Permanent pacemaker insertion postmitral surgery: Do the atrial access and the origin of the sinoatrial node artery matter?

Anas Boulemden FRCS | Dharsicka Nadarajah MBBS | Adam A Szafranek FRCS | David Richens FRCS

**Abstract**

**Background and aim of the study:** To determine whether the type of atrial access to the mitral valve (left atriotomy, superior trans-septal, or limited trans-septal) influenced postoperative permanent pacemaker implantation and to investigate the effect of the sinoatrial (SA) node artery origin (right coronary or circumflex arteries) on the rate of pacemaker insertion.

**Methods:** We retrospectively reviewed consecutive cases of patients who had mitral valve surgery at the Trent Cardiac Centre (2008-2016). The primary outcome was the incidence of permanent pacemaker insertion. The data were analyzed using univariate then binary multivariate regression analysis.

**Result:** Four hundred sixty-nine patients had mitral valve surgery. The mean age was 66.5 ± 12.3 years and 47.5% were female. One hundred fifty patients (32%) had mitral valve surgery via the standard left atriotomy approach, while 226 (48.2%) and 93 (19.8%) cases were performed using the limited trans-septal and superior trans-septal approaches, respectively. Concomitant tricuspid valve surgery was carried out in 33 cases (7%). The overall rate of pacemaker implantation was 5.3%. On univariate analysis, only age (≥70 years old) and concomitant tricuspid valve surgery were significant predictors of postoperative pacemaker insertion, while on multivariate analysis only age (≥70 years old) remained a predictor. The type of atrial incision and the origin of the SA node artery did not affect the rate of pacemaker implantation.

**Conclusion:** The type of atrial approach to the mitral valve and the origin of the SA node artery did not influence the incidence of postoperative permanent pacemaker insertion.

**Keywords**

mitral valve, permanent pacemaker, sinoatrial node artery, superior trans-septal approach
Traditionally, left atriotomy is the incision of choice to access the mitral valve. Guiraudon et al. were the first to report the extended vertical transatrial septal approach, also known as the superior trans-septal approach. Early results were encouraging with excellent exposure of the mitral valve without inherent complications. Subsequently, the superior trans-septal approach was accepted and adopted due to the ease of access to the mitral valve, especially in cases when the left atrium is small. In our review, we found that the superior trans-septal incision was safe and all papers except for one showed a similar rate of postoperative permanent pacemaker implantation (PPM) in comparison to the limited trans-septal approach and the standard left atriotomy. Some authors hypothesized that due to its anatomical topography, the sinoatrial (SA) node artery was at risk of injury during the superior trans-septal approach. In our study, we investigated the risk of postoperative PPM in three types of mitral valve approaches, the left atriotomy, the limited trans-septal, and the superior trans-septal incisions. We also studied the anatomical variation of the origin of the SA node artery on coronary angiography and the impact of this variation on the rate of postoperative PPM.

2 MATERIALS AND METHODS

2.1 Operative techniques

Following a median sternotomy, cardiopulmonary bypass was instituted with cannulation of the aorta and both venae cavae.

2.1.1 Left atriotomy

An incision is made just posterior and parallel to the interatrial groove (also known as Waterston’s or Sondergaard’s groove). The incision is extended to the right superior pulmonary artery superiorly, and inferiorly to the back of the heart toward the mitral annulus to improve exposure while leaving a generous cuff for the closure.

2.1.2 Limited trans-septal incision

The two caval snares are secured. An incision is made parallel to the atrioventricular (AV) groove, leaving a 1-cm atrial cuff to facilitate later atrial closure and to avoid injury of the right coronary artery (RCA). The incision is extended cephalad toward the right atrial appendage and caudad toward a midpoint between the inferior vena cava and the AV groove. A separate incision is made through the fossa ovale. It is extended caudad to the base of the fossa ovale and cephalad toward the base of the superior vena cava; care must be taken not to injure the aortic root by keeping the trans-septal incision medial.

2.1.3 Superior trans-septal incision

Similar to limited trans-septal incision, the two caval snares are secured and a right atriotomy is made as described above. The trans-septal incision through the fossa ovale is directed cephalad toward the dome of the left atrium and connected with the extended right atrial incision (Figure 1).

2.2 Patients

From 2008 through 2016, we reviewed the medical notes and electronic database of all patients who had mitral valve surgery at the Trent Cardiac Centre, Nottingham University Hospitals. Patients who had mitral valve surgery via one of the incisions mentioned above were included in the study. Patients who had permanent pacemaker insertion before surgery and other subgroups were excluded from the study (Figure 2).
Coronary angiograms were performed preoperatively in the majority of patients older than 45 years. For younger patients, angiograms were performed dependant on the presence of cardiovascular risk factors or symptoms suggestive of ischemic heart disease. We reviewed all the preoperative coronary angiograms to define the origin of the SA node artery.

### 2.3 Choice of the type of atrial incision

The choice of the atrial incision was surgeon-dependent, irrespective of the size of the left atrium. Each surgeon opted toward a particular type of atrial incision due to familiarity with the technique. One surgeon changed his technique from the limited to the superior trans-septal incision in rare occasions when the left atrium was small.

### 2.4 Postoperative period and follow-up

All patients had continuous electrocardiogram recordings (telemetry) during the first 48 to 72 hours after surgery and for a more extended period when indicated. Twelve lead electrocardiograms were recorded on day 1, day 4, and 6-weeks after hospital discharge.

Indications for permanent pacemaker insertion were in line with the American College of Cardiology/American Heart Association guidelines for implantation of cardiac pacemakers. In all cases, the cardiologists were involved in the decision making of PPM.

### 2.5 Statistics

The data are presented as means with standard deviation and medians with interquartile range (IQR). For comparing the three incision types, one-way analysis of variance test was used to compare the difference in means and for binary or categorical outcomes (proportions). Standard binary univariate then multivariate regressions were conducted with permanent pacemaker insertion as the dependent variable and age (≥70 years old), male sex, previous cardiac surgery, tricuspid valve surgery, aortic valve surgery, left atriotomy, trans-septal approach, superior trans-septal approach, and the origin of the SA node artery (circumflex origin) as independent variables. SPSS (IBM Corp Released 2015, IBM SPSS Statistics for Windows, version 23.0; IBM Corp, Armonk, NY) was used for data analysis.

### 3 RESULTS

Baseline characteristics of patients' subgroups and their comparison are summarized in Tables 1 and 2.

For comparing the baseline characteristics between the three groups (left atriotomy, limited trans-septal, and superior trans-septal approaches), only sex (female) and concomitant tricuspid valve surgery were significantly different between the three groups (P = .007, P <.0001, respectively). Over the last 2 years of this study, we tended to perform more concomitant tricuspid valve repairs in patients with moderate tricuspid regurgitation and also in tricuspid annular dilatation (more than
as per the European Society of Cardiology and European Association of Cardio-Thoracic Surgery valve guidelines on the management of valvular heart disease (version 2012). The incision of choice in concomitant tricuspid valve repair was the limited trans-septal approach.

3.1 | Postoperative pacemaker insertion

In total, 25 permanent pacemakers were implanted (5.3%). The rate of PPM insertion was similar between the three incisions (left atriotomy; 5.3%, limited trans-septal; 5.3%, and superior trans-septal; 5.4%, \( P = 1.00 \)). The causes of PPM insertion are summarized in Table 3. The median duration from time of surgery to PPM insertion was 13 days (IQR; 5).

On univariate analysis, only age and concomitant tricuspid surgery were the risk factors for PPM insertion, \( P = .004 \) and .015, respectively (Table 4). On multivariate analysis, age remained as a risk factor for PPM insertion (\( P = .015 \)) while the type of atrial incision and the origin of the SA node artery were not the predictors of PPM insertion (Table 5).

Two-hundred sixty nine patients (57.4%) were in sinus rhythm, preoperatively. In this subgroup, 12 (4.5%) patients had PPM implantation (causes: heart block =6, sinus bradycardia =2, slow atrial fibrillation =4). The rates of PPM implantation were 4.8%, 3.2%,

| TABLE 1 Baseline characteristics |
|----------------------------------|
| Median age (IQR) | 69 (61-76) |
| Mean age (SD)    | 66.5 ± 12.3 |
| Preoperative rhythm |
| Sinus            | 269 (57.4%) |
| AF               | 200 (42.6%) |
| Type of mitral surgery |
| Replacement      | 356 (75.9%) |
| Repair           | 113 (24.1%) |
| Concomitant procedure |
| CABG             | 115 (24.5%) |
| Tricuspid valve repair | 33 (7%) |
| Aortic valve replacement | 95 (20.3%) |
| Redo surgery     | 42 (8.9%) |
| Native valve pathology |
| Degenerative     | 250 (53.3%) |
| Rheumatic        | 106 (22.6%) |
| Ischemic/functional | 54 (11.5%) |
| Infective endocarditis (active or previous) | 38 (8.1%) |
| Other            | 21 (4.5%) |
| Origin of SA node artery on angiogram (angiogram done in 376 [80.1%] patients) |
| RCA              | 250 (66.5%) |
| Circumflex       | 116 (30.8%) |
| Both             | 3 (0.8%) |
| Unable to assess | 7 (1.9%) |

Abbreviations: AF, atrial fibrillation; CABG, coronary artery bypass graft; IQR, interquartile range; RCA, right coronary artery; SA, sinoatrial, SD, standard deviation

| TABLE 2 Comparison of baseline characteristics |
|-----------------------------------------------|
| Characteristics                              | Left atriotomy (n = 150) | Trans-septal (n = 226) | Superior trans-septal (n = 93) | \( P \)-value |
| Age                                          | 66.8 ± 11.3 | 66.9 ± 12.4 | 64.9 ± 13.8 | .40 |
| Female sex                                   | 73 (49%) | 119 (52%) | 31 (33%) | .007 |
| Concomitant tricuspid valve surgery           | 1 (0.6%) | 31 (13.7%) | 1 (1.07%) | <.0001 |
| Concomitant AVR                              | 29 (19%) | 50 (22%) | 16 (17%) | .57 |
| Origin of SA node artery                     | | | | |
| RCA                                          | 79 (71.8%) | 113 (63.1%) | 58 (72.5%) | .10 |
| Circumflex                                   | 31 (28.2%) | 65 (36.3%) | 20 (25%) | |
| Both                                         | 0 | 1 (0.6%) | 2 (2.5%) | |
| Logistic EuroSCORE                           | 9.4 ± 9.2 | 12.1 ± 13.1 | 10.6 ± 14.4 | .10 |
| Redo surgery                                 | 14 (9.3%) | 25 (11.1%) | 3 (3.2%) | .08 |

Abbreviations: AVR, aortic valve replacement; RCA, right coronary artery; SA, sinoatrial
and 6.5% in the left atriotomy, the limited trans-septal, and superior trans-septal approaches, respectively. As the number of events (n = 12) was small, it was not feasible to conduct statistical analysis in this subgroup of patients.

3.2 | Origin of the sinoatrial node artery

Coronary angiograms were performed in 376 cases, the SA node artery originated from the right coronary (Figure 3) and the left circumflex (Figure 4) arteries in 66.5% and 30.8%, respectively. In 0.8% of cases, the SA node artery had a dual origin from both the right coronary and the circumflex arteries. It was not possible to assess the origin of the SA node artery due to concomitant significant coronary artery disease in 1.9% of the cases. On univariate and multivariate analysis, the origin of the SA node artery from the circumflex was not a risk factor for PPM implantation (Table 4; Figure 5).

### Table 4 Univariate regression analysis

| Hazard ratio | 95% confidence interval | P-value |
|--------------|------------------------|---------|
| Age (≥70 y old, n = 233) | 4.3 | 1.60-11.76 | .004 |
| Male sex (n = 246) | 1 | 0.45-2.28 | .96 |
| Previous cardiac surgery (n = 42) | 1.4 | 0.40-4.91 | .59 |
| Tricuspid valve surgery (n = 33) | 3.7 | 0.09-0.77 | .015 |
| Aortic valve surgery (n = 95) | 0.8 | 0.30-2.05 | .63 |
| Left atriotomy (n = 150) | 1 | 0.42-2.37 | .99 |
| Trans-septal approach (n = 226) | 0.9 | 0.44-2.22 | .98 |
| Superior trans-septal approach (n = 93) | 1 | 0.37-2.77 | .98 |
| SA node artery (circumflex origin, n = 116) | 1.3 | 0.27-2.19 | .62 |

Abbreviation: SA, sinoatrial

### Table 5 Multivariate regression analysis

| Hazard ratio | 95% confidence interval | P-value |
|--------------|------------------------|---------|
| Age (≥70 y old, n = 233) | 4 | 1.3-12.6 | .015 |
| Tricuspid valve surgery (n = 33) | 3.7 | 0.06-1.15 | .078 |
| SA node artery origin (circumflex, n = 116) | 1.2 | 0.27-2.30 | .66 |
| Atrial incision (STS, n = 93) | 1 | 0.29-3.44 | .99 |
| Atrial incision (TS, n = 226) | 1.7 | 0.17-1.84 | .34 |

### Figure 3
Sinoatrial node artery: right coronary artery origin (arrow)

### Figure 4
SA node artery origin: left circumflex (arrow). SA, sinoatrial

4 | DISCUSSION

In this large study, there was no difference in the rate of PPM between left atriotomy, limited trans-septal, and superior trans-septal approaches. The patient age was a risk factor for PPM. The SA node artery originated from either the RCA, the left circumflex, or had a combined origin. The origin of the SA node artery was not a risk factor for postoperative PPM implantation.

Guiraudon et al\(^1\) described the superior trans-septal approach (referred in the paper as the extended vertical transatrial septal
The SA node artery crossed the superior posterior border of the interatrial septum (retrocaval course) in all 17 cases of the left SA node artery (34%), whereas, the right SA node artery crossed the superior posterior border in only 10 cases (20%). The authors concluded that there is potentially a high risk of intraoperative injury to the SA node artery during the superior trans-septal approach, especially when the SA node originates from the left coronary artery.\(^3\)

Guiraudon et al\(^1\) suggested that the blood supply from the SA node artery does not seem essential to maintain sinus node function. Noncoronary blood supply contributes considerably to atrial myocardial revascularization, and this argument is supported by the fact that after heart transplantation (bilateral technique), patients seldom develop atrial ischemia. Furthermore, in an experimental study, Sealy et al\(^11\) investigated atrial rhythm following total excision of the SA node in 20 dogs. They showed that a normal rhythm resumed immediately postoperatively in a third of the dogs and for the remainder, there was a period of dysrhythmias of up to 15 days, but eventually a normal rhythm ensued. The site of the substitute sinus impulse was found to be in the region of the coronary sinus. The findings of Sealy et al are noteworthy and may explain the restoration of a normal rhythm in the majority of patients who had atrial incisions, namely the superior trans-septal, despite the inherit risk of injury to the SA node artery.

In our study, we did not investigate temporary postoperative dysrhythmias; whilst we had a robust prospective database of pacemaker implantation occurrence, there were no such prospective data in the case of transient arrhythmias. There was some documentation of postoperative rhythm complications, however, we were concerned about the risk of significant bias due to missing data and thus we elected not to study transient postoperative dysrhythmias; this is one of the limitations of our study. Nonetheless, based on our clinical observations, we noted that early postoperative junctional rhythm tended to occur more often with the superior trans-septal approach, which in most cases resolved within 1 week with a restoration of normal sinus rhythm.

This observation tallies up with the findings of our review whereby we concluded that the incidence of transient junctional rhythm was higher in the superior trans-septal approach.\(^4\) Progression from junctional to sinus rhythm in some cases of the superior trans-septal approach could be explained by a change of the site of the sinus impulse to a different region as described in the experimental study conducted by Sealy et al.,\(^11\) or by the fact that the SA node does not rely entirely on the SA node artery for blood supply as suggested by Guiraudon et al.\(^1\)

We acknowledge that our study is limited by its retrospective nature, and also, the sample size did not allow for full risk adjustment, which is a major limitation.

5 | CONCLUSIONS

In summary, we found no significant difference in the rate of PPM between the three atrial incisions. The origin of the SA node artery...
did not influence the rate of pacemaker implantation. It is the surgeon’s choice to decide on the type of atrial incision to access the mitral valve.

AUTHOR CONTRIBUTIONS

AB contributed in concept/design, data collection, data analysis/interpretation, drafting article, critical revision of article, approval of article, and statistics. DN performed data collection, article drafting, critical revision of article, and approval of article. AS contributed in concept/design, critical revision of article, and approval of article.

ORCID

Anas Boulemden http://orcid.org/0000-0003-1728-2772

REFERENCES

1. Guiraudon GM, Ofiesh JG, Kaushik R. Extended vertical transatrial septal approach to the mitral valve. Ann Thorac Surg. 1991;52:1058-1062.
2. Boulemden A, Nadarajah D, Szafranek A, Richens D. Atrial approaches to the mitral valve: is there a difference in postoperative rhythm disturbance and permanent pacemaker implantation? Interact Cardiovasc Thorac Surg. 2018;27:536-542. https://doi.org/10.1093/icvts/ivy111
3. Berdajs D, Patonay L, Turina Ml. The clinical anatomy of the sinus node artery. Ann Thorac Surg. 2003;76:732-736.
4. Gregoratos G, Cheitlin MD, Conill A, et al. ACC/AHA guidelines for implantation of cardiac pacemakers and antiarrhythmia devices. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Pacemaker Implantation). J Am Coll Cardiol. 1998;31(5):1175-1209. Apr
5. Authors/Task Force Members, Vahanian A, Alfieri O, et al. Guidelines on the management of valvular heart disease (version 2012): The Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J. 2012;33(Issue 19):2451-2496. 1 October. https://doi.org/10.1093/eurheartj/ehs109
6. Lukac P, Hjortdal VE, Pedersen AK, Mortensen PT, Jensen HK, Hansen PS. Superior transseptal approach to mitral valve is associated with a higher need for pacemaker implantation than the left atrial approach. Ann Thorac Surg. 2007;83:77-82.
7. García-Villarreal O, González-Oviedo R, Rodríguez-Gonzalez H, Martínez-Chapa HD. Superior septal approach for mitral valve surgery: a word of caution. Eur J Cardiothorac Surg. 2003;24:862-867.
8. Masiello P, Triumbari F, Leone R, Itri F, Del Negro G, Di Benedetto G. Extended vertical transseptal approach versus conventional left atriotomy for mitral valve surgery. J Heart Valve Dis. 1999;8:440-444.
9. Gaudino M, Alessandri F, Glièca F, et al. Conventional left atrial versus superior septal approach for mitral valve replacement. Ann Thorac Surg. 1997;63:1123-1127.
10. Vikse J, Henry BM, Roy J, et al. Anatomical variations in the sinoatrial nodal artery: a meta-analysis and clinical considerations. PLoS One. 2016;11(2):e0148331. https://doi.org/10.1371/journal.pone.0148331
11. Sealy WC, Bache RJ, Seaber AV, Bhattacharga SK. The atrial pacemaking site after surgical exclusion of the sinoatrial node. J Thoracic Cardiovasc Surg. 1973;65(6):841-850. Jun

How to cite this article: Boulemden A, Nadarajah D, Szafranek AA, Richens D. Permanent pacemaker insertion postmitral surgery: Do the atrial access and the origin of the sinoatrial node artery matter? J Card Surg. 2019;34:563-569. https://doi.org/10.1111/jocs.14074