



## CLINICAL REVIEW

# Axillary vein access using ultrasound guidance, Venography or Cephalic Cutdown—What is the optimal access technique for insertion of pacing leads?

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**Abstract**

We reviewed the different approaches used for central vein access during insertion of cardiac implantable electronic devices. The benefits and hazards of each approach (cephalic vein cutdown, axillary vein cannulation using venography and ultrasound) are discussed. Each approach has its advantages and hazards that need to be considered for the individual patient and balanced against the skills of the operator. The benefits of ultrasound guided venous access in reducing radiation exposure to the patient and implanter, avoiding the need for angiographic contrast and in minimizing the risk of pneumothorax and inadvertent arterial puncture are highlighted. Trainees should be taught each approach to deal with patient variability. Ultrasound guidance should be considered as a mainstream option for most patients.

**KEYWORDS**

axillary vein, pacemaker, ultrasound guidance

Cardiac Implantable Electronic Device implantation is associated with a small risk for pocket hematoma partially due to inadvertent axillary/subclavian artery puncture, pneumothorax and infection and more rarely thoracic duct injury and brachial plexus injury and in the long term lead fracture.<sup>1</sup> The traditional anatomic based approach for subclavian vein puncture is particularly associated with an increased risk.<sup>2,3</sup> These risks could be reduced by accessing the axillary vein and not the subclavian vein using a venogram based approach,<sup>4-7</sup> or by an ultrasound based approach for lead insertion<sup>4,6-8</sup> or cephalic vein cut down.<sup>4-7</sup> Most implanters prefer cephalic cutdown as their initial approach.<sup>9</sup> We argue that an ultrasound guided axillary vein approach also should be considered for all such procedures.

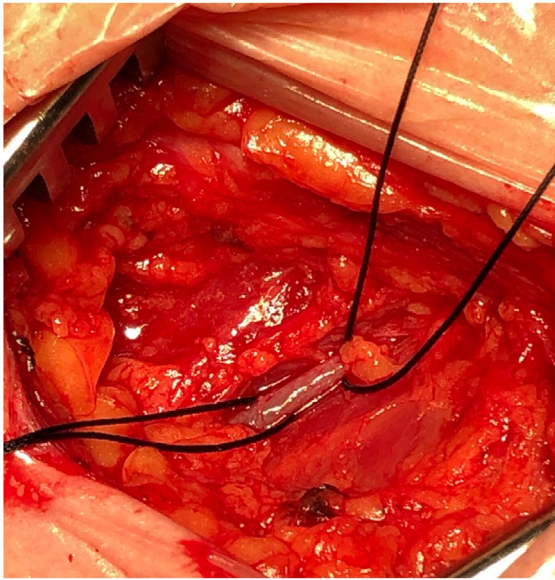
## 1 | CEPHALIC VEIN CUTDOWN

Cephalic cutdown has been suggested to be the preferred venous access to reduce the risk for lead crush and to avoid needle stick injury to surrounding structures.<sup>10</sup> However it is only suitable for some patients<sup>11</sup> due to small vein size, tortuosity, difficulty surgically isolating the vein and in some cases vein absence.<sup>10</sup> It is approached with surgical dissection of the deltopectoral groove, the vein lying between the pectoralis major and deltoid muscles (Figure 1). The vein is bluntly dissected free from the surrounding structures and cannulated either with an intravenous (IV) cannula and glidewire or venotomy, a vein pick and then passage of a wire or lead down the vein lumen. In some cases, venography also is

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used to direct passage of the wire if the vessel is tortuous.<sup>10</sup> It is limited in the number and size of leads that can be introduced and has a lower success rate than the alternate approaches.<sup>1</sup> In skilled hands a single pacing lead was able to be introduced with this technique in 64%–91% of cases.<sup>10,11</sup> The vein is ligated distally and ultimately proximal to the venotomy site during which there is potential for tearing of the vein and difficulties with hemostasis and long-term damage to leads. Despite these considerations, some authors have passed multiple leads through the same puncture/venotomy site.<sup>12,13</sup>



**FIGURE 1** Cephalic vein cutdown. The vein has been dissected from the surrounding fascia between the pectoralis major on the left of the photo and the deltoid muscle on the right of the photo. Surgical silk ties mark the vein and have been positioned to be able to ligate the vein proximally and distally to the planned puncture site

## 2 | VENOGRAPHY FOR AXILLARY VEIN CANNULATION

Venography is often used with X-ray guidance for needle puncture either in a posterior-anterior or caudal view with good results.<sup>14</sup> Axillary vein cannulation usually is obtained after either a subclavicular<sup>15</sup> or deltopectoral<sup>16</sup> skin incision. Blind puncture guided by anatomic landmarks under fluoroscopy has been used but in about 7% of these cases venography has ultimately been required.<sup>17</sup> The needle is walked along the outer edge of the first rib immediately inferior to the clavicle.<sup>18</sup> Even early in some operators' experience fluoroscopic guided axillary vein cannulation has an approximately 50% shorter venous access time (5.7 minutes) and 30% shorter total procedural time (34 minutes) compared to a cephalic cutdown.<sup>19</sup> Fluoroscopic guided blind puncture carries a risk for axillary artery puncture compared to an imaging-based approach.<sup>17</sup> Venography (Figure 2) has the advantage of confirming vein patency in those that have had previous procedures and demonstrating variations in anatomy. However, it suffers from the need to use IV contrast and radiation. Contrast is only transiently present in the vein which then is often radiolucent by the time of a second venipuncture. A microwire introduced from the antecubital vein can be used as an alternate fluoroscopic landmark.<sup>4</sup> Depending on the X-ray angle there is also a persisting but low risk for pneumothorax. Usually, the operator aims for the first or second ribs and can use a caudal view to ensure the needle trajectory is extrathoracic. Contrast usage has a risk of anaphylaxis that although rare can be fatal and may be nephrotoxic depending on the dose used. For this reason, it is preferable to avoid contrast use in those with severe renal impairment. The operator is exposed to radiation and suffers a cumulative 'small' lifetime risk from radiation exposure. This is difficult to mitigate against even with shielded gloves, barium impregnated drapes and other equipment.



**FIGURE 2** Venogram of the axillary vein. The needle can be seen indenting and puncturing the vein lateral to the first rib and inferior to the clavicle

### 3 | ULTRASOUND GUIDANCE FOR AXILLARY VEIN CANNULATION

Ultrasound guidance does not involve irradiation of the operator nor the patient, allows imaging of the needle in space showing the surrounding structures to avoid and thus in skilled hands is associated with a low risk for arterial perforation and pneumothorax.<sup>20,21</sup> It has become a guideline approach for insertion of internal jugular lines and in France for axillary vein cannulation in the anesthetic literature.<sup>2,3</sup> Cardiologists surprisingly seem slow to adopt this despite its initial report in 2013.<sup>22</sup>

### 4 | IS ULTRASOUND GUIDANCE DIFFICULT?

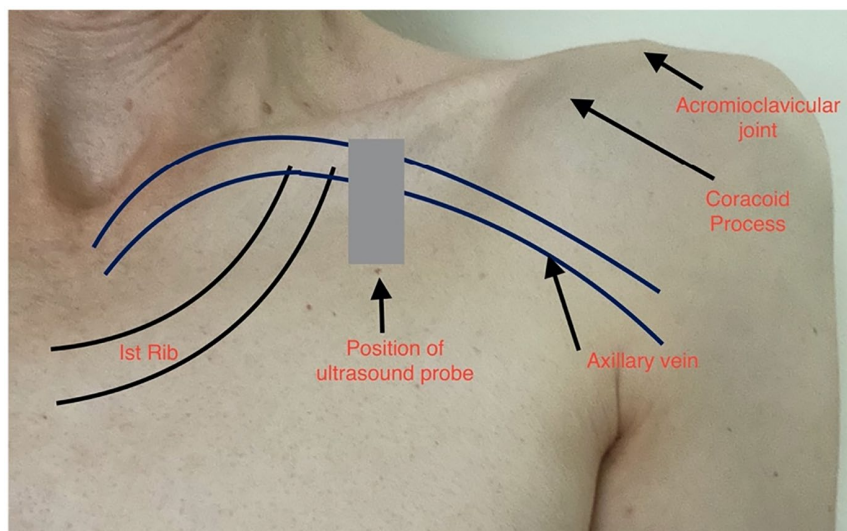
Some operators argue that ultrasound guidance is difficult and only possible in some patients. This is not the case.<sup>23,24</sup> Ultrasound guidance is easily learnt and works in almost every patient.<sup>8,20,25</sup> There are multiple videos on the internet to demonstrate appropriate techniques and pitfalls.<sup>26</sup> A mannikin model for learning has been developed<sup>27</sup> but where not available initial practice on accessing the femoral vein could help to provide a low risk path to safely using this technique.

Our technique is to prepare the patient's skin and operative draping as per usual. We prefer that the patient is well hydrated and that they have an IV line in the arm on the side of the implant in case venography is needed though this is rarely used. Relative dehydration and low venous pressure can markedly reduce the size of the axillary vein. The ultrasound probe is covered with a long sterile cover. Some operators image the vein and then cannulate this under ultrasound guidance and then dissect down from the skin to the vein. In our case, we image the course of the axillary vein before skin incision. Usually this is only possible inferior to the clavicle (Figures 3 and 4). Abduction of the arm potentially can facilitate axillary vein imaging and provide more extended access sites to that provided in

the traditional adducted position.<sup>28</sup> An incision is then made in the deltopectoral groove or a little lateral to this to permit puncture of the axillary vein under ultrasound guidance. We dissect down to the fascia and create a pocket superficial to the pectoral fascia. Care is taken to avoid disturbing the tissue near the vein when injecting local anesthetic and when creating the pocket. If air enters the tissue planes ultrasonographic images will be substantially degraded. We place the needle into the edge of the pectoral muscle and then image the vein and needle tip with the probe placed over the overlying skin. Care must be taken to avoid too much pressure over the vein so that it is not squashed. The needle tip needs to be followed or visualized from the muscle entry site all the way during its passage to the axillary vein (Figures 4 and 5). This generally needs the needle to enter at about 45-60° and the probe angulated to obtain adequate reflection off the needle tip. An echogenic needle can be used to enhance visualization of the needle tip though this is not mandatory. A longitudinal view also can be used. The needle can be seen to indent and then perforate the vein wall. Care needs to be taken to stop at this point to prevent passage of the needle beyond the vein into the pleura or other structures. The ultrasound can be used to confirm passage of the introducer wire into the vein and the absence of a pneumothorax both at this point and after completing the procedure. Although this technique has been almost always successful in our hands others have described this to be less successful in patients with larger BMIs.<sup>29</sup> The ultrasound is superior to X-ray for detecting a pneumothorax particularly with the patient recumbent. We would argue that ultrasonography done after the procedure could obviate the need for a postoperative chest X-ray.

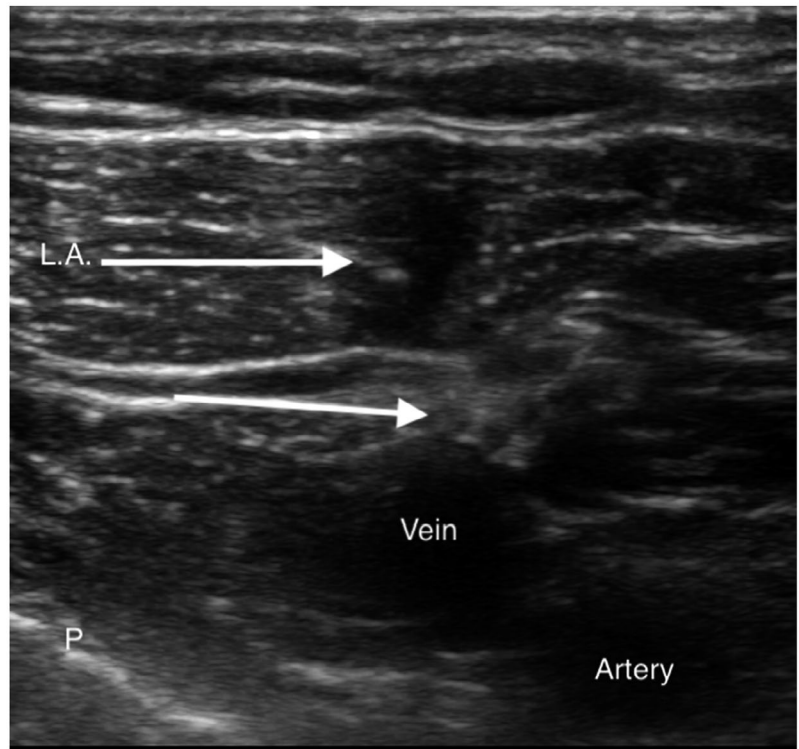
### 5 | DETERMINING THE BEST APPROACH

The choice of approach is often guided by training and previous experience and the individual's proficiency with each access technique. Doctors are more likely to change practice only if they can see a major advantage. In pacing, complication rates are generally



**FIGURE 3** Location of ultrasound probe lateral to first rib but medial to deltopectoral groove and immediately caudal to the clavicle

**FIGURE 4** Short axis view of the axillary vein. The tissue planes are clearly seen with P marking the pleural boundary. Fluid (L.A.) from the local anaesthetic has distorted the tissue planes superficial to the vein. The vein lies caudal and more superficial to the artery. The vein is compressible with pressure from the probe but the artery not so. The inferior arrow points to the tip of the needle about to enter the axillary vein. The shaft of the needle is out of the ultrasound plane



**FIGURE 5** Axillary vein puncture. The arrow shows the echogenic reflection of the needle entering the axillary vein



low in large volume centers so the incentive to reduce these further is also low.

Table 1 summarizes the short term acute procedural differences between these different approaches. The axillary vein approaches are associated with a higher acute procedural success rate and shorter procedural time than a cephalic cutdown.<sup>30,31</sup> In skilled hands ultrasound guided axillary vein access can take less than one

minute.<sup>32</sup> Pneumothorax is more frequent with a subclavian approach (about 1% of cases) but is rare with an axillary or cephalic vein approach (0%-0.2% of cases).<sup>30</sup> Both approaches have the same risk of bleeding.<sup>30</sup> From the patient perspective there are not a lot of long-term outcome differences between these approaches. There are no differences between a cephalic and axillary vein approach for lead dysfunction both of which avoid insulation defects from lead



**TABLE 1** Advantages of different venous approaches for venous access

Venous approach	Cephalic <sup>1,10,11</sup>	Axillary (ultrasound guided) <sup>25</sup>	Venography <sup>1,25</sup>
Acute success rate	60%-85% <sup>1,10,11</sup>	90%-95% <sup>29</sup>	96% <sup>1,25</sup>
Multiple leads	Sometimes <sup>1,10,11</sup>	Always <sup>25</sup>	Always
Complications			
Fluoroscopy for puncture	No	No	Yes
Pneumothorax	Rarely <sup>30</sup>	Rarely <sup>31,36</sup>	Rarely <sup>37</sup>
Arterial puncture	Never	Rarely	Rarely
Contrast reaction (anaphylaxis, nephrotoxicity)	Never	Never	Rare

crush seen with a subclavian approach<sup>30,33</sup> nor are there differences in the incidence of subclavian vein thrombosis nor vein stenosis<sup>34</sup> nor device infection.<sup>30</sup>

The risk to the proceduralist also needs to be considered. Infrequent risks are often ignored especially if they present years later. This is repeatedly seen in the catheter laboratory with the large variations in X-ray dosage due to differences in collimation between operators and X-ray angles with similar results and the variable use in lead and barium shielding. The long-term radiation risk to the proceduralists is stochastic.<sup>35</sup> Cardiologists are not impervious to radiation induced cataracts and tumors and in fact have a higher incidence of both types of tissue injury than others.<sup>35</sup> We would argue that as for all procedures, radiation is best minimized and avoided when possible. Given this, operators should consider either a cephalic vein cutdown or ultrasound guided axillary vein access as their initial approach and all techniques should be taught to future proceduralists.

## 6 | CONCLUSION

In summary, both cephalic cutdown and axillary vein approaches for pacing lead implantation provide excellent outcomes though the axillary vein approach has a higher acute procedural success rate. Ultrasound guided axillary vein access should be considered as an access technique in preference to venographic guidance. It should be mandated in training programs. Operators need to learn the skills for all access techniques to cope with patient variability. As a group, ultrasound guided access should be embraced by all implanters in preference to current X-ray guided access techniques.

## CONFLICTS OF INTEREST

Authors declare no conflict of interests for this article.

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