The Usual Vascular Access

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The most frequent access for routine cardiac catheterisation is through the femoral artery and vein. Almost every position within the heard can be reached over these two vessels. The only exception is the pulmonary position in children with partial bidirectional cavopulmonary anastomosis. Therefore, access through one of the major veins of the upper part of body is needed, either the jugular or the subclavian veins.

Accurate vessel puncture requires either orientation on the surface anatomy or direct visualisation of the target vessel by ultrasound.

Local anaesthesia effectively diminishes pain and reduces complications related to patient movement. Gradually, injection of small volumes is preferable than an excess of volume that causes more pain and distorts the anatomy.

In general, forcing the guidewire almost never results in success [1].

5.1 Femoral Venous and Arterial Access

5.1.1 Positioning and Anatomic Landmark Guidance

Especially in small children, a rolled towel under the buttock may facilitate access of the femoral vessels. The legs should be fixed in a slightly outward rotated position.

Technique:

- Landmark is the inguinal ligament (Fig. 5.1).
- Puncturing level is at the inguinal skin crease or just below.
- For arterial puncture, the needle should be advanced targeting the umbilicus; the vein runs parallel to the artery.

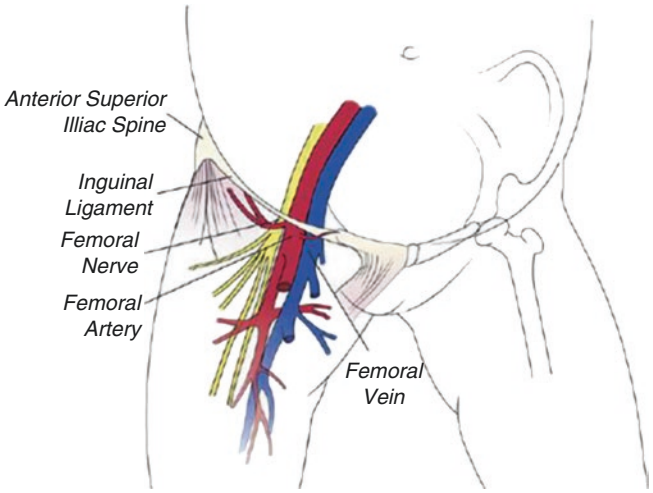

Fig. 5.1 Landmarks of the femoral artery and vein access. The inguinal ligament runs between the superior iliac spine and the pubic tubercle. The femoral artery crosses the inguinal ligament at approximately its midpoint and should be palpated there. The femoral vein runs closely medial and parallel to the artery (from Bergersen [2], with permission)

- The angle is flat in the newborn (10°–20°) and steepens with age (45°–60° in the adults).
- Introduce gently the guidewire; it should pass with minimal resistance.
- Once the guidewire is positioned, the needle should be removed and the sheath-dilator assembly advanced with a rotatory motion.

The direction of the artery can also be checked by simultaneous palpation of the pulse with two or three fingers. For venous puncture, it is helpful to advance the needle with a syringe attached under continuous suction. Some operators prefer to puncture the artery without a syringe attached. Free pulsatile flow might be easily identifiable.

If the guidewire cannot be advanced gently but a backflow of blood is still visible, it is probable that the vessel was not hit appropriately. Then a slight change of the direc-

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tion, or the angle of the needle might facilitate the advancement of the guidewire. If this is still not possible, the needle and guidewire should be removed and a new attempt performed.

5.1.2 Ultrasound-Guided Puncture

Routine use of real-time ultrasound guidance reduces the number of attempts, time to access, and risk of vascular complications [3].

Possible transducers:

- A hockey stick or a 12 MHz for newborns and small children
- A 6 MHz or linear transducer for adults

Real-time ultrasound guidance can be performed either in a long-axis or a short-axis approach. Especially in small children, visualisation of the vessels in the long axis might be advantageous because needle and vessel can be visualised at the same time.

Technique:

- Transducer and cord should be inserted into a sterile sheath (Fig. 5.2).
- Distinguish the vessels—the vein is compressible and located medial to the artery; colour flow or Doppler imaging can distinguish the vessels, too.
- Optimise image quality (maximise the transducer frequency and the sector field focus; adjust the gain setting, able to detect low-velocity flow)
- Once the entire course of the target vessel is visualised, the position of the transducer should not be changed.

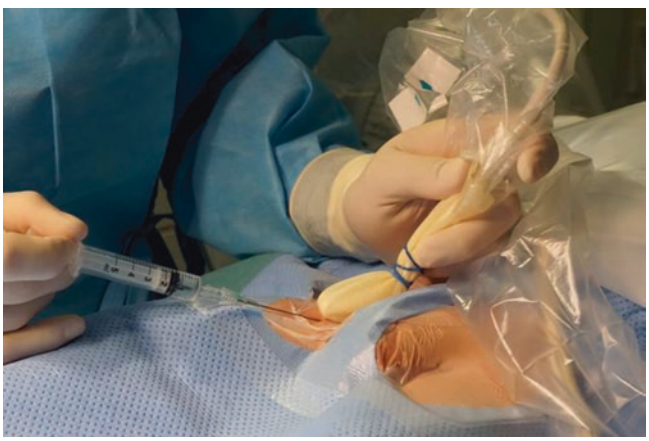

Fig. 5.2 A hockey stick array placed inside a sterile sheath. The needle is placed directly to the contact face of the transducer

- Introduce the needle closely to the contact face of the transducer and advance it in the same direction until it penetrates the vessel wall.

If the vessel and needle cannot be visualised at the same time, it is mostly because the tip of the needle is outside the ultrasound beam of the array. Changing the position of the transducer to pick up the needle is mostly not helpful. It is better to adjust the needle to the long axis of the transducer.

Introduction of the guidewire and of the sheath-dilator assembly is performed in the same manner as for anatomic landmark guidance.

5.2 Internal Jugular Vein Access

5.2.1 Positioning and Anatomic Landmark Guidance

The patient should be positioned supine with a rolled towel under the shoulders and the head turned to the contralateral side of the puncture. A slight Trendelenburg position of approximately 10°–15° will facilitate vessel access because it increases the diameter of the vein. An overextension or overrotation of the head will inadvertently compress the jugular vein.

The right internal jugular vein is preferred over the left one since:

- The apex of the lung is lower on the right side.
- The path to the atrium is more direct.
- There is less risk of damaging the thoracic duct.

5.2.2 Ultrasound-Guided Puncture

For ultrasound-guided puncture of the internal jugular vein (IJV), the anterior approach is the most appropriate. Mostly, the IJV lays anterolateral to the carotid artery, but anatomic variations with a complete anterior or lateral position are possible.

- A gentle probe pressure will compress the vein and will help to avoid arterial puncture according to the close relationship of both vessels, but both vessels can be differentiated sufficiently either by pulsation of the artery or by colour flow Doppler.
- The short axis will visualise both vessels at the same time, helping to distinguish them, while the long axis will help to rule out the direction in which the needle has to be advanced.
- Puncturing technique is the same as for femoral vessel cannulation.

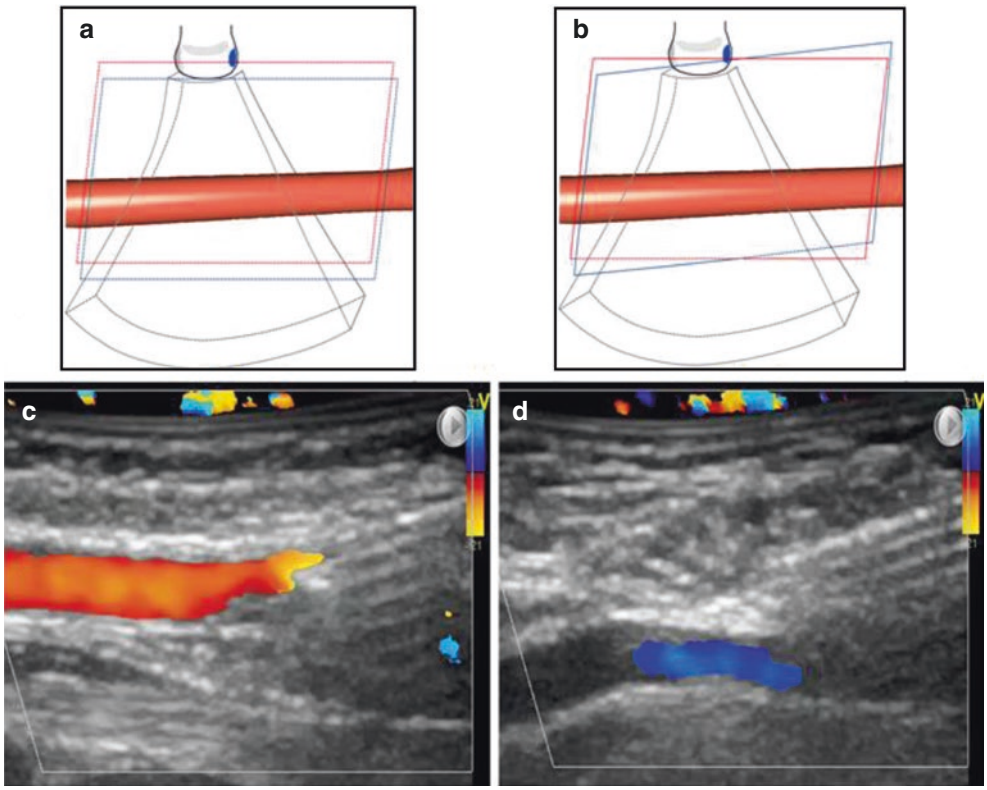

Fig. 5.3 Technique of ultrasound-guided puncture. The transducer should be aligned to the course of the vessel—red plane in (**a**) and (**b**). If the needle is advanced in the same plane—blue plane in (**a**) the tip and distal parts of the needle become visible (**c**). Notice aliasing in the colour flow image in (**c**), as the tip of the needle penetrates the vessel wall. In (**b**) the plane in which the needle is introduced—blue plane is not aligned to the red plane of the transducer and the vessel. The vessel cannot be hit appropriately. In the corresponding ultrasound image (**d**) just mid parts of the needle are visible. The tip of the needle is near the vessel—as the vessel course is distorted—but not visible

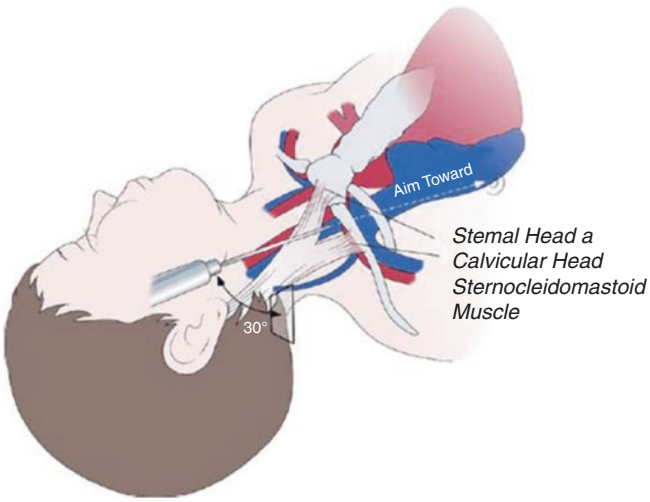

Fig. 5.4 Landmarks of the internal jugular vein access. The essential surface anatomy is a triangle comprised of the sternal and clavicular heads of the sternocleidomastoid muscle medially and laterally and the medial third of the clavicle inferiorly, named the Sedillot's triangle. The internal jugular vein lies underneath this triangle and is located laterally to the carotid artery (from Bergersen [2], with permission)

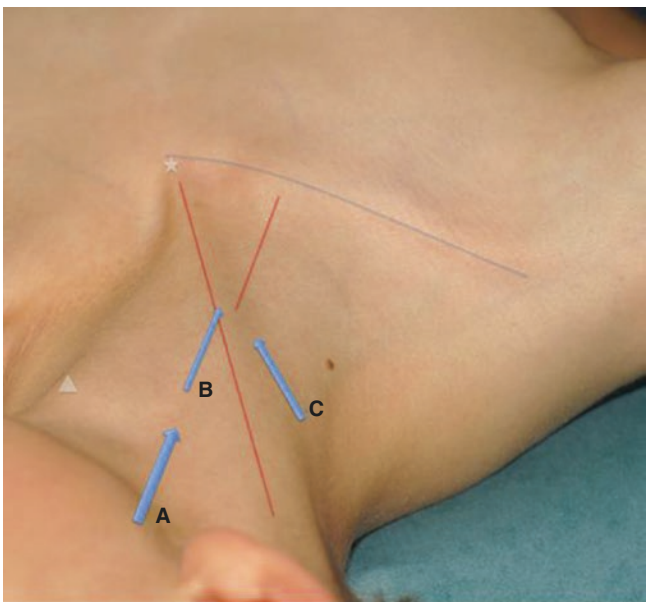

Fig. 5.5 Three approaches to the internal jugular vein. The blue line represents the course of the clavicle. The red lines show both heads of the sternocleidomastoid muscle. Star—suprasternal notch. Triangle—thyroid cartilage. (*A)* For the *anterior approach*, the needle is introduced at the medial margin of the sternocleidomastoid muscle approximately at the level of the thyroid cartilage and directed towards the ipsilateral nipple; (*B)* for the *middle route*, the needle enters the apex of the triangle formed by both heads of the sternocleidomastoid muscle and the clavicle and also directed towards the ipsilateral nipple; (*C*) in the *posterior route,* the needle should be introduced along the lateral margin of the sternocleidomastoid muscle cephalad to the apex of the Sedillot's triangle. In this case, it should be directed towards the suprasternal notch

5.3 Subclavian Vein Access

Because of attachments of the subclavian vein to surrounding tissues, the vein remains patent even in hypovolemic patients.

- A slight Trendelenburg position of the patient will not increase the diameter of the vessel but will avoid complications of air embolism.
- The head should be kept neutral, as an excessive rotation to the contralateral side will increase the angle between the internal jugular and the subclavian vein, facilitating the advance of the guidewire into the IJV or the anonymous vein.
- The needle should be advanced parallel to the floor targeting the suprasternal notch.
- A close puncture to the clavicle is disadvantageous because the needle has then to be directed posteriorly to negotiate with the clavicle—this will increase the risk for pneumothorax.

The vein can be located by ultrasound, but because of the anatomic position between the clavicle and first rib, real-time ultrasound localisation during puncture is difficult. Ultrasound localisation without real-time ultrasound guidance does not offer advantages.

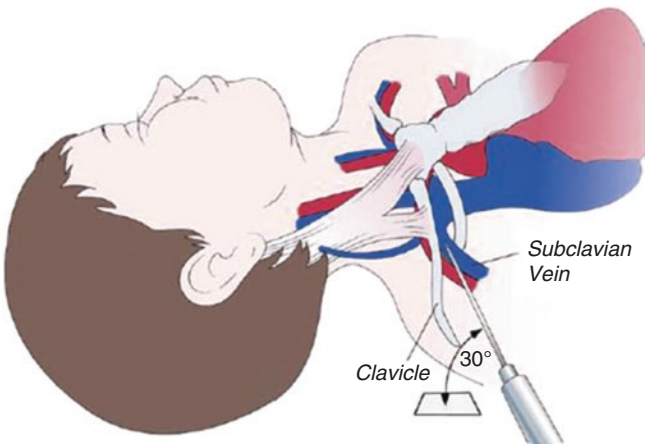

Fig. 5.6 Landmarks of the subclavian vein access. The subclavian vein lies between the first rib and the clavicular bone and is bordered posterior by the subclavian artery and brachial plexus. The anatomic landmark is the junction of the medial one third and lateral two thirds of the clavicular bone. From medial, this corresponds to the first slope of the bone when the anterior convexity goes on to the anterior concavity. The cutaneous puncture should be inferiorly and laterally to this point (from Bergersen [2], with permission)

5.4 Umbilical Venous Access

Catheterisation of the umbilical vessels (two arteries and one vein) is well described in neonatal textbooks and is a standard procedure in the neonatal care.

- Catheterisation of the vessels is performed with a 3.5 or 5 F umbilical catheter.
- The 3.5 F catheter takes a 0.021″ and the 5 F catheter a 0.025 “guidewire.
- If these catheters are in place, they can be cut with a scalpel short above the umbilicus, and a sheath can be inserted over a guidewire.

Problems:
Umbilical vein

- The guidewire and catheter are difficult to manoeuvre into the ductus venosus due to the entering of the portal vein.
- Withdraw the catheter into the umbilical vein and give a small injection of contrast to delineate the course of the ductus venosus into the IVC.

Umbilical artery

- It might be difficult to advance the guidewire into the aorta due to the tight curves of the umbilical artery entering the iliac artery.
- A normal straight guide may be more suitable than a torque guidewire.

5.5 Radial Artery Access

Positioning and landmarks

- The arm is abducted 90 ° and positioned on an arm support.
- Slight elevation of the wrist by a cotton swab and fixation of the hand is advantageous.
- The landmarks are the distal ends of the radial and ulnar bone and the radial pulse.

Technique:

- The needle entry superficially with a 30 ° angle without a syringe attached
- Advance until jerks of pulsating blood will flow

References

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3. Seto AH, et al. Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial). JACC Cardiovasc Interv. 2010;3(7):751–8.