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Needle-guided ultrasound technique for axillary artery catheter placement in critically ill patients: A case series and technique description

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ABSTRACT

Purpose: Axillary arterial cannulation for blood pressure monitoring has been reported in adults since 1973. Reported failure rates using palpation landmarks are high. This report describes a needle-guided ultrasound technique for axillary arterial line placement in critically ill patients.
Methods: A retrospective review of all patients requiring axillary arterial cannulation attempts with ultrasound-assisted needle guidance for hemodynamic monitoring was performed from July 2010 to June 2016 at a single institution.
Results: One hundred fifty nine (159) cannulation attempts were performed in 155 patients. The overall success rate was 97%, with a first pass success rate of 84%. Inexperienced operators performed 49% of procedures under direct faculty supervision, and had a 99% success rate, which was not different from experienced operators. Almost 20% of patients had moderate-to-severe coagulopathy (platelets < 50 k/uL, INR > 2.0 or PTT > 60 s). Complications reported included the following: nonfunctioning of catheter (6%) and hematoma (6%). Ischemia was noted in 2 patients (1%), but only one was attributed to the arterial catheter.
Conclusions: Use of the needle-guided ultrasound assisted approach for axillary arterial line placement is easily teachable and can be used to promote safe and successful placement of axillary arterial lines for novice learners.

1. Introduction

Percutaneous arterial cannulation is routinely used for hemodynamic monitoring of critically ill patients [1]. The radial artery is the most frequently used site for arterial cannulation due to accessibility, simplicity, low rate of complications, and historical precedence [2].

Axillary arterial cannulation has been reported in adults since 1973 [3-9]. It has also been described in pediatrics [10-12] and neonates [13]. However, there are no published large series using real time ultrasonography nor the success rate of a given technique. The objective of this study was to retrospectively review ultrasound-guided cannulation of the axillary artery with needle guide-assisted puncture for hemodynamic monitoring in critically ill patients, focusing on patient characteristics, cannulation technique, operator experience, presence of coagulopathy, and complications.

2. Materials and methods

The study consisted of a retrospective review of all axillary arterial cannulation attempts performed by the study investigators at Stanford Medical Center between July 2010 and June 2016, and was approved by our Institutional Review Board without requiring individual patient consent. Patient identification and details of the procedure and operators were extracted from an internal quality assurance audit database and the medical record. Patient demographics, presence of coagulopathy, type of catheter, experience of inserter, and complications were recorded and all data was de-identified from individual patients. Axillary arterial cannulations were performed because of the clinical need for central arterial pressure monitoring and/or lack of other access sites. All procedures were performed under the supervision of a single attending physician. Cannulations were performed in the operating room or intensive care unit.

2.1. Catheterization technique

Previously described techniques to identify vessels on ultrasound and guide the insertion of the needle were applied [14]. Each patient was placed in a supine position with the arm externally rotated and abducted at 90° from the body. The axillary artery was identified with a high-frequency transducer (6–13 MHz, Sonosite Xporte®) via the transverse out-of-plane approach. The depth of the posterior wall of the axillary artery was noted on ultrasound and used to select an appropriate needle guide (Civco®P09072-01). After administration of local anesthetic with

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Fig. 1. Transverse view of axillary artery on ultrasound (top image) and axillary artery catheterization using ultrasound with a needle guide in left axilla (bottom image). Please view procedural video (supplemental video).

2% lidocaine, the Seldinger technique was used to puncture the artery with an 18-ga thin-walled needle passing through the needle guide. Return of pulsatile blood flow confirmed arterial puncture. A guidewire was passed into the artery. While holding pressure over the puncture site, the needle was removed over the wire. Changing hand position in order to hold counter-traction just distal to the entry site, the catheter was advanced over the guidewire into the artery. (Fig. 1) (Supplemental video 1). A 16 ga 20 cm catheter (Arrow®CDC-24301-1A) or 16 ga 15 cm catheter (Cook®G01950) was used for all catheterizations except for one patient, where a 20 ga Arrow catheter (Arrow®A-04020) was used. All procedures were completed using full barrier precautions and aseptic technique. While in place, patients were allowed to rest arm in any comfortable position, and movement of the arm was not restricted. In the operating room, patient positioning for the surgery dictated arm position. Dressing changes occurred every 4–7 days. Flushing of catheters followed directives to use interrupted, low volume (2 ml) flushes, pushed slowly in order to minimize the risk of cerebral embolism. All patients were assessed for bleeding, ischemia, and infection as per routine care in the ICU, and catheters were removed when clinically indicated.

2.2. Statistical analysis

We used descriptive statistics for overall results and chi square analysis to compare success rates and complications between experienced and unexperienced operators with a p value of 0.05.

3. Results

A total of 159 axillary arterial cannulations were attempted in 155 patients. Patient demographics are provided in Table 1. Axillary arterial cannulations were successful in 155 of 159 (97%) attempts. Success with the first needle pass occurred in 133 out of 159 (84%) attempts, and was not affected by operator experience (p = ns). In 3 of the 4 failures, an axillary arterial line was placed easily in the other arm (and considered another cannulation attempt), and in one, a femoral arterial line was placed. First-time operators (residents/fellows) performed 56 out of 159 (35%) cannulations, and another 23 (14%) cannulations were performed by an operator with <5 experiences, all under direct supervision of an experienced faculty member. Success rate of all inexperienced operators was 99% (78 of 79).

Table 1
Characteristics of patients with axillary artery cannulations.

Patient characteristics	
Cannulation attempts	159
Male/female	70/89
	Median (range)
Age	59 yr (16–94)
BMI	29 kg/m^2 (13–89)
Platelets	200 × 10^9/L (4–643)
INR	1.2 (0.9–4.2)
PTT	31.2 s (14–300)

The median duration of the catheter was 3 days (range 1–26 days). Nine catheters (6%) became nonfunctional (no blood return or loss of waveform) after 1–14 days because of kinking, misplacement, or clotting of the catheter. Almost 20% of patients (30 total) had moderate-to-severe coagulopathy defined as: platelets < 50 k/uL, INR > 2.0, or PTT > 60 s. The overall incidence of minor complications was 13% (20 incidents reported). Novice operators experienced more complications than the attending supervisor (15/79, 19% vs 5/80 6%, p 0.03). Hematoma developed in 10 patients (6%), where 4 had a coagulopathy and 2 developed a hematoma only after removal of the catheter. By post-hoc analysis, hematoma occurrence with multiple needle passes was compared to first pass success (5/26, 19% vs 5/133, 4%, $p < 0.01$). In the patients with coagulopathy, 4 of 30 (13%) developed hematomas compared to 6 of 129 (5%) in patients without coagulopathy, which was not statistically significant (p = ns). No patient required a transfusion for catheter-related blood loss. Ischemia was noted in 2 patients but only 1 (0.6%) where it was directly related to the arterial catheter. One patient was found to have a cold hand on the side of catheter placement at day 5, and the catheter was removed; the patient had a normal sensation on neurological exam afterwards. The second patient had an ischemic limb with loss of peripheral pulses on day 3 and the catheter was removed; however, the cause was thought to be secondary to arterial emboli from bacteremia, since other extremities were also involved. There were no cerebral embolic events related to flushing of the arterial catheters.

4. Discussion

We report our experience with an ultrasound technique of axillary artery cannulation utilizing a needle guide. Although catheterizing the axillary artery may require more skill than other anatomic sites, our data demonstrate an excellent success rate of ≥97%, even among first time operators. Without the use of ultrasound, the failure rate was reported to be 30% among trainees and 5% among ICU attending staff and fellows in one large series of 435 patients [6], and a failure rate of 11% (9 of 86 axillary arteries) in another series [7]. It is known that ultrasound-guided arterial cannulation improves the success rate on the first attempt, requires fewer overall attempts, and less time to successful cannulation when compared to the traditional landmark techniques in adults for radial and femoral arteries [14,15]. Using ultrasound with a needle guide improves needle visualization compared to free-hand ultrasound techniques for central venous catheter access in a simulation model [16] and improves first pass success rate during central venous cannulations in patients [17]. The added control of a needle guided ultrasound technique likely contributed to our high success rate. While not proven in this study, the authors believe that the needle guide design provides; the ability to choose the location of arterial puncture, direct visualization of vessel puncture and permits puncture at the 12 o'clock position on the artery. The latter point may also minimize the chance of vessel rolling, intimal dissection or other arterial injury. These features are more important in axillary arterial line placement because the axillary artery is highly mobile, compared to the femoral artery.

Our complication rates were comparable to those reported in prior studies in adults. In De Angelis' study, 8 out of 86 cannulations developed hematoma, but only one was considered extensive [7]. Gordon et al. reported a hematoma rate of 11% (3 out of 28 cannulations) [8]. In a larger study, only 4 out of 435 patients developed a large hematoma [6]. We experienced a higher hematoma rate (6%) than that study, but did not try