Superior septal approach for mitral valve surgery: a word of caution

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Abstract

Objective: Superior septal approach provides excellent exposure of the mitral valve and the subvalvular structures. The unavoidable section of the sinus node artery is in relationship with this technique. We have studied the electrical changes associated after using this approach.

Material and Methods: We studied 247 cases of mitral valve surgery from 1996 to 2003. The patient population was divided into two comparative groups: group I (128 cases) was represented by the superior septal approach and group II (119 cases) composed the conventional right lateral approach through the left atrium. Preoperatively, 48 patients (37.5%) in group I and 46 (38.6%) in group II were in a normal sinus rhythm. Mean follow-up was 30.7 months in group I and 33.5 months in group II. Results: There was no mortality in group I and eight cases (6.7%) in group II. A high incidence of changes as junctional rhythm was observed in group I, especially after weaning of cardiopulmonary bypass and on the first day after surgery (P > 0.001). Postoperative P–R interval of the patients in sinus rhythm was 100 ± 30 ms in group I and 148 ± 24 ms in group II (P > 0.05). P–R interval in group I was shorter than normal. P-wave morphology changed becoming inverted in leads II, III and aVF after surgery in these cases in group I. A full recuperation in P–R interval and the P-wave axis was seen in 52 cases (87.5%) in patients in group I after the third postoperative month. A definitive pacemaker implantation was need in two cases (1.5%) in group I and in six (5%) in group II (P > 0.05). Conclusions: A superior septal approach is directly related with the loss of normal sinus rhythm because of the section of the sinus node artery. After a brief period of transient electrical changes, a new low atrial or coronary sinus rhythm slower than normal sinus rhythm appears. In consequence, a word of caution must be strongly considered in patients critically dependent on normal sinus rhythm, despite the low incidence of definitive electrical changes. Normal sinus rhythm appears again after the third postoperative month.

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1. Introduction

First described by Berreklouw [1] and Guiraudon [2], superior septal approach (SSA) provides an excellent operative visualization for mitral leaflets and subvalvular structures. This is a crucial aspect for mitral valve (MV) reconstruction or replacement, especially when left atrium (LA) is small. The need of transecting the sinus node artery becomes a theoretical ‘hazard and potential’ complication because of the lack of normal sinus rhythm (SR). We report herein our experience using the SSA for MV surgery in 128 cases.

2. Material and methods

From March 1996 to January 2003, we operated on 247 cases of MV disease. We divided this population into two groups: 128 cases operated by means of SSA (group I), and 119 cases using the conventional right lateral approach through LA (group II). All cases of the SSA group were operated on by one of us (OAGV). In our series, the type of mitral lesions are very similar in both groups. In group I (SSA) 18 cases (14%) were stenosis, 44 (34.4%) mixed stenosis and regurgitation, 51 (40%) regurgitation, 10 (7.8%) infective, and five (3.8%) prosthetic malfunction. In group II (conventional approach) 13 cases (10.9%) were stenosis, 67 (56.3%) mixed stenosis and regurgitation, 30 (25.2%) regurgitation, and nine (7.5%) reoperations for rheumatic recidivant mixed mitral lesions. With regard to
the MV etiology, in group I (SSA) 62 cases (48.4%) were rheumatic, 12 (9.4%) ischemic, 12 (9.4%) myxomatous, 27 (21%) degenerative, 10 (7.8%) infective, and five (3.8%) by prosthetic malfunction. In group II (conventional approach) 89 cases (74.8%) were rheumatic, three (2.6%) ischemic, seven (5.8%) myxomatous, and 20 (16.8%) degenerative. The rest of the preoperative characteristics in both groups are shown in Table 1.

### 2.1. Surgical technique

All cases were operated by median sternotomy with cardiopulmonary bypass to 28°C, and cold, hyperkalemic, intermittent, retrograde cardioplegic solution was delivered through the coronary sinus.

In group I, for SSA, conventional cannulation in ascending aorta and inferior vena cava were employed. Superior vena cava was cannulated by means of a right angled cannula, then enough space and free mobilization of this vena cava were obtained. The aorta was cross-clamped and the right atrium was opened longitudinally 1–2 cm from the atrioventricular groove. This incision was extended superiorly, medial to the right atrial appendage (Fig. 1). A second vertical incision was performed on the atrial septum beginning at the fossa ovalis and extended into the superior dome of the LA. At the point where the two incisions met, the roof of the LA was opened 4–5 cm underneath the ascending aorta (Fig. 2). MV exposure was achieved by gentle traction with a simple vein retractor (Fig. 3). Closure of atrial incisions was made starting from the more distant point on the LA roof and finishing just at the lower angle at the fossa ovalis. Then, right atrial incision was closed from the superior trabeculated portion to the inferior extreme near to the inferior vena cava. After this, the aortic cross-clamp was removed. All incisions were closed with 3-0 polypropylene running suture.

In group II, a traditional left atrial incision was made in front of right pulmonary veins, just parallel to the interatrial sulcus. This one was closed with a 3/0 polypropylene running suture.

Surgical procedures performed in both groups are summarized in Table 2.

### 2.2. Follow-up

All patients underwent 12-lead electrocardiography and 24-h Holter monitoring on the first postoperative day, the day just before hospital discharge, and at third and sixth postoperative months. Mean follow-up was 30.7 months in

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**Table 1**

Preoperative characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I</th>
<th>Group II</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>55</td>
<td>26</td>
<td>0.03</td>
</tr>
<tr>
<td>Female</td>
<td>73</td>
<td>92</td>
<td>0.05</td>
</tr>
<tr>
<td>Mean age</td>
<td>48.5 ± 16.9</td>
<td>47.7 ± 13</td>
<td>NS</td>
</tr>
<tr>
<td>NYHA</td>
<td>2.9 ± 0.6</td>
<td>2.8 ± 0.6</td>
<td>NS</td>
</tr>
<tr>
<td>LVEF</td>
<td>0.52 ± 13</td>
<td>0.51 ± 9</td>
<td>NS</td>
</tr>
<tr>
<td>PSAP</td>
<td>46 ± 13.2</td>
<td>47.2 ± 12.6</td>
<td>NS</td>
</tr>
<tr>
<td>Left atrium</td>
<td>6.4 ± 1.7</td>
<td>6.1 ± 1.8</td>
<td>NS</td>
</tr>
<tr>
<td>NSR</td>
<td>48</td>
<td>46</td>
<td>NS</td>
</tr>
<tr>
<td>AF</td>
<td>78</td>
<td>70</td>
<td>NS</td>
</tr>
<tr>
<td>JR</td>
<td>2</td>
<td>4</td>
<td>NS</td>
</tr>
</tbody>
</table>

NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; PSAP, pulmonary systolic artery pressure; NSR, normal sinus rhythm; AF, atrial fibrillation; JR, junctional rhythm; NS, no statistically significant (P > 0.05).

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**Fig. 1.** In this transoperative image the right atrium is shown opened longitudinally from the trabeculated portion of the right atrial appendage, up very near and medially to the purse string of the inferior vena cava. IVC, inferior vena cava; SVC, superior vena cava; RA, right atrium; RV, right ventricle.

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**Fig. 2.** This picture shows the second step of the superior septal approach. Both incisions from the right atrium and from the intraatrial septum in the fossa ovaris are all joined together. The arrow indicates this point in the dome of the left atrium. LA, left atrium; RA, right atrium.
group I (range, 1–82 months) and 33.5 months in group II (range, 1–82 months).

2.3. Statistical analysis

Data are presented as mean ± standard deviation. Differences between groups were analyzed with Student’s t-test for independent samples. Contingency tables and $\chi^2$ were used for examination of categoric data. A $P$-value of less than 0.05 was considered to be of statistical significance.

3. Results

3.1. Mortality and morbidity

There was no mortality cases in group I. In group II there were five deaths because of left ventricular failure, and three cases of left ventricular rupture after MV replacement. The mortality in group II was 6.7% (8/119). Postoperative complications in both groups are enlisted in Table 3. Five patients were re-explored because of excessive postoperative chest bleeding (two in group I and three in group II, with no significant difference; $P > 0.05$). In no case was bleeding related to atrial incisions. Mean blood loss into the first 24 h after surgery was very similar in both groups (391 ± 168 ml, range 1100–1000 ml in group I; and 367 ± 180 ml, range to 100–1200 ml in group II; $P > 0.05$).

3.2. Cardiopulmonary bypass and aortic cross-clamping time

Cardiopulmonary bypass time and aortic cross-clamping time were a little bit longer in SSA than the other group (73.7 ± 24.9 min, range 40–150 min, and 57.7 ± 21 min, range 25–130 min in group I versus 64.2 ± 23.7 min, range 40–170 min, and 49.4 ± 20.1 min, range 25–150 min in group II, respectively). In both cases, there was no statistical difference ($P > 0.05$).

3.3. Cardiac rhythm

Preoperatively, 48 (37.5%) patients in group I and 46 (38.6%) in group II were in normal SR whereas 78 (60.9%) in group I and 70 (58.8%) in group II showed atrial fibrillation. No significant $P$-value was observed in any case ($P > 0.05$). An important elevation in the number of the cases in normal SR changing into junctional rhythm was noted in group I. These changes were found just after weaning from cardiopulmonary bypass and maintained during the first 24 h after surgery. However, there was a significant difference in both groups at the moment just after cardiopulmonary bypass weaning ($P > 0.001$). All patients with prior normal SR recovered the normal SR at hospital discharge, except five in group I and six in group II. Eight patients needed definitive pacemaker implantation, two (1.5%) in group I and six (5%) in group II with no statistical difference ($P = 12.3$). Patients with atrial fibrillation did not exhibit major changes in cardiac rhythm in both groups (Figs. 4 and 5).

Table 2

<table>
<thead>
<tr>
<th>Mitral valve procedure</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVRp</td>
<td>49</td>
<td>59</td>
</tr>
<tr>
<td>MVR</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>Combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVRp</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>MVR</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>

MVRp, mitral valve replacement; MVR, mitral valve repair.

Table 3

<table>
<thead>
<tr>
<th>Postoperative complication</th>
<th>Group I</th>
<th>Group II</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low cardiac output</td>
<td>3</td>
<td>5</td>
<td>NS</td>
</tr>
<tr>
<td>Reexploration for bleeding</td>
<td>2</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>Complete AV block</td>
<td>2</td>
<td>6</td>
<td>NS</td>
</tr>
<tr>
<td>Renal failure</td>
<td>1</td>
<td>2</td>
<td>NS</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>–</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Left ventricular rupture</td>
<td>–</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>after mitral valve replace</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>–</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>Amiodarone pulmonary toxicity</td>
<td>1</td>
<td>–</td>
<td>NS</td>
</tr>
<tr>
<td>Sternal dehiscence</td>
<td>3</td>
<td>2</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS, no statistically significant difference ($P > 0.05$).
3.4. Electrocardiographic changes

We found the following data in the 12-lead electrocardiography of these patients. Postoperative P–R interval of the patients in SR was $100 \pm 30$ ms in group I and $148 \pm 24$ ms in group II. No statistical significance was observed ($P > 0.05$). However, this P–R interval in group I was shorter than normal parameters (120–200 ms). In addition, P wave morphology changed becoming inverted in leads II, III and aVF in group I. Nevertheless, this change tended to disappear after the third postoperative month. In fact, a whole recuperation into normal parameters, both the P–R interval as well as P-wave axis, was seen in 86.7% (52/60) of the patients who experienced the previous changes described above.

3.5. Follow-up

At a late follow-up only two patients who were prior to surgery in normal SR changed to junctional rhythm in group I, and five in group II with no statistical difference ($P > 0.05$). Twelve (15.4%) patients in group I and 10 (14.3%) in group II with preoperative atrial fibrillation became in normal SR. There was no statistical difference ($P > 0.05$).

4. Discussion

Optimal exposure of the MV and the subvalvular apparatus plays a key role in the successful outcome of MV surgery. Exposure of the MV can be particularly difficult especially in the case of a small LA. Several approaches for MV operations have been described [3–5].

The technique described by Selle [5] transecting totally the superior vena cava certainly gives an excellent exposure of the mitral valve. The conventional left atriotomy can be extended toward the dome of the left atrium and behind the superior vena cava as well as toward the inferior vena cava. Sinus node artery is avoided by means of this technique. However, anticipated problems related with the section and reanastomosis of the superior vena cava may be present. Feeble thin tissue of the superior vena cava and potential unexpected torsion at the time of the anastomosis are situations that should not be underestimated.

SSA, described by Berreklouw [1] and Guiraudon [2], invariably provides an in-depth undistorted exposure of the complete anatomy with no forceful retraction of the LA necessary. Another fundamental matter, such as the lack of the surgeon’s vision toward the MV by bulging the atrial septum, is avoided by SSA. This approach combines the advantages of both superior approach and transseptal approach of the LA for MV surgery. Since all the atrial incisions with this technique are performed medial to the superior vena cava, this one lies on the right side as all the right ventricle and the rest of the right atrium do on the left side. Thus, a little and gentle traction with stay sutures or some vein retractor are enough to achieve an adequate MV exposure.

Certainly, the closure of these incisions in the SSA is more difficult than the conventional approach. Nevertheless, it takes a little more time, but the exposure of the MV is really beautiful. With the practice and the use of pledgets in the suture at the extreme of the incisions, the risk of bleeding becomes small.

In fact, the three cases of left ventricular rupture were present in group II (conventional approach). All of them were type I (at the level of the left atrio-ventricular sulcus). One case was mitral stenosis, and the other two were mixed mitral lesions. All the cases were treated by MV replacement with mechanical devices. Presumably, one can suppose that all these cases were the result of a deficient exposure and visualization of the MV in a small left atrium, with a great forceful of the same while resecting it and implanting the new prosthesis. This condition was absent in all cases of SSA.

Nevertheless, the great concern related to the unavoidable division of the sinus node artery and its further consequences on the cardiac rhythm still remains...
controversial. Berreklouw [1], Guiraudon [2], Alfieri [6], Kon [7] and Gaudino [8] suggest that no major postoperative rhythm disturbances are assessed in cases of SSA for MV operation. On the other hand, Kovacs [9], Smith [10], Kusar [11] and Masiello [12] emphasized the fact that a high incidence of postoperative rhythm disturbance may be present after the same approach. Transient changes in cardiac rhythm include prolonged PR interval [13], variations in P-wave axis and morphology [10], junctional rhythm, atrioventricular block, atrial flutter and atrial fibrillation [14].

The exact role of the sinus node ischemia and its impact on cardiac rhythm is not absolutely understood yet. Actually, we know that once the sinus node artery is totally sectioned, a period of instability, termed ‘atrial chaos’ by Smith [15], is generally observed during 1–2 weeks. Then, a regular atrial rhythm usually develops at a slower rate, with no clinical impact over most of the patients.

The major concern is about how this new cardiac rhythm can be restored. Several explanations have been given over the years. Collateral blood supply on the sinus node area, starting just 2 weeks after surgery, has been stated by Misawa [13]. However, a more convincing idea has been enunciated by Sealy [14]. According to this concept, the lack of normal SR as a result of the division of the sinus node artery provokes the genesis of a new atrial rhythm on the coronary sinus area with little if any change in electrocardiogram, which is almost undistinguishable from normal SR. This electrical impulse would travel up the posterior internodal tract to the right atrial appendage and up the anterior tract of Bachman’s bundle to the left atrial appendage. The development of stability could be an adjustment, inherent to the pacemaking cells, which appears to render the low atrial area predominant as well as a reliable pacemaker.

Smith [10] found a loss of normal SR as well as changes in P-wave morphology with abnormal P-wave axis in two of three cases underwent SSA with preoperatively normal SR. These same changes were seen in our group I in the early postoperative period and maintained until the third month after surgery.

All this suggests that superior septal approach might be directly related to the loss of normal SR because of the section of the sinus node artery. So, after a brief period of transient electrical changes, a new coronary sinus rhythm or low atrial rhythm, clinically undistinguishable from normal sinus rhythm, can take place in these patients. This new rhythm tends to be slower than normal SR. As a consequence, caution must be advised in patients critically dependent on normal sinus rhythm, despite the low incidence of definitive electrical changes in the conduction system or the need of definitive pacemaker implantation after SSA in this pool of patients.

None of the patients underwent anything other than 24-h ECG-Holter recording study. The heart rate of the patients in sinus rhythm after surgery was slower than normal (55–85 beats per minute) during the day. So, this parameter is maintained even in the third month, with the patient’s lifestyle being without clinical repercussions. Maybe more specific electrophysiological tests should be done in this pool of patients, however, the P-wave morphology in the ECC changed to inverted in leads DII, DIII and aVF as well as the shorter PR interval in these cases seems to be oriented to a new coronary sinus atrial rhythm working as a new atrial pacemaker after the ‘unavoidable’ division of the sinus node artery with this surgical approach.

The transport function of the left atrium studied by transmitral flow on ECHO Doppler was not considered in this paper. This is part of a second phase of our study.

We should emphasize the fact that the superior septal approach should be reserved for those cases in which a difficult and complicated MV visualization is expected. The small left atria in ischemic coronary disease with acute MV regurgitation is a particular situation that can be approached by this technique. However, special attention must be paid in the first three postoperative months, because the most of these patients depend critically of the normal sinus rhythm.

In other words, despite the ECHO study, it is necessary to evaluate the transport function of the left atrium after this approach, this approach should be reserved for special circumstances like small, non-dilated left atrium, and acute ischemic conditions of the MV. Other less important and relative indications would be the redo MV operations. The usefulness of this approach avoids the need to transect the adhesions between pericardium and epicardium at the level of the left ventricle, with the aim of MV visualization.

References


