Arterial Access/Monitoring (Line Placement)

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11.1 Introduction

Cannulation of an artery for the purpose of monitoring a patient's hemodynamic status is a common procedure in the critical care environment [1–4]. Descriptions of arterial cannulation appeared in the literature in the late 1940s through the early 1960s when Barr first described the use of an indwelling Teflon catheter in the radial artery to continuously measure blood pressure [5–7]. Continuous measurement of blood pressure through an arterial line is considered to be the most accurate measurement of systemic blood pressure and is the most common form of invasive monitoring [1, 4]. In addition to monitoring of blood pressure, the arterial line may also be used for phlebotomy when frequent laboratory studies are needed, reducing the need for repeated peripheral blood draws. Advanced practice clinicians working in the ICU commonly perform arterial cannulation [8] and therefore should have knowledge of indications and contraindications, relevant anatomy, technique, and potential complications from the procedure [1, 9].

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11.2 Indications

Insertion of an indwelling line into an artery is indicated in the following situations:

- Need for continuous monitoring of blood pressure in a patient with hypotension/hemodynamic instability.
- Patient receiving vasoactive medications.
- Inability to accurately monitor blood pressure by noninvasive technique (e.g., morbidly obese patient or patient with severe burns or trauma to the extremities).
- Patient requiring frequent arterial blood gases or venous blood samples (e.g., patient in respiratory failure, on mechanical ventilation or with a severe acid/base disturbance).
- To measure mean arterial pressure (MAP) when targeting a specific level is indicated (e.g., to maintain cerebral perfusion pressure following head injury) [9–12].

11.2.1 Site Selection

There are several arterial sites that may be used in the adult patient, including the radial, femoral, axillary, brachial, and dorsalis pedis [3]. The radial artery is most commonly used because of its proximity to the skin surface, ease of access, and low rate of complications [10, 13–15]. Measurement of mean arterial blood pressure in

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radial or femoral arteries is clinically interchangeable. However, in severely hypotensive patients or during cardiopulmonary resuscitation, the femoral artery is usually the most readily palpable and accessible for successful cannulation [10]. There are no clinically significant differences in measurement of blood pressure between the radial and femoral artery, and it is not mandatory to cannulate the femoral artery, even in critically ill patients receiving high doses of vasoactive drugs [2].

Long-standing practice protocols have recommended that a patient undergoing radial or dorsalis pedis artery cannulation should have collateral flow to extremity assessed by physical examination (e.g., Allen's test), Doppler ultrasound, or pulse oximetry (modified Allen's test) [13] prior to procedure to identify potential increased risk for ischemic complication in the extremity [16]. However, several research studies conclude that the Allen's test was not useful in predicting the rare ischemic event following radial artery cannulation [4, 17, 18].

11.2.2 Anatomic Considerations

- Radial artery
  - The radial artery can be palpated just medial to the radial styloid and approximately 1–2 cm proximal to the flexor crease of the wrist. The puncture site should be approx. 1 cm proximal to the styloid process so as to keep from puncturing the transverse carpal ligament [12].
  - Collateral circulation to the hand is provided by the ulnar artery and palmar arch [3].
- Femoral
  - The femoral artery originates from the external iliac artery at the inguinal ligament. It passes under the ligament at approximately the midpoint between the anterior superior iliac spine and the pubis. It lies between the femoral nerve (laterally) and the femoral vein and lymphatics (medially) [3, 12].
  - The larger vessel diameter allows for greater longevity of the catheter compared to the radial artery [3].
  - To minimize risk for bleeding into the pelvis, the femoral artery should be accessed approximately 2.5 cm below the inguinal ligament [12].
- Dorsalis pedis
  - Although the dorsalis pedis is also relatively superficial, it may be absent (typically bilaterally) in up to 12 % of the population [10].
- Brachial
- The brachial artery can be palpated at the medial border of the antecubital fossa and is typically accessed above the antecubital crease. This artery is rarely used because of the lack of extensive collateral circulation [3]. Reported complications include ischemic occlusion and median nerve injury [3, 19].

11.3 Contraindications

Absolute contraindications (extremity cannulation): [1, 10, 12]

- Absent pulse
- Ischemic extremity
- Raynaud's syndrome
- Thromboangiitis obliterans (Buerger's disease)
- Preexisting inadequate collateral blood flow distally to the extremity
- Full-thickness burns over the cannulation site

Relative contraindications: [1, 10, 12, 20]

- Anticoagulant therapy
- Severe atherosclerosis
- Bleeding disorder
- Severe dermatitis or infection at the cannulation site
- Partial-thickness burn at the cannulation site
- Previous surgery in the area
- Synthetic vascular graft

11.4 Preparation

Insertion of an arterial line is commonly performed at the patient's bedside. After obtaining appropriate informed consent, all supplies should be gathered. The APC should ensure that appropriate informed consent is obtained from the patient/family. Prior to the procedure, a "time-out" assures correct patient identification and site selection. Full universal precautions with mask, hat, sterile gown, and gloves should be implemented by the operator, as this procedure involves potential exposure to blood (Fig. 11.1).

Equipment

- Sterile towels or drape
- 1 % lidocaine without epinephrine
- Sterile 5 cc syringe with 23 gauge needle
- Gauze pads
- Arm board
- Tape
- Chlorhexidine or povidone-iodine skin preparation solution
- Integrated arterial line kits (femoral or radial)
- Number 11 blade scalpel
- Nonabsorbable suture (3–0 or 4–0)
- Needle holder, scissors
- Occlusive dressing
- Chlorhexidine gluconate dressing (e.g., Biopatch©)

Nursing supplies

- Three-way stopcock
- Pressure transducer kit
- Pressure tubing

11.5 Procedure

There are three ways to obtain arterial cannulation: Seldinger technique [21], modified Seldinger technique using integrated kits (Fig. 11.2), and direct puncture cannulation, e.g., with an intravenous catheter [16]. For the purposes of this chapter, only the modified Seldinger technique will be described.

There is evidence that ultrasound guidance, if available, improves rate of successful cannula-

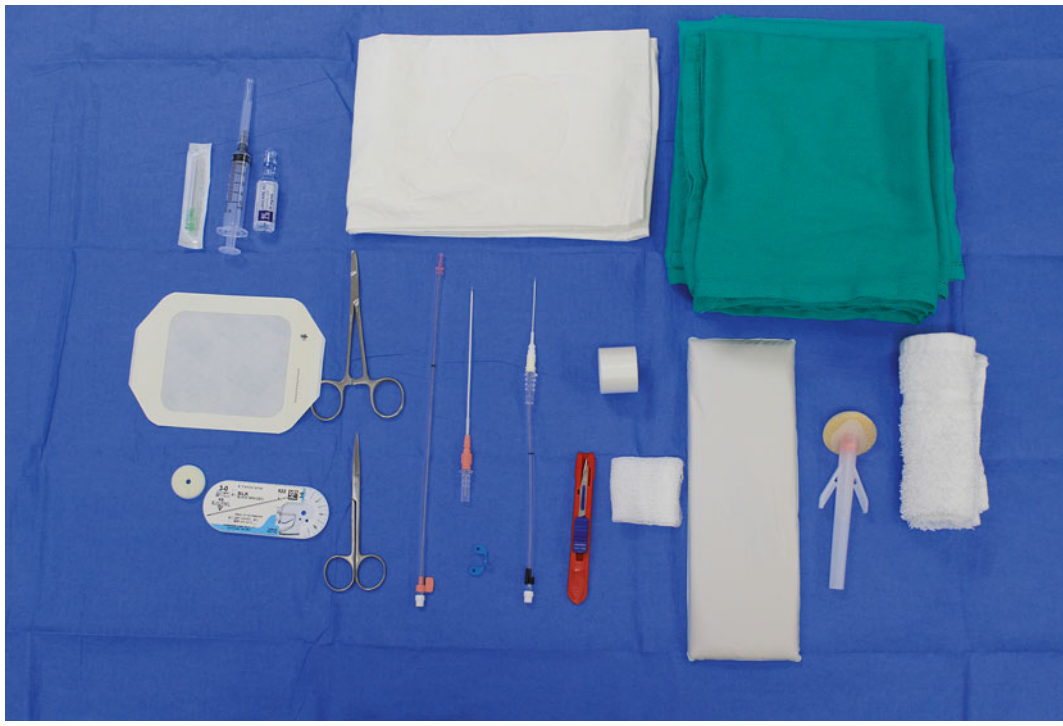

Fig. 11.1 Equipment for arterial access

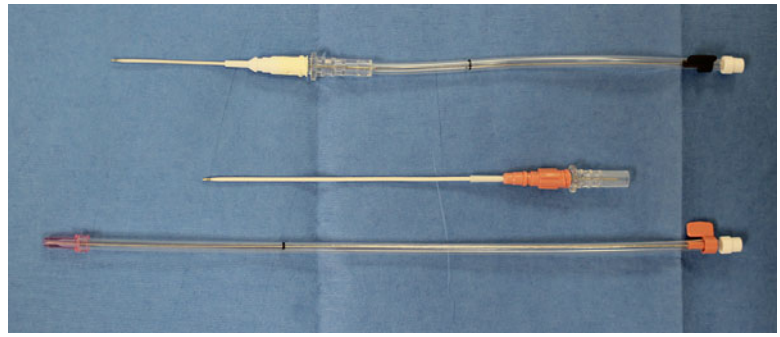

Fig. 11.2 Integrated arterial access kit

tion at first attempt [22], especially if the patient is in shock, receiving vasoconstrictive medications, or morbidly obese.

11.5.1 Radial Artery

For the radial site, the patient is usually supine or semi-recumbent. The wrist is positioned in slight dorsiflexion, with the palm up. The hand can be taped to a flat surface, such as an armboard or a bedside table. A small towel may help in the extension of the wrist (Fig. 11.3). Preparation of the arm should cover the entire ventral aspect of the forearm, as the cannulation can occur wherever the pulse is best felt along the course of the radial artery, but usually occurs just proximal to the radial styloid process at the wrist. The area is draped widely with towels, as the devices can be unwieldy due to their length, and contact with non-sterile surfaces is to be avoided.

Local infiltration with lidocaine is carried out by injecting a small weal at the anticipated puncture site. A small nick with the number 11 scalpel may facilitate passing of the needle. The operator should assume a position that allows the nondominant hand to palpate the pulse proximally and the dominant hand holding the integrated arterial catheterization device pointing proximally, at about a 30–45° angle to the surface of the forearm (Fig. 11.4).

The pulse is palpated gently by the nondominant hand so as to prevent occlusion of the target site. The needle is advance until pulsatile blood return is seen to readily enter the device. The nondominant hand then steadies the device, as it is important to maintain the needle tip inside the artery lumen. The wire is advanced into the artery lumen. Little to no resistance should be felt throughout the course of the wire advancing. Once the wire is in place, the catheter is advanced over the wire, and the needle and wire are removed together. Pulsatile flow should be seen from the catheter at this point, which is attached to the pressurized system for flushing and monitoring. Suturing of the catheter hub to the skin can now occur and ideally should be done with the local anesthetic previously injected. Following placement of a chlorhexidine gluconate dressing (e.g., Biopatch©) and locally occlusive dressing (Fig. 11.5), additional gauze dressing may be applied around the wrist and forearm to reduce likelihood of accidental dislodgement. Assess for continuing adequate distal circulation and document that the hand remains pink and warm (Fig. 11.6).

11.5.2 Femoral Artery

The approach to the femoral artery by necessity involves a supine patient with the selected leg in slight adduction and external rotation. The area prepared should be well above the inguinal fold, down to mid-thigh, and from the medial to the lateral aspects of the thigh and is similarly draped with towels.

Ultrasound guidance is particular useful in locating the femoral vessels. The acronym "NAVL" reminds the operator of the order of

Fig. 11.3 Use of a towel roll for wrist extension

Fig. 11.4 Operator positioning for arterial access

arrangement of the femoral neurovascular bundle from lateral to medial (nerve, artery, vein, lymphatics). The nondominant hand palpates the pulse at or just below the inguinal crease, and the dominant hand guides the integrated device over the pulse, to a point approximately one to two fingerbreadths below the inguinal fold, advancing the needle at about a 45–60° angle (Fig. 11.7). A skin nick with the number 11 blade facilitates passage of the 18-ga needle-catheter-integrated device. Once blood return is obtained, insertion of the catheter proceeds similar to the radial approach, as do the securing and dressing of the catheter (Fig. 11.8). An additional suture may be placed at the other side of the hub of the pressure tubing to prevent "kinking" of the line with patient movement.

11.6 Complications

The decision to place an arterial line for patient monitoring should always be made considering the risk/benefit ratio for each patient. In the criti-

Fig. 11.5 Dressings for arterial cannulation

Fig. 11.6 Assessment of peripheral circulation following arterial line placement

cally ill patient, the need for accurate and timely information about respiratory and hemodynamic status may outweigh the risks based on relative contraindications. As with all invasive procedures, accurate monitoring of patient status and response is vital. A higher rate of ischemic complications has been documented in patients with preexisting vascular disease such as Raynaud's syndrome or Buerger's disease, thus the reason for listing these conditions as absolute contraindications [1, 16].

According to Scheer et al., the incidence rate for major complication (sepsis, pseudoaneurysm, or permanent ischemia) from cannulation of the radial, femoral, or axillary artery is low, occurring in less than 1 % of cases [14]. Although this clinical

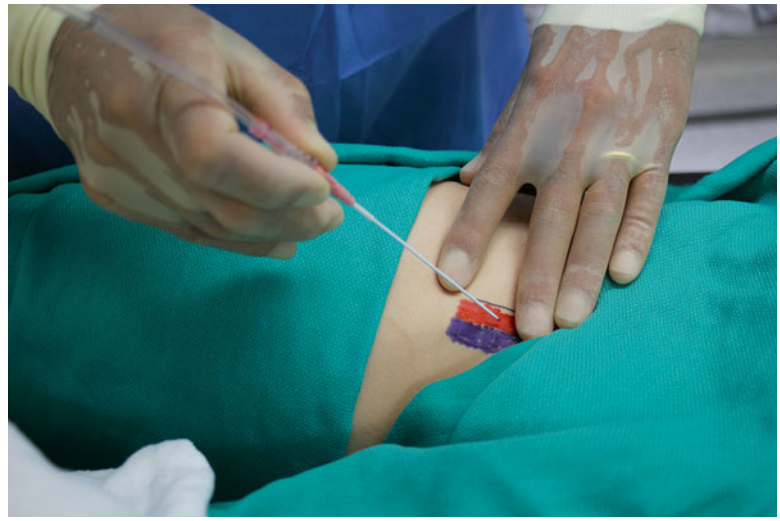

Fig. 11.7 Placement technique for femoral arterial access with arterial landmark (*red*) and venous landmark (*blue*) noted

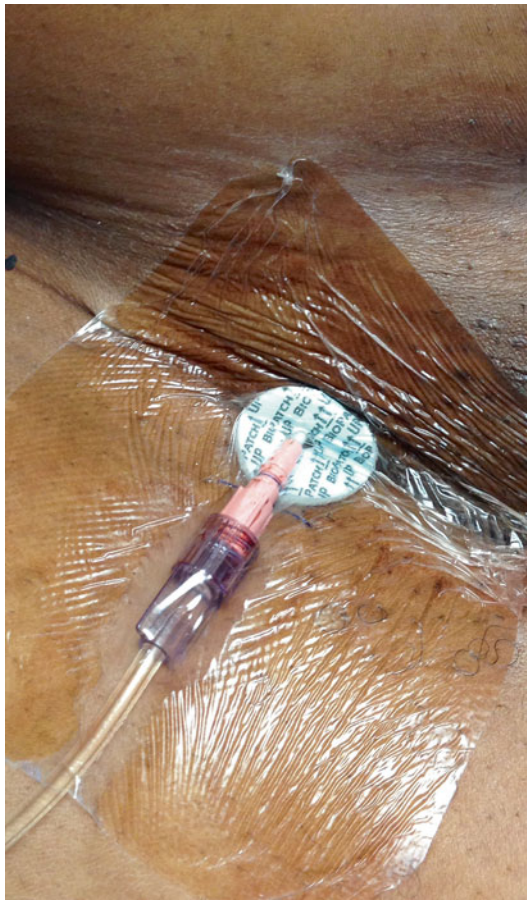

Fig. 11.8 Securing and dressing of the femoral arterial line

review indicates that arterial cannulation is generally a safe procedure, the APC should be aware of the potential complications that can occur.

Common Complications

- *Temporary arterial occlusion*
- *Hematoma*

The most common complications following radial artery cannulation include *temporary* occlusion of the artery (19.7 %) and hematoma (14.4 %). For the femoral artery, the most common complication is hematoma (6 %) followed by bleeding and temporary occlusion (both less than 2 %). Local site infections and sepsis have been reported but the incidence is generally low, and higher incidence is reported with prolonged use (generally beyond 4 days) [14]. A large study of patients in intensive care found no significant difference in infection rates between femoral and radial artery catheters [18].

Rare (<2 %) Complications: [1, 10, 12, 14]

- *Aneurysm or pseudoaneurysm (pulsatile mass)*
- *Arterial thrombosis (risk increases with longer duration of use and smaller diameter of artery)*
- *Cerebral air embolization (due to manual flushing)*

- *Significant blood loss (port valve is left open or tubing is disconnected)*
- *Nerve injury*
- *Permanent ischemic damage*
- *Artery dissection*

In summary, a large body of research suggests that arterial cannulation is a safe procedure with a very low incidence of complication.

11.7 Conclusions

Insertion of an arterial line for accurate monitoring of systemic blood pressure and to allow for frequent blood sampling is a common procedure in the intensive care unit with few complications when the patient is appropriately selected. Cannulation of the radial and femoral arteries is the most common; cannulation of the brachial or axillary artery is rare and would typically only be performed by anesthesia providers in the operating suite.

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