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Research Article

# Real-time in-plane ultrasound-guided supraclavicular approach to subclavian vein cannulation in cardiac surgery: An underused approach

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**KEYWORDS**

Subclavian vein;
Supraclavicular approach;
Cardiac surgery;
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**Abstract** *Background:* Although the subclavian vein has several anatomical advantages; it has been underused in cardiac surgery. In this feasibility study, the author aimed to test real-time in-plane ultrasound-guided supraclavicular subclavian vein cannulation during elective cardiac surgical procedures as an acceptable alternative for the routinely used internal jugular vein.

*Methods:* This prospective feasibility study included forty adult patients undergoing elective on-pump cardiac surgical procedures performed during the period from June 2012 to January 2013. The aim of this study is to test real-time in-plane ultrasound-guided supraclavicular subclavian vein cannulation in terms of time of placement, number of attempts to puncture the vein, inadvertent arterial puncture, usability before and after sternal retractor expansion, and catheter tip position.

*Results:* Successful cannulation of the subclavian vein was accomplished in an average time of 43.8 (14.9) s. The median number of skin punctures was 1 (range 1–3). All lumens of the catheters were usable both before and after using the sternal retractor in all cases except one. The central venous pressure waveform has been recorded in all cases except one. Using transesophageal echocardiography all catheter tips were found to lie within 1.6 cm from the crista terminalis.

*Conclusion:* Real-time in-plane ultrasound-guided supraclavicular subclavian vein cannulation is an easy and safe approach to be used in adult patients undergoing cardiac surgical procedures.



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## 1. Introduction

The subclavian vein has been used less frequently for central venous cannulation. Several anatomic advantages favor the use of the subclavian vein for central venous access: its large diameter, the absence of valves, and ability to remain patent and in a relatively constant position [1,2]. Subclavian

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catheterization carries a lower risk of catheter-related infection and thrombosis than femoral or internal jugular vein [3].

Since Aubaniac's original description in 1952 [4], subclavian vein catheterization via the infraclavicular approach has become a well-established technique. The reason why infraclavicular subclavian vein catheterization has not been popular in cardiac surgery patients may be the possibility of losing the central venous pressure waveform on the monitor during surgery when the sternal retractor is expanded. This is thought to result from the mechanical compression of the catheter after sternal retraction at the level where the subclavian vein crosses over the first rib [5].

In 1965 an alternate supraclavicular approach was described by Yoffa [2]. This supraclavicular route to the subclavian vein has some distinct advantages over the infraclavicular approach; however it is less often taught and utilized for reasons that are not clear [6]. Advantages of the supraclavicular approach over the infraclavicular technique include the following: a well-defined insertion landmark (the clavisternomastoid angle); a shorter distance from skin to vein; a larger target area; a straighter path to the superior vena cava; less proximity to the lung; and fewer complications of pleural or arterial puncture [2,7,8]. In addition, the supraclavicular approach less often necessitates interruption of cardiopulmonary resuscitation than the infraclavicular method [9]. The right side is preferred because of the lower pleural dome, more direct route to the superior vena cava, and the absence of thoracic duct [6].

Although ultrasound use was uncommon for cannulation of the subclavian vein, either as the primary technique or as the rescue technique, success rates were high with ultrasound guidance even when surface techniques were unsuccessful [10].

In this prospective study, the author aimed to test real-time in-plane ultrasound-guided supraclavicular subclavian vein cannulation technique during elective cardiac surgical procedures as an acceptable alternative in terms of time of placement, number of attempts to puncture the vein, inadvertent arterial puncture, usability before and after sternal retractor expansion, and catheter tip position.

## 2. Patients and methods

Following approval from institutional Ethics and Research Committee and obtaining written informed consents, a prospective feasibility study was conducted including forty patients undergoing elective on-pump cardiac surgical procedures during the period from June 2012 to January 2013 at the Cardiac Surgery unit in Nasser Institute. The following were the exclusion criteria: patients with musculoskeletal anomaly in the neck region, local skin infection or hematoma in puncture site, previous radical neck surgery, previous radiotherapy in the neck region and patients who already were catheterized before cardiac surgery for any indication.

### *2.1. Position and preparation*

Central venous catheters were inserted after induction of anesthesia. The patient head was kept in the neutral position with no pillow and without using the Trendelenburg position. All catheters were inserted in the right subclavian vein (lower dome of right pleura and the absence of thoracic duct). Complete sterile technique was adopted. The ultrasound probe together with some sterile gel was inserted into a long sterile sheath.

### *2.2. Equipments*

General Electric ultrasound system Logic-e (General Electric Medical Systems, Milwaukee, WI, USA) with linear 12 MHz (12L-RS) Vascular Probe was used for scanning. B-Braun 7F triple lumen catheter Certofix® Trio [B Braun Melsungen AG, Melsungen, Germany] was used for cannulation of the subclavian vein and Hewlett Packard (Philips) Ultrasound System with T6210 omniplane transesophageal echocardiography probe (HP Sonos 5500, Best, The Netherlands) was used to perform the Intraoperative transesophageal echocardiographic examination and confirmation of central venous catheter tip position.

### *2.3. Scanning and insertion technique*

Holding the probe with the left hand, ultrasound scanning of the internal jugular vein started in the neck down to the supraclavicular region to visualize the subclavian vein where it joins the brachiocephalic vein. The needle was guided from lateral to medial in an in-plane approach targeting the subclavian vein. After visualization of the tip of the needle inside the vein and free aspiration of blood the J-tip end of the wire was introduced and followed ultrasonographically down its course in the brachiocephalic vein (Fig. 1). Dilatation down to the vein followed by threading of the triple lumen catheter into the subclavian vein with a sterile cable connecting the guidewire to the ECG cable replacing the right shoulder surface electrode for intracardiac monitoring of the tip of the catheter. Observing the P-wave amplitude until it was as large as or larger than that of the QRS complex (P atriale). As the catheter tip passed the sinoatrial node the P-wave then became biphasic. Once the biphasic P-wave was observed, the catheter was withdrawn until the largest P-wave or P atriale was once again obtained. Then the distal lumen was connected to a pressure transducer to monitor the central venous pressure and to record any obstruction of the catheter when the sternal retractor was applied. The depth of catheter insertion in all patients was 15 cm.

Transesophageal echocardiography probe was inserted after fixation of the central venous line. In the mid-esophageal bicaval view, the central venous catheter was verified to lie in the superior vena cava and the distance between the catheter tip and the crista terminalis (border between right atrium and superior vena cava) was measured. In case of difficulty to visualize the catheter tip a bolus of 20 ml normal saline was rapidly injected to see the micro-bubbles passing through the catheter tip (Fig. 2).

The following parameters were collected: age, sex, body mass index, surgical procedure, insertion time (time from the beginning of scanning until visualization of the tip of the needle inside the vein and free aspiration of blood), number of separate skin punctures attempted, usability (aspiration and administration of fluids and drugs) of the catheter before and after sternal retractor expansion, the presence of central venous pressure waveform (transducer connected to the distal lumen) on the monitor before and after sternal retractor expansion, inadvertent arterial puncture, and catheter tip position confirmed by intra-atrial ECG and intraoperative

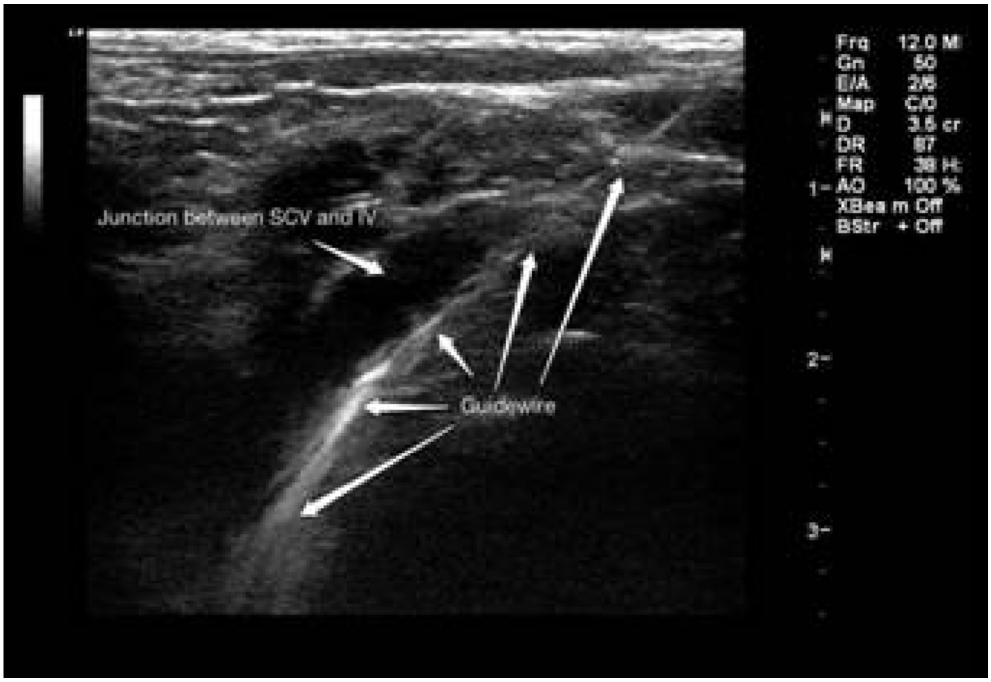


**Figure 1** Guide wire is seen to pass from the subclavian vein (SCV) down to the innominate vein (IV).

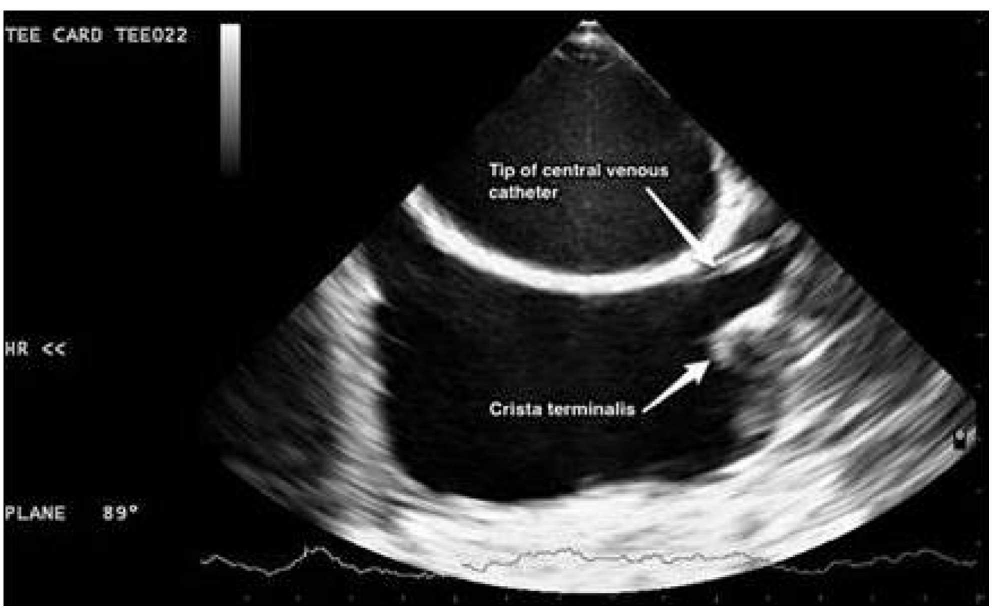


**Figure 2** Mid-esophageal bicaval view of the catheter tip in relation to crista terminalis.

transesophageal echocardiography and distance from crista terminalis.

## 3. Results

A total of 40 patients were enrolled in this study. Patients' demographics and details of surgical procedures are given in Table 1.

Visualization of the subclavian vein from the supraclavicular fossa was easily accomplished in all cases. Successful can-

**Table 1** Patients' characteristics.

| | |
|---|---|
| **Age** (years) mean (SD) | 49.4 (14.2) |
| **Sex** (male/female) | 31/9 |
| **BMI** mean (SD) | 28.6 (4.8) |
| **Type of surgery** (No. of patients) | |
| Valve repair or replacement | 19 |
| Valve repair or replacement + CABG | 9 |
| Aortic root surgery | 7 |
| CABG | 2 |
| Others | 3 |

nulation of the subclavian vein was accomplished in an average time of 43.8 (14.9) s. The median number of skin punctures was 1 (range 1–3). The guide-wire could be identified passing through the subclavian vein then down the innominate vein except in one case which was identified only in the subclavian vein. All lumens of the catheters were usable (aspiration and administration of drugs) both before and after using the sternal retractor in all cases except one. The central venous pressure waveform has been recorded in all cases except one. Using transesophageal echocardiography all catheter tips were found to lie within 1.6 cm from the crista terminalis except one case (Fig. 3).

The single difficult case was a female patient (weighing 105 kg with a height of 146 cm-BMI 49.3). She had a short neck and huge breasts. Cannulation of the subclavian vein took 90 s. Difficulty encountered threading the guide-wire and the catheter. The guide-wire has not been visualized in the innominate vein. The P-wave of the intra-cardiac wire could not be detected due to the basic rhythm of the patient; atrial fibrillation. The distal port was non-functioning and difficult to transduce the central venous pressure. Intraoperative echocardiography failed to detect the catheter tip in the subclavian vein. Postoperative chest X-ray showed the catheter tip to lie in the ipsilateral axillary vein (Fig. 4). There were no cases of inadvertent (0%) arterial puncture in the current study.

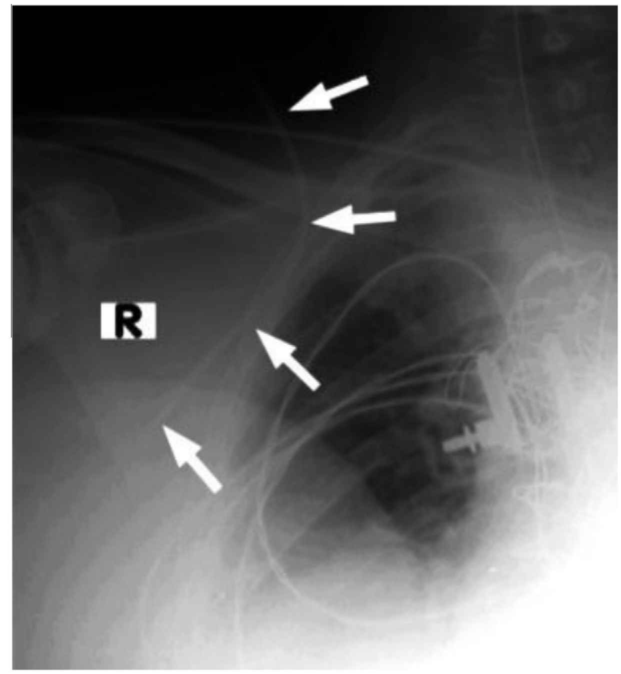


**Figure 4** Central venous catheter passing to the ipsilateral axillary vein (white arrows).

## 4. Discussion

The utility of ultrasound for supraclavicular subclavian vein cannulation has been described in several studies, most of them in the pediatric population [11–17]. This pilot study is the first to describe real-time in-plane ultrasound-guided supraclavicular subclavian vein cannulation in adult cardiac surgery. Forty adult patients were enrolled in this study. Intra-cardiac ECG and intraoperative echocardiography confirmed catheter tip position. All catheters (except one) were usable before and after sternal retraction. There were no incidents of accidental arterial punctures.

In an anatomical landmark-guided randomized study conducted by Kocum and colleagues [18], 65 patients were enrolled in the supraclavicular approach group. Thirty-nine cases were catheterized from the first attempt, 16 from the second attempt, 7 from the third attempt, 2 from the fourth attempt and 1 failed to catheterize. This gives a cumulative success rate of 98% (64) and a first attempt success rate of 60%. In the current study forty catheters were inserted successfully, 37 in the first attempt, 2 in the second attempt and one in the third attempt. Real-time in-plane ultrasound guidance displays the subclavian vein and the needle in the long axis throughout the insertion procedure from the skin to the subclavian vein. This may have increased the overall success rate (100%) and the first attempt success rate of 92.5% (37 out of 40). These results coincide with the results from a

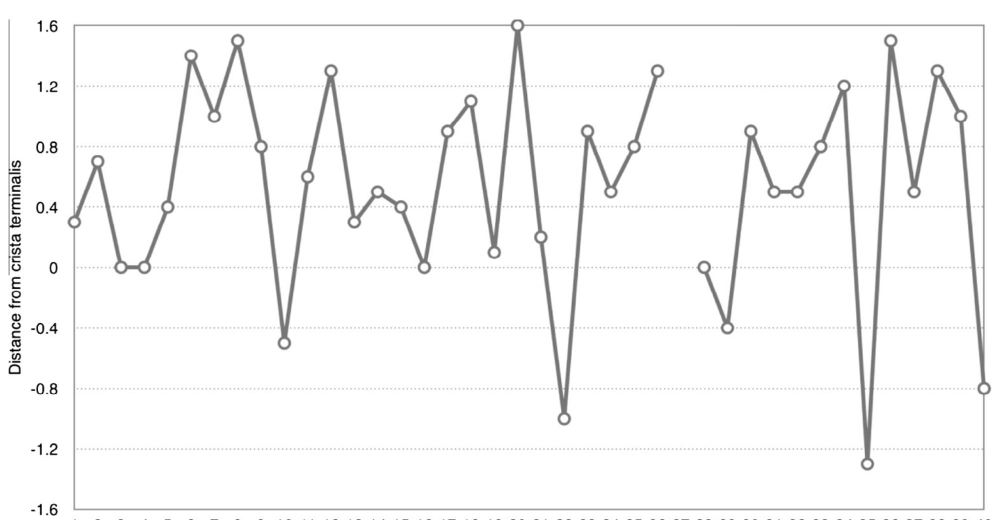


**Figure 3** Catheter tip position in relation to crista terminalis (39 cases are included in this figure).

study conducted by Fragou et al. comparing real-time ultrasound-guided subclavian vein cannulation versus the anatomical landmark method in critical care patients [19]. They included 200 patients in the ultrasound-guided group and 201 patients in the anatomical landmark group. In the ultrasound-guided group they had a success rate of 100% compared to 87.5% in the anatomical landmark group. The average number of attempts in the ultrasound group was 1.1 (0.3), while the median number of skin punctures in the current study was 1 (range 1–3).

The average time for insertion of the central venous catheter in the current study was 43.8 (15) s, a few seconds longer than the average ''access time'' for the ultrasound group in the study conducted by Fragou et al. which was 26.8 (12.5) s [19]. In the present study the insertion time was defined as the time from the beginning of scanning until visualization of the tip of the needle inside the vein and free aspiration of blood. Fragou et al. defined the ''access time'' as the ''time between penetration of skin and aspiration of venous blood into the syringe'' excluding the time needed to scan the target vessel, which may explain the time difference between both studies. When they considered the scanning time 118 (23) more seconds were added in the ultrasound-guided group, this time included scanning both supra- and infraclavicular views, measuring the depth and caliber of the axillary vein and the subclavian and evaluation of their patency and scanning adjacent structures. Doppler techniques were additionally utilized to confirm the two-dimensional findings [19].

Difficulty in aspirating blood and tracing the central venous pressure from the distal port was encountered only in one case. The encountered difficulty was the same both before and after sternal retraction. Injecting drugs was not affected. This was the case in which the catheter was inadvertently inserted in the ipsilateral axillary vein. Kocum et al. reported showed 3 cases (4.6%) of difficulty in infusion and loss of central venous pressure trace after sternal retraction [18]. They did not mention whether this was related to catheter tip malposition; however they had 4 cases of malposition (2.1%), three of them the catheter tip was inadvertently positioned in the left internal jugular vein and one in the right atrium.

There were no cases of inadvertent (0%) arterial puncture in the current study. Fragou et al. described no cases of pneumothorax (0%) and arterial puncture in a single case (0.5%) [19]. According to recent literature, complication rates during infraclavicular subclavian vein catheterization and internal jugular vein catheterization are often found to be several times higher when compared with supraclavicular subclavian vein catheterization [20]. The incidence of carotid artery puncture during internal jugular vein catheterizations is approximately 6% [21]. Higher rates have been reported with the anatomical landmark method [22,23]. Of greater clinical significance is the fact that up to 40% of carotid punctures are associated with a hematoma; 10 of 25 in one study [22]. This, in conjunction with manual pressure, has been interpreted as the mechanism responsible for the appearance of cerebrovascular neurologic deficits [21,24,25] and death [26]. Puncture of the subclavian artery during catheterization attempts occurs in 0.5–4% of the patients [27–29]. Real-time in-plane ultrasound guidance in the current study might have contributed to decreased complication rates.

In the current study, catheter tip position was verified using intra-atrial ECG and transesophageal echocardiography. There has been a single catheter malposition with an incidence of 2.5%. In a study conducted by Apsner et al. they inserted 81 double lumen Hickman catheters and they had zero catheters malpositioned. Misplacement into adjacent vessels was not observed in their study although fluoroscopy was not used in any procedure. This is obviously due to the straight path of the catheter to the right atrium, even if the puncture is performed from the left side [7]. All catheter tips in this study were found to lie within 1.6 cm of the crista terminalis (the junction between the superior vena cava and the right atrium) except one case where the catheter tip could not be identified using intra-atrial ECG (the underlying rhythm was atrial fibrillation) and the catheter tip could not be identified using transesophageal echocardiography.

In the current study there was no difficulty visualizing or cannulating the subclavian vein while keeping the head in the neutral position and without using the Trendelenburg position. Putting the patient in the Trendelenburg position did not yield a significant increase in the cross-sectional area of the subclavian vein [30,31]. Positioning the patients head in the neutral anatomic position during subclavian venipuncture may facilitate the desired catheter entry into the innominate vein [32,33].

### 4.1. Study limitation

The relatively small sample size and the non-comparative study design are attributed to the fact that it was a single investigator study with the aim of investigating the feasibility of this technique in this patient population. Future controlled comparative studies, accommodating larger sample size are encouraged to get stronger conclusions on the use of the recommended technique.

Real-time in-plane ultrasound-guided supraclavicular subclavian vein cannulation is an easy, safe, and feasible technique to be used as an alternative to the classic internal jugular vein approach in adult patients undergoing cardiac surgical procedures.

## 5. Conflict of Interest

No conflict of interest.

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