Clinical Research

A Comparison of Lead Placement Through the Subclavian Vein Technique With Fluoroscopy-Guided Axillary Vein Technique for Permanent Pacemaker Insertion


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ABSTRACT

Background: The intrathoracic subclavian venous technique for pacemaker implantation may be associated with serious complications. We describe an alternative technique for obtaining venous access for pacemaker implantation through axillary vein under fluoroscopic guidance and compare it with the conventional, subclavian approach.

Methods: We conducted a single-centre, prospective, nonrandomized study. All adult patients with indication for permanent pacing who consented were recruited during a 3-year period. To access the axillary vein, we used the alternative technique with a new fluoroscopic landmark. The subclavian access was obtained as per the usual approach.

Results: We studied 478 lead placements during 3 years; 315 lead placements through axillary venous technique (group 1) were compared with 163 lead placements through subclavian venous technique (group 2). Both routes had a high and comparable success rate, 98.09% in group 1 and 96.93% in group 2. The axillary approach was successful at the first attempt in 194 punctures (61.6%), as vs 60 in group 2 (36.8%) \( P < 0.0001 \). The average number of attempts in group 1 was 2.06 per patient and 2.56 in group 2 (\( P < 0.001 \)). There were 3 (2.94%) pneumothoraxes in group 2 and none in group 1.

During a mean follow-up period of 3.2 months in group 1 and 3.7 months in group 2, 1 patient in group 2 had a lead fracture.

Obtaining venous access for lead placement can sometimes be a major stumbling block in the implantation of permanent pacemakers and implantable defibrillators. Multiple venous access techniques have been proposed by various operators, the most frequently used being anatomically guided intrathoracic subclavian vein (ISV) puncture technique introduced by Littleford in 1979. Though it is relatively easy to learn, it may be associated with some serious complications, including pneumothorax, hemopneumothorax, brachial plexus injury, subclavian crush syndrome, lead fracture, and loss of lead insulation. Alternative techniques of venous access include the cephalic venous approach, which is safe but has a failure rate of 15% to 45%. The contrast venography–guided extrathoracic subclavian approach, which is effective in more than 90% of patients, has the drawback of needing contrast medium use and requires patent ipsilateral forearm veins. Anatomically guided extrathoracic subclavian puncture, as originally described for the intrathoracic approach, may provide a safer and more reliable alternative method of access.
fluoroscopically guided axillary venous approach for implanting permanent pacemakers is equivalent to the traditional anatomic landmark–guided intrathoracic subclavian approach and has fewer complications and shorter procedural time to access the vein.

Methods

Consecutive patients undergoing pacemaker implantation at the Department of Cardiology, All India Institute of Medical Sciences, New Delhi, India, were prospectively subjected to fluoroscopically guided, axillary venous puncture (group 1) or anatomically guided ISV (group 2) puncture for lead implantation. The choice of approach in a given patient was operator dependent. Informed written consent was obtained from all participants. The study was approved by the institute ethics committee. Consecutive patients aged 18 years or older undergoing permanent pacemaker implantation for any indication were potentially eligible participants. Patients undergoing lead replacement and those unable to provide informed consent were excluded from the study.

Technique of venous puncture

An incision was made in the deltopectoral groove, below which a pacemaker pocket was created. The point of entry of the puncture needle is the point where the second rib meets the thoracic cage in the fluoroscopic image of the chest (Fig. 1, A and B) with the patient’s hand resting by the side of the thorax and the head turned 45° to the contralateral side. The needle is pointed and subsequently advanced toward the area of interest, which is the intersection between the outer border of the first rib and the clavicle. An angle of about 60° (depending on the body habitus) between the needle and the horizontal plane was maintained while the needle was being introduced. In case the vein is not entered in the first attempt, a medial trajectory is taken. Care is taken to avoid going medial to the outer border of the first rib (Fig. 1, A and C). A maximum of 5 attempts were allowed per patient as part of the study protocol, and it was strictly followed in all the patients. If venous access could not be obtained after a maximum of 5 attempts, the operator could opt to change to another approach, of the operator’s choice; attempt access from the contralateral side; or perform a contrast-guided venipuncture. This course was considered a failed attempt with the technique used. While defining the landmark of axillary vein fluoroscopically, an initial 10 venipunctures were done with the help of a guidewire introduced into the subclavian vein through the ipsilateral brachial vein. Patients whose venipunctures were done during the first 3 months after introduction of the new fluoroscopic landmark were not part of the study. ISV was punctured with the help of conventional anatomic landmarks, as described by Littleford et al. The number of attempts needed and the time taken to obtain venous access were observed in all patients. In addition, complications while obtaining venous access and any complication during the index hospitalization deemed to be due to the venous access were noted. We classified the complications related to the procedure into acute and chronic. Acute complications included pneumothorax, hemopneumothorax, and hematoma that required surgical interventions. Chronic complications included crush injury to the lead, shoulder pain, and any residual complications related to the acute complications. All the procedures were done by experienced operators in this field. All participants were followed up in a dedicated arrhythmia and devices clinic a week after the procedure and at 3-month intervals later.

Statistical analysis

The Wilcoxon rank sum test was used to compare the differences between the 2 groups at baseline and after intervention. A $P$ value $< 0.05$ was considered to be significant. All analysis was done on STATA (version 9.2; College Station, TX).

Results

A total of 300 patients were enrolled into the study. In group 1, 315 lead placements were attempted in 202 patients (some of the patients had more than 1 lead placed as they were undergoing implantation of dual-chamber pacemakers), and 163 lead placements were attempted in 98 patients in group 2. There were significantly more men in group 2 (73.5% vs 63.86% in group 1). The age distributions of the patients were comparable in both groups (Table 1).

Axillary venous puncture was successful in 309 out of the 315 lead implantations attempted (98.09%), as compared with the subclavian approach, which was successful in 158 out of 163 lead implantations (96.93%; $P$ = NS for axillary vs subclavian approach). In 194 cases, axillary venous access could be obtained in a single attempt (61.6%), as vs 60 cases in group 2 (36.8%; $P < 0.0001$). The average number of attempts in group 1 was 2.06 per patient, compared with 2.56 in group 2 ($P < 0.001$). The average time taken to obtain a venous access was 81.4 seconds in group 1, compared with 142.53 seconds in group 2 ($P < 0.001$; Table 1). The average time to obtain a venous access among patients in whom it was obtained at the first attempt was not significantly different between the 2...
Among the 6 patients in group 1 in whom axillary venous puncture was unsuccessful, 1 patient had significant kyphoscoliosis, which had distorted the relationship of the vein to the bony landmarks. Lead placement in this patient was finally done with the help of a contrast-guided subclavian puncture. Contrast injection into the ipsilateral brachial vein in another one of the failed axillary approaches showed thrombosis up to the cephalic vein. This patient subsequently had a successful contralateral fluoroscopically guided axillary venous puncture. There was no such discernible cause for failure in the remaining 4 patients; 2 of them had the leads successfully implanted through the ipsilateral, anatomically guided subclavian approach; in another, contrast venography-guided puncture of the same axillary vein was successful; in the sixth patient, who received a dual chamber rate-adaptive (DDDR) pacemaker, and in whom 1 axillary puncture was successfully obtained, both venous and atrial leads were introduced through the same venous access. One of the patients who had an unsuccessful anatomically guided subclavian access had a successful contrast venography–guided subclavian access through the same vein; the rest had successful contralateral anatomically guided subclavian access.

We did not encounter any hemopneumothorax. There was no significant difference in major hematomas between the 2 groups (Table 1). Three patients (2.94%) in group 2 had pneumothorax. Two of the 3 did not require any intervention, while 1 required insertion of a chest tube for the pneumothorax. No patient in group 1 had this complication.

During a mean follow-up period of 3.2 months in group 1 and 3.7 months in group 2, 1 patient in group 2 had a lead fracture at the level of the thoracic inlet. The lead was replaced, this time through an axillary approach. One patient in group 2 had asymptomatic atrial lead dislodgement at 1 month follow-up. Two patients in group 1 had ventricular lead dislodgements, 1 of which was a symptomatic microdislodgement detected at 2 weeks and the other, an asymptomatic microdisplacement detected at a routine interrogation 1 month after implantation. These were adjudicated to be unrelated to the technique of venous approach. All the 3 leads were reim-

Figure 1. (A) Anatomic relation of the venous and arterial system of the upper limb in relation to first rib and clavicle. It also shows the directions of progressive medial insertion to get axillary venipuncture. (B) Contrast venogram demonstrating normal anatomy of the veins in relation to the bony landmarks. (C) Fluoroscopically guided axillary vein puncture showing the point of entry into the vein at the junction of the outer borders of the clavicle and the first rib.

### Table 1. Characteristics and outcomes of the 2 groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1: axillary approach</th>
<th>Group 2: subclavian approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>202</td>
<td>98</td>
</tr>
<tr>
<td>No. of leads</td>
<td>315</td>
<td>163</td>
</tr>
<tr>
<td>No. of men (%)</td>
<td>129 (63.86%)</td>
<td>75 (73.55%)*</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>58</td>
<td>62‡</td>
</tr>
<tr>
<td>Age range (years)</td>
<td>18-85</td>
<td>18-85</td>
</tr>
<tr>
<td>Mean time to access (seconds)</td>
<td>81.40</td>
<td>142.53</td>
</tr>
<tr>
<td>Mean attempts to obtain access</td>
<td>2.06</td>
<td>2.56†</td>
</tr>
<tr>
<td>No. of accesses obtained at first attempt (%)</td>
<td>194 (61.6%)</td>
<td>60 (36.8%)§</td>
</tr>
<tr>
<td>Major hematoma</td>
<td>9</td>
<td>4*</td>
</tr>
<tr>
<td>No. of pneumothoraxes (%)</td>
<td>0 (%)</td>
<td>3.06 (3.06%)</td>
</tr>
</tbody>
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* P = 0.01.
† P = not significant.
‡ P < 0.001.
§ P < 0.0001.
planted. Barring these 4 patients, there were no significant differences in lead impedance, pacing, or sensing parameters between the 2 groups.

**Discussion**

We found that the alternative fluoroscopically guided axillary venous approach for implanting permanent pacemakers is equivalent to the traditional anatomic landmark–guided intrathoracic subclavian approach, with fewer complications and shorter procedural time to access the vein. The intrathoracic subclavian venous puncture technique has been compared previously with the extrathoracic subclavian venous puncture or with cephalic venous puncture techniques, while the axillary venous puncture has been compared with the cephalic venous puncture technique. However, a prospectively conducted comparison of the fluoroscopically guided axillary venous technique and the subclavian technique has not been reported previously. In this study, we not only evaluated the role of a new fluoroscopic axillary venous puncture technique, but also prospectively compared it with the conventional intrathoracic subclavian technique for implantation of ventricular leads in permanent pacing.

An axillary puncture is usually attempted with the use of anatomic landmarks alone or with a contrast injection technique whereby contrast is injected into the ipsilateral upper limb veins to visualize the axillary vein. The former technique is perceived to be relatively difficult and is associated with more chances of complications, while the latter has all the disadvantages related to contrast solution, including life-threatening anaphylaxis.

Byrd described the safer extrathoracic subclavian venous technique in 1992. In his technique, the needle is held perpendicularly on the medial edge of the first rib, then it is walked laterally and posterior on the rib till the vein is punctured. In our technique, the point of entry is the point where the second rib meets the thoracic cage in the fluoroscopic image of the chest and hence is different from the one described by Byrd. The needle is subsequently directed toward the area of interest, which is the intersection between the outer border of the first rib and the clavicle. In the recent past, Burri et al. described 61% success with a fluoroscopically guided method of axillary vein puncture, and 97% when contrast venography was used in failed cases. Their technique was to puncture the pectoral muscle at the intersection of the inferior border of the second rib and the superior border of the third rib at the rib cage margin, with subsequent advancement of the needle pointing toward the head of the patient.

The success rates of venous access techniques are usually described to be between 93% and 95%. Burri et al. reported a 97% success rate for axillary vein puncture, and Calkins et al. reported a success rate of 99% for extrathoracic subclavian puncture. However, both these were contrast-guided techniques. In our study, it was found that the approaches have very high and comparable success rates. The described technique is noteworthy because it avoids the need for contrast injection, and because of its low complication rate, with shorter procedural time, compared with the subclavian approach. The only other noncontrast-guided extrathoracic subclavian puncture described with a similar success rate is the anatomically guided technique of Magney et al. Although some authors have reported a steep learning curve for this technique, Kar et al., in a study of 102 patients, reported a > 90% success rate and no pneumothorax, hemopneumothorax, or brachial plexus injury with this technique, which would make this technique comparable with our technique. In the presence of distorted bony landmarks, as seen in 1 of our patients, one needs to exercise extra caution before using this technique.

The anatomic basis for the safety of axillary vein puncture has been reviewed recently in detail. Since we are confining the needle to the outer border of the first rib, our technique carries very low risk of injuring the brachial plexus nerves or pleura. Moreover, there is no requirement of marching the needle over the rib, which can be painful. Despite a short follow-up period, in our study, of 3 to 4 months, lead fracture due to the subclavian crush syndrome occurred in 1 of our patients in the subclavian approach group, whereas none was reported in axillary group. Similarly, there was a 2.94% incidence of pneumothorax for the subclavian approach and none for the axillary approach, which is explainable by the anatomic position of the axillary vein.

**Conclusion**

In the light of the equivalent success rate and the shorter procedure time, with few complications, it is proposed that a fluoroscopically guided axillary venous approach to implanting permanent pacemakers may be superior to the traditional, anatomic landmark–guided intrathoracic subclavian approach.

**Limitations**

The study is a nonrandomized, single-centre study that looked at early complications only. Absence of long-term follow-up is one of the limitations of the study. A randomized study with a long-term follow-up is required. The choice of technique was left to the discretion of the operator, and therefore bias cannot be ruled out.

**Disclosures**

The authors have no conflicts of interest to disclose.

**References**


