Ultrasound-Guided Arterial Puncture

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Introduction

Arterial blood gas (ABG) analysis can yield information vital to the management of both acute and chronic disorders affecting gas exchange. In the setting of a restrictive ventilatory impairment due to chest-wall deformities (eg, scoliosis), hypercapnia indicates severe impairment and should prompt consideration of noninvasive ventilation.[1] However, arterial puncture is often painful, particularly when more than one attempt is required.[2] We report the use of 2-dimensional ultrasound to guide arterial puncture for arterial blood sampling from a patient with severe scoliosis due to arthrogryposis multiplex congenita.

Case Summary

A 35-year-old female presented to the pulmonary function laboratory because of progressive dyspnea on exertion, cough, wheezing, and chest tightness. She had been diagnosed with asthma, but without pulmonary function tests, and had little to no relief from bronchodilators or inhaled corticosteroids. Her pulmonary function test orders included ABG analysis. Her radial, brachial, and dorsalis pedis arteries were very difficult to palpate. A single attempt at brachial-artery puncture was unsuccessful and unfortunately very painful for her. She expressed reluctance to have the arterial puncture repeated. We agreed to move on to the other pulmonary function studies and to revisit arterial puncture after those studies.

The pulmonary function data revealed very severe restrictive lung disease, respiratory muscle weakness, and room-air S_{pO_2} of 89%. These findings underscored the importance of ABG analysis to assess alveolar ventilation and blood oxygenation. However, we were faced with the conundrum of very-difficult-to-palpate pulses and a patient who understood the importance of the test but was unwilling to undergo protracted and painful phlebotomy. To try to overcome these obstacles, we used 2-dimensional ultrasound (MicroMaxx, SonoSite, Bothell, Washington) to assess her arterial anatomy and to guide arterial puncture.

We visualized the radial artery via ultrasound, but the vessel was very small and well below the skin. We concluded that the radial site was less than ideal for puncture, keeping in mind that she might only permit one more attempt at arterial puncture. We then used ultrasonography to visualize the brachial artery, which was also small and approximately 2 cm below the skin, but we decided that the brachial artery would probably be easier to puncture than the radial. Because the median nerve appeared to overlay the brachial artery at our original puncture site, we relocated the puncture site a few centimeters cephalad. At that point we attempted brachial arterial puncture with ultrasound guidance (Fig. 1), and were successful after one needle redirection. We sent the blood sample for analysis. Unfortunately, the ultrasound unit we used was not equipped to capture or print images; however, Figure 2 provides an ultrasound image of the blood vessels and median nerve near the elbow.[3] Our patient expressed relief and satisfaction that the sample had been procured without causing her a lot of additional discomfort. The ABG analysis revealed chronic severe hypercapnia and hypoxemia, and the patient was referred to a pulmonologist for further evaluation and consideration of nocturnal noninvasive ventilation.

Discussion

Ultrasound technology has become more compact and consequently more prevalent in emergency departments and intensive care units. Ultrasound can obviously aid in diagnosis, but increasingly it is also being used to guide invasive procedures such as vascular access. Two-dimensional ultrasound improves the success, efficiency, and safety of central venous cannulation at both peripheral and central puncture sites.[3-5] Doniger et al[6] found better success, shorter procedure time, and fewer attempts at es-

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Fig. 1. Ultrasound-guided puncture of the brachial artery.

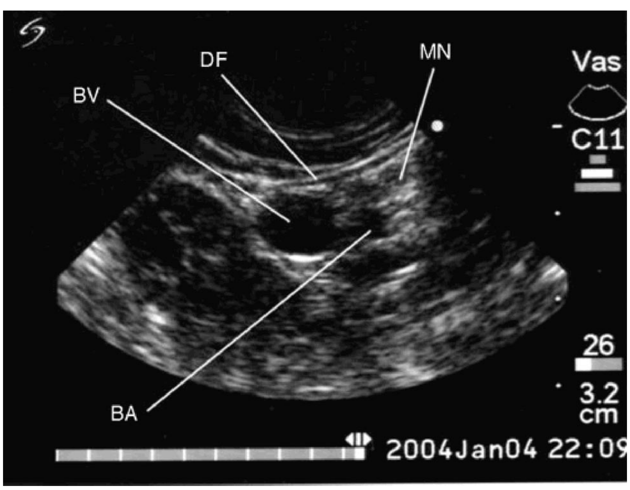

Fig. 2. Ultrasonogram shows the basilic vein (BV), brachial artery (BA), median nerve (MN), and deep fascia (DF) in the mid-arm. (From Reference 3, with permission.)

tablishing peripheral venous catheterization in pediatric emergency-department patients.

Several studies have evaluated ultrasound-guided versus blind arterial catheterization. Shiver et al[7] randomized 60 patients to ultrasound-guided or blindly inserted arterial catheterization in the emergency department. Ultrasound-guided arterial cannulation was quicker (107 s vs 314 s) and involved fewer attempts and fewer changes in puncture site than did blind insertion. Levin and colleagues[8] randomized 69 preoperative patients to ultrasound-guided or blindly inserted arterial catheterization. While there was no difference in overall success rate, arterial catheterization required fewer attempts in the ultrasound-guided group. However, in a similar study of stable children undergoing preoperative arterial line placement, Ganesh et al[9] found no difference between ultrasound-guided and blind arterial cannulation in terms of success and time to cannulation. Clearly, clinician skill and patient characteristics (eg, anatomy, pulse intensity) impact arterial cannulation success, so it is unlikely that ultrasound guidance would be necessary for all, or perhaps even most, patients requiring arterial cannulation. However, ultrasound-guided arterial puncture for catheterization and blood sampling may be very helpful in patients whose pulse is difficult to palpate.

Ultrasound-guided puncture of the radial or brachial artery is a relatively easy procedure to learn. The following should be regarded as only a basic overview. The first step is to use ultrasound to assess the pertinent anatomical structures in the area you are considering for puncture. With our patient we chose the brachial artery, so we will discuss the procedure in terms of that site. When assessing the brachial area, the brachial artery, basilic vein, and median nerve are key structures to identify (see Fig. 2). After cleaning the skin with alcohol, ultrasound gel is applied to the transducer, and the transducer is held against the skin with light pressure (see Fig. 1). Differentiating an artery from a vein is usually very easy, since most veins collapse under compression, whereas arteries pulsate. Once the brachial artery is found, assess the suitability for puncture. The ideal puncture site is an area where the artery is: close to the skin (distance markers are usually visible on the ultrasound image display screen); isolated as much as possible from other vessels; and not near the median nerve or the likely trajectory of the needle. We relocated our initial puncture site a few centimeters cephalad, to avoid the median nerve. An acceptable site can be marked with a surgical ink pen so it is easy to return to the chosen site. Prepare the ABG syringe for use and don clean gloves. With your non-dominant hand, position the ultrasound probe so that the artery is in the center of the ultrasound image display screen. Many ultrasound transducers feature a median arrow or line to align with guide markers on the screen. Once the artery is positioned in the middle of the screen, use your dominant hand to insert the needle just below the transducer, at the median marker, at an angle of 45–60° (see Fig. 1). A deeper vessel will require a greater needle angle. The needle should now be visible on the ultrasound image. Slowly advance the needle to the top of the artery, then into the artery, draw the blood sample into the syringe, and then set aside the ultrasound probe, which frees your non-dominant hand to apply pressure to the puncture site with a sponge pad as you withdraw the needle. Always follow the American Association for Respiratory Care guidelines[10] for ABG sampling and analysis.

Teaching Points

In our patient with difficult anatomy, ultrasound guidance proved to be the difference between success and failure in obtaining an arterial blood sample. In addition, with ultrasound guidance we were able to avoid the median nerve. While this patient would probably qualify for domiciliary noninvasive ventilation on the basis of her severe restrictive ventilatory defect and respiratory muscle weakness, without documentation of hypercapnia,[1] the ABG data were nonetheless valuable in the management of this patient. We are unaware of any other studies of ultrasound guidance for ABG sampling; however, we believe this technique should be investigated. Newborn and critically ill patients with difficult-to-palpate arteries might be good candidates for ultrasound-guided arterial puncture. Perhaps the days of long waits for ABG data while multiple needle sticks are performed in the pursuit of a single arterial sample may soon be behind us.

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