II, III and aVF.

MICRA TPS was deployed in RVOT in only 20% (7) of the patients (Fig. 3a and b). ECG of this group of patients showed relatively broad paced QRS, as compared to mid septum, but narrower than apical septum, with a LBBB pattern (left bundle branch block) and positive R in inferior leads, and late R/S transition.

Mean pQRS was broadest (166.6 ± 7.66 ms) in apically implanted MICRA TPS and narrowest in mid septum group (139.33 ± 5.53 ms). MICRA deployed at RVOT septum had an intermediate pQRS of 151.14 ± 5.76 ms. In all three subgroup of patients there was no change in Left ventricular ejection fraction on follow up as compared to that during implantation.

Total procedure time and fluoroscopy time was shortest in apical group (7 min fluoroscopy time) and longest in RVOT group (12 min fluoroscopy time). Among 35 cases one patient developed pericardial effusion with no features of tamponade, which improved after 2 days of conservative management. One patient whose MICRA had been deployed in apical septum developed intermittent diaphragmatic pacing exacerbated by deep inspiration after 12 h of implantation. Device parameters were checked and pacing output was decreased from 2.5 V to 1.6 V, which relieved the patient's symptoms.

There were no other complications in the cohort and all the patients in this study were discharged within 24 h of procedure except these two patients.

## 4. Discussion

Our study evaluates the possible implantation sites of leadless pacemakers. In this study we have demonstrated that RV can be

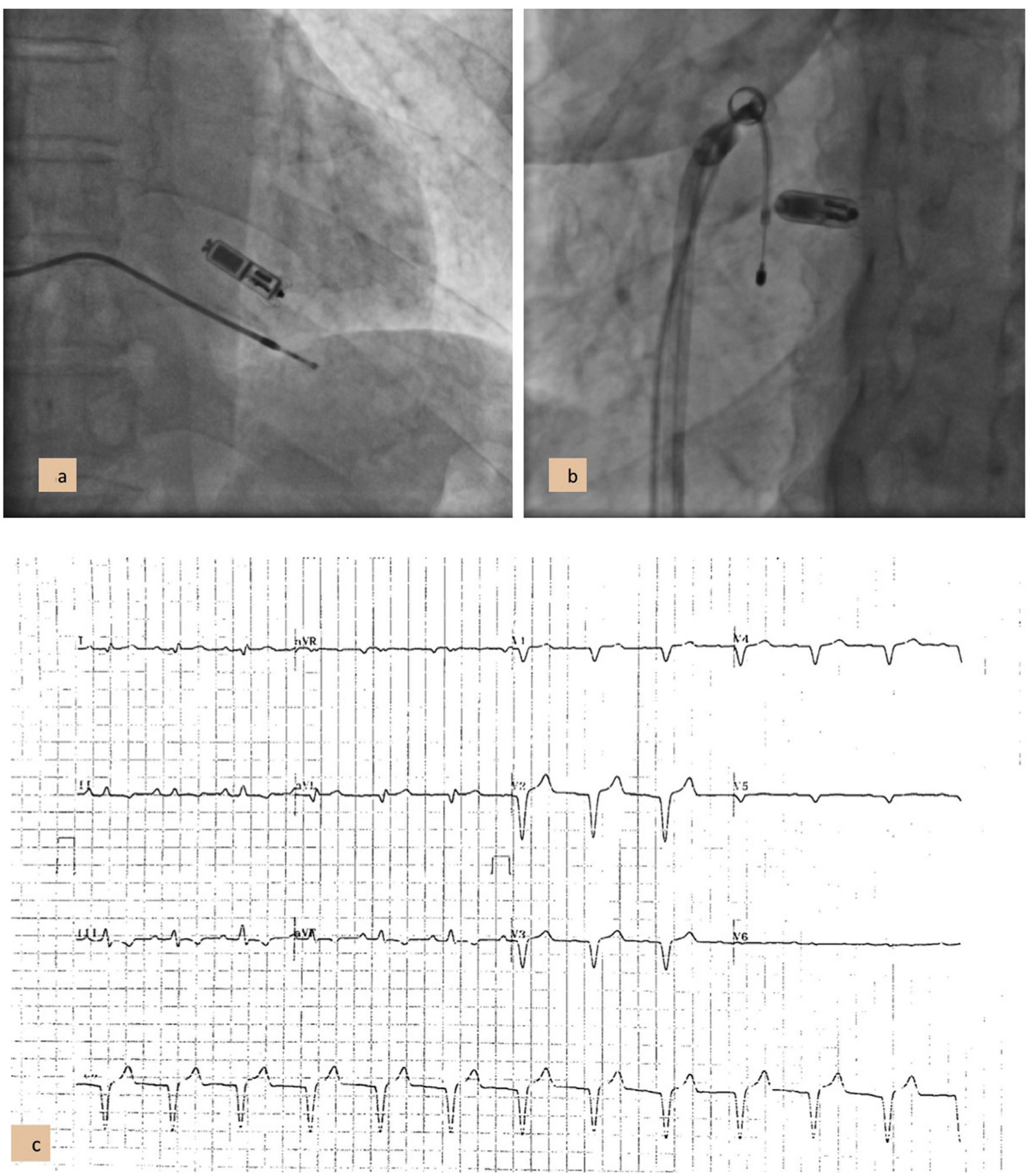


**Fig. 2.** 2a and 2b MICRA TPS was deployed at mid septum and position was confirmed in RAO 30 and LAO respectively. ECG (2c) of this group of patients showed relatively narrow pQRS with a LBBB pattern (left bundle branch block) and biphasic QRS morphology in lead I and inferior leads, suggestive of pacing site exactly at mid septum.

paced from RVOT, mid septum and apex with MICRA TPS achieving good pacing results in Indian population.

Initially, because of procedural ease and relatively safe position, RV apex was the preferred implantation site of MICRA TPS.[5] With conventional pacemakers, it has been demonstrated that pacing site and ventricular synchrony are closely related to each other. If pacing is done from apex, impulse travels via myocardial cells instead of specialised Purkinje fibres, taking more time, which in turn widens the paced QRS. Contrary to this if pacing site is RVOT or mid septum, it resembles physiological pacing being closer to natural conduction tissue, and produces a relatively narrow paced QRS as compared to apex. There is enough evidence in medical literature to prove that narrower the paced QRS, better is the long term prognosis.[6,7] In long term studies, for every 10 ms increase in QRS width, cardiovascular death has been found to be increased by up to 21%.[8]

In our study 51.4% patients had MICRA implanted at mid septum, 28.6% in RVOT and 20% in apical septum. These three pacing sites had characteristic features in paced ECG. RVOT pacing produced positive QRS in inferior leads and a negative or isoelectric vector in lead I and aVL. RVOT free wall pacing resulted in notched wide QRS in inferior leads and a late transition (after $V_4$).[9,10] Mid septal pacing had isoelectric QRS in inferior leads. Mid septal pacing can be from rightward – posterior location producing positive QRS in lead I or antero-leftward that has a negative QRS in lead I. Sites that are in

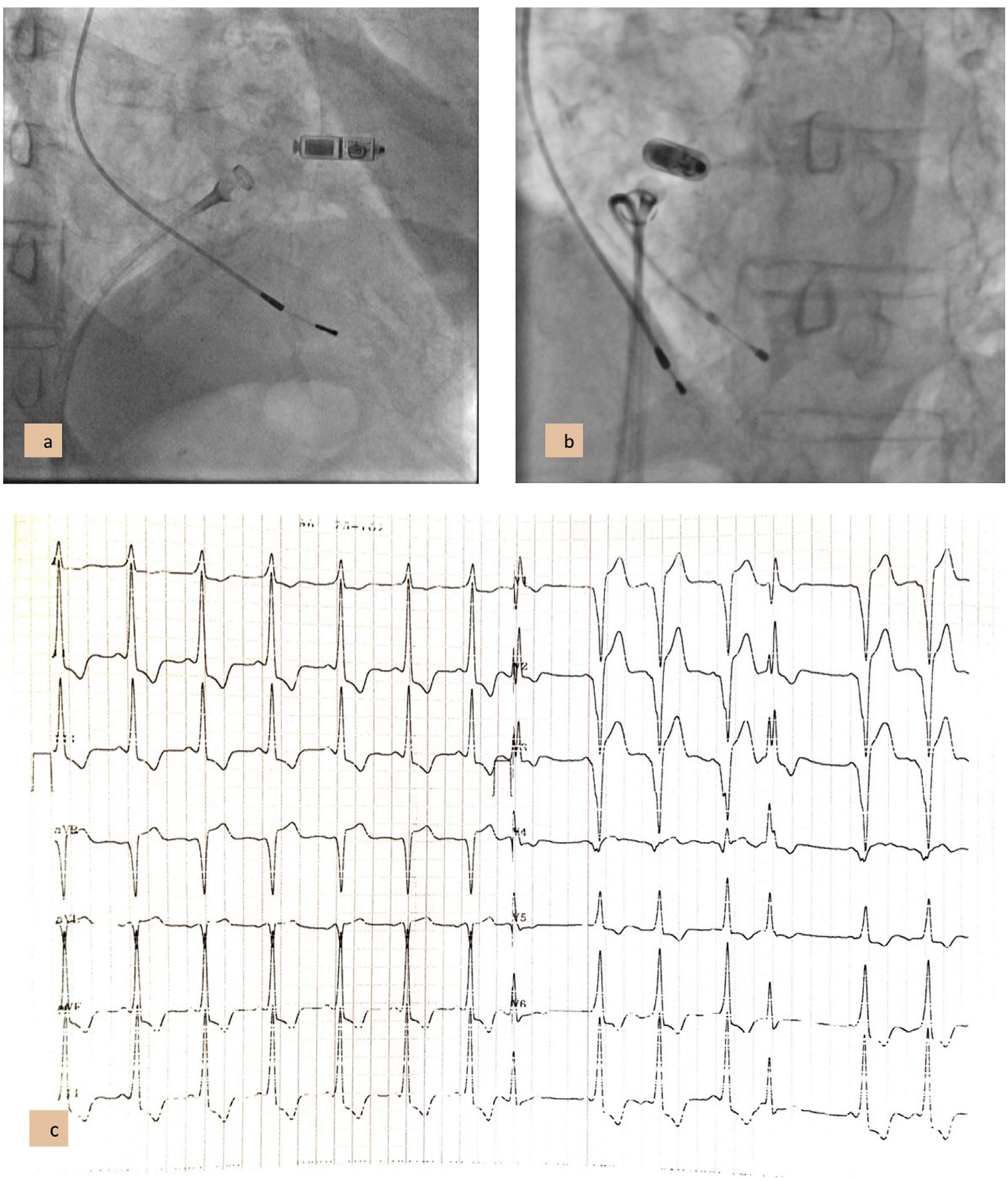


**Fig. 3.** 3a and 3b MICRA TPS was deployed at RVOT and position was confirmed in RAO 30 and LAO. ECG (3c) of this group of patients showed relatively broad paced QRS with a LBBB pattern (left bundle branch block) and positive R in inferior leads.

between these two locations produce biphasic or multiphasic QRS in lead I. RV apical pacing had a widened QRS (LBBB pattern), a negative QRS in inferior leads and a positive QRS in aVL.[11,12]

Chistophe et al[13] have evaluated paced QRS duration with MICRA TPS at RVOT, mid septum and apex, similar to our study. They have similarly documented relatively reduced paced QRS duration at non apical pacing sites as compared to RV apex. Narrowest paced QRS was observed in RVOT pacing; whereas in our study mid septum had the narrowest QRS (139 ± 5.53 ms) followed by RVOT (151.14 ± 5.76 ms). Apical pacing had broadest paced QRS in both of these studies.

Some studies advocate non apical pacing sites in presence of abandoned RV pacing leads, difficult RV anatomy and presence of previous leadless pacemaker. Non apical pacing sites may facilitate the deployment of up to 3 successive leadless pacemakers in RV over time.[14]

Follow up showed no change in electric parameters or change in pacing thresholds after implantation. After an average follow-up of 1.4 years pacing threshold at 0.25 V, R-wave amplitude and impedance showed no change as compared to time of implantation. None of the patients had device dislodgement, embolization or cardiac perforation. Only one patient whose MICRA had been deployed in apical septum developed intermittent diaphragmatic pacing which improved after the pacing output was decreased. Hai et al[15] have documented cardiac perforation in one case because of inaccurate anchoring of the device in the right free wall. Among 35 cases, in our study one patient developed pericardial effusion, after deployment of MICRA TPS in RVOT position. He had no features of tamponade, and improved after 2 days of conservative management. All the patients, in our study were discharged within 24 h of the procedure except the already described 2 patients.

Sick sinus syndrome was the commonest indication of pacing in this study (51.5%), followed by high degree AV block (34.2%). In 66% cases MICRA TPS was implanted because of recurrent pocket site infections.In these subset of patients commonest indication of pacing was sick sinus syndrome. Around 22.8% (8) patients who were elderly frail with BMI <20 kg/m$^2$ with hardly any pectoral muscle mass also received MICRA TPS. All patients were doing well on follow-up, irrespective of site of implantation and in all three subgroup of patients there was no change in Left ventricular ejection fraction on follow up as compared to that during implantation.

Proponents of mid septal pacing advocate avoiding apical septum for pacing as there is a long term risk of left ventricular dysfunction. Also deployment of MICRA TPS in subpulmonary infundibulum of RVOT is difficult because of lack of trabeculations. Therefore mid septum which has maximum density of trabeculations, has been proposed to be the ideal site for leadless pacemaker implantation.[16,17] We agree to this and through this study we have further proved that mid septum deployment is associated with narrowest paced QRS as compared to RVOT and RV apex. Taking all this into consideration, as per our study, mid septum seems to be best site for MICRA TPS implantation in Indian population.

## 5. Conclusion

Our study validates the possible implantation sites of leadless pacemakers. We have demonstrated that RV can be paced from RVOT, mid septum and apex with MICRA TPS achieving good pacing results. Among these three implantation sites mid septum deployment is associated with narrowest paced QRS as compared to RVOT and RV apex. Mid septum seems to be best site for MICRA TPS implantation in Indian population.

## Conflicts of interest

All authors have none to declare.

## Appendix

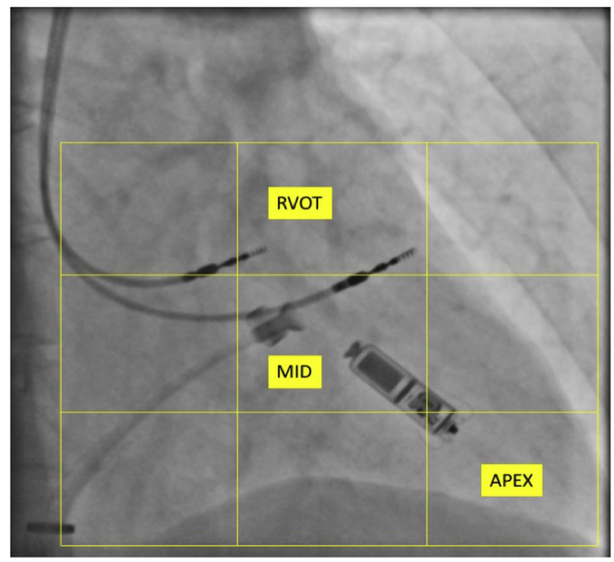


Fig. AIn the RAO 30 view, the cardiac silhouette was sub divided into 9 quadrants, lateral boundaries being the external border of the heart and the spinal column using.

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