Video Article

The Supraclavicular Fossa Ultrasound View for Central Venous Catheter Placement and Catheter Change Over Guidewire

Se-Chan Kim[1], Christian Klebach[1], Ingo Heinze[1], Andreas Hoeft[1], Georg Baumgarten[1], Stefan Weber[1]

[1]Department of Anesthesiology and Intensive Care Medicine, University Hospital Bonn

Correspondence to: Se-Chan Kim at Se-Chan.Kim@ukb.uni-bonn.de

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Abstract

The supraclavicular fossa ultrasound view can be useful for central venous catheter (CVC) placement. Venipuncture of the internal jugular veins (IJV) or subclavian veins is performed with a micro-convex ultrasound probe, using a neonatal abdominal preset with a probe frequency of 10 Mhz at a depth of 10-12 cm. Following insertion of the guidewire into the vein, the probe is shifted to the right supraclavicular fossa to obtain a view of the superior vena cava (SVC), right pulmonary artery and ascending aorta. Under real-time ultrasound view, the guidewire and its J-tip is visualized and pushed forward to the lower SVC. Insertion depth is read from guidewire marks using central venous catheter. CVC is then inserted following skin and venous dilation. The supraclavicular fossa view is most suitable for right IJV CVC insertion. If other insertion sites are chosen the right supraclavicular fossa should be within the sterile field. Scanning of the IJVs, brachiocephalic veins and SVC can reveal significant thrombosis before venipuncture. Misplaced CVCs can be corrected with a change over guidewire technique under real-time ultrasound guidance. In conjunction with a diagnostic lung ultrasound scan, this technique has a potential to replace chest radiograph for confirmation of CVC tip position and exclusion of pneumothorax. Moreover, this view is of advantage in patients with a non-p-wave cardiac rhythm were an intra-cardiac electrocardiography (ECG) is not feasible for CVC tip position confirmation. Limitations of the method are lack of availability of a micro-convex probe and the need for training.

Video Link

The video component of this article can be found at https://www.jove.com/video/52160/

Introduction

Central venous catheter (CVC) tip position has to be confirmed since misplaced catheters can lead to trauma and erosion of endothelium and vessel walls with subsequent potentially fatal pericardial tamponade[1]. Furthermore, CVC in the upper superior vena cava (SVC) can provoke thrombotic events, especially in cancer patients. The same is true for misplaced CVC in opposite brachiocephalic vein or internal jugular vein (IJV)[2].

Several methods have been established to confirm CVC tip position in the lower SVC. Chest radiograph has been performed traditionally as a bedside method to visualize the CVC tip and exclude pneumothorax. However, additionally to exposure to radiation and costs, the accuracy of chest radiograph for tip position and sensitivity for pneumothorax have been questioned, specifically for the patient in a supine position[3]. Computer tomography is highly accurate and sensitive for both CVC tip position and pneumothorax, respectively. However, the costs and exposure to radiation do not justify this method for the sole indication of CVC tip confirmation. Transesophageal echocardiography (TEE) is highly accurate for tip position, but indication for TEE is limited to patients with cardiac pathology[4]. Intra-cardiac electrocardiography (ECG) is an accurate method but depends on a p-wave cardiac rhythm[5].

Parasternal and subcostal ultrasound view were suggested to verify the CVC tip position, but success depends on deep insertion of the guidewire into the right atrium. A negative result does not exclude misplaced catheters[6,7]. The right supraclavicular fossa ultrasound view has been solely described for diagnostic purposes in cardiac failure. In a pilot study, we have demonstrated that this view can also be safely used for venipuncture of the right IJV and accurate positioning of the CVC guidewire with subsequent CVC placement in real-time[8]. The right supraclavicular fossa ultrasound view can be established with a microconvex probe which has the advantage of a small footprint, deep pentetration and, yet a sufficient resolution for venipuncture when compared to a linear probe[8-10].

The proposed procedure has the advantage of visualizing venipuncture and guidewire advancement with a single ultrasound probe within the sterile field in real-time. CVCs insertion length does not have to be corrected afterwards and extra manipulations and potential sources of contamination are prevented. In conjunction with lung ultrasound for exclusion of a pneumothorax, the proposed procedure has the potential to replace chest radiograph for CVC tip position confirmation and exclusion of pneumothorax, reducing costs and exposure to radiation and increasing patient comfort in any hospital setting where an ultrasound machine equipped with a microconvex ultrasound probe is available.

Protocol

NOTE: The following protocol follows our internal guidelines and standard operation procedures approved by the chair of our department. The same protocol was approved by our institutional review board and was used for studies published in a previous paper[8].

1. Pre-ultrasound Scan Preparation

1. Place the patient in a supine position with an optional elevated head of bed or stretcher for comfort if the patient is awake.
2. Position the ultrasound machine in a line with operator´s position and the puncture site to prevent operator´s head or body twisting to see the display. Turn on the ultrasound machine and connect the micro-convex ultrasound probe.
3. Choose a pre-set that allows deep tissue penetration, *e.g.,* set probe to 8 MHz or lower. Use alcoholic disinfection on skin for acoustic coupling of the ultrasound probe.

2. Ultrasound Scan of the CVC Insertion Site and Superior Vena Cava

1. Place the micro-convex ultrasound probe on the puncture site.
   NOTE: A B(rightness)-mode short axis view and out of plane puncture technique is preferred. Adjust gain, depth and focus position for an optimal image.
2. Confirm vein by applying pressure to test for compressibility and to exclude thrombus at puncture site. Use color flow doppler if there is uncertainty. Move ultrasound probe centrally to detect potential thrombus.

3. Supraclavicular Fossa Ultrasound View

1. Place the ultrasound probe in the right supraclavicular fossa to obtain a view of the confluence of the internal jugular vein and subclavian vein to detect a potential thrombus. Change gain, depth and focus using knobs of the ultrasound machine.
   NOTE: Set gain high enough to differentiate between hyperechoic vessel walls and hypoechoic vessel lumen. Set depth (10-12 cm) to have a full view of the SVC and right pulmonary artery (RPA). Set the Focus to the level of the RPA.
2. Increase depth (4-6 cm) using the knob of the ultrasound machine to obtain a view of the confluence of the brachiocephalic veins. This will also correspond to the beginning of the upper superior vena cava. Adjust depth (10-12 cm) and angulation of the ultrasound probe to obtain a full longitudinal view of the superior vena cava, adjacent ascending aorta and right pulmonary artery.
   NOTE: Probe frequency will be adjusted by the ultrasound machine depending on depth of imaging.
3. Evaluate the brachiocephalic veins and the superior vena cava for intravenous thrombus. Turn the ultrasound probe 90° clockwise to obtain a sagittal view of the superior vena cava. Observe the right pulmonary artery in short axis dorsal of the lower superior vena cava. Additionally, observe a short axis view of the pulmonary veins distal of the right pulmonary artery. Use optional Doppler to confirm superior vena cava.

4. Ultrasound Guided Venipuncture

1. Prepare CVC kit and dress with sterile gown and gloves. Disinfect skin with alcohol wipes and apply sterile drapes. Insert ultrasound probe into a sterile cover. Ultrasound guided venipuncture can be performed in non-sedated as well as in anesthetized patients.
   NOTE: For non-sedated patients a local infiltration anesthesia before venipuncture is highly recommended.
2. Obtain an ultrasound view of the vein to be punctured. Right-handed operators use the needle attached to a syringe in the right hand and the ultrasound probe in the left hand.
3. Perform a venipuncture under ultrasound guidance.
   NOTE: Out of plane and in plane techniques are both appropriate.
4. Following venipuncture, insert the guidewire through the needle. At this point, a long axis view of the vein can confirm the guidewire within the vein.

5. Ultrasound Guided Guidewire Advancement

1. Switch ultrasound probe to the right hand. Obtain a view of the superior vena cava by adjusting depth and focus position of the ultrasound image (**Figure 3A** and supplemental video loop).
   NOTE: This has to be done by an assisting person or by the operator himself if the ultrasound machine is operated with a sterile cover. Angulation of the ultrasound probe needs to be in a small angle in relation to neck.
2. Advance the guidewire with the left hand. Do not introduce the guidewire too far into the superior vena cava because this will make it difficult to identify the guidewire tip. Visualize the guidewire J-tip during advancement and crossing of the upper wall of the right pulmonary artery (**Figure 3B**).
3. If the ultrasound beam cannot be aligned with the J-tip and the right pulmonary artery, use the ascending aorta as a landmark. Turn the ultrasound probe 90° clockwise to obtain a sagittal view of the superior vena cava. With this view, confirm the guidewire position relative to the right pulmonary artery observed in the short axis.

6. Measurement of Insertion Depth

1. Use the central venous catheter to measure the insertion depth of the guidewire. In order to do so, align the 20 cm markings of the CVC and the guidewire and read the cm marking at the venipuncture site.

NOTE: The guidewire has markings at 10, 20 cm and at the position indicating that the J-tip leaves the distal lumen. These markings may be different depending on the manufacturer. Be careful not to move the guidewire.
NOTE: From this point on, complete placement according to standard hospital protocol, including dilation of skin and vein, insertion of the CVC over guidewire, aspiration and flushing and suture.

7. Lung Ultrasound

1. In the perioperative setting, perform a lung ultrasound examination in the patient to exclude pneumothorax following CVC placement.
   NOTE: This procedure has been described by Lichtenstein *et al.*[11].
2. Place the ultrasound probe in all four quadrants of the anterior chest bilaterally to obtain view in B-mode for lung sliding and M-mode for seashore sign. Preferably use a linear ultrasound probe. For obese patients, use an ultrasound probe with higher penetration, *e.g.,* curved array or micro-convex probes.

8. Central Venous Catheter Change Over Guidewire

NOTE: CVC change over guidewire is a single contributor to catheter-related blood stream infection and should be avoided. In patients with a high risk of mechanical complication related to CVC insertion or limited venous access, CVC change over guidewire still can be considered[12].

1. In case of a misplaced central venous catheter (not using the ultrasound guided tip position method), obtain a supraclavicular view to advance the guidewire into the correct position. Under sterile conditions, introduce a guidewire into the distal lumen of the misplaced central venous catheter. Change of a CVC over a guidewire with ultrasound guidance works in non-sedated patients as well as in anesthetized patients.
   1. Pull back the central venous catheter. Visualize the guidewire from thesupraclavicular fossa view.
   2. Advance the guidewire into the correct position in the superior vena cava. Introduce the new central venous catheter over the guidewire.
   3. From this point on, complete procedure according to standard hospital protocol.

Representative Results

In a previously published study, chest radiographs were obtained in all patients following ultrasound guided CVC placement[8]. The CVC tip position in relation to the carina on chest radiographs was analysed by a radiologist who confirmed a correct position of the CVC in the lower SVC in all investigated patients. In 90% of all cases CVC tip was within 35 mm distance of the carina. In 17% the CVC tip was above, in 19% at the level of and in 64% below the carina. In 4% the CVC tip was more than 55 mm below the carina (**Figures 1-2**).

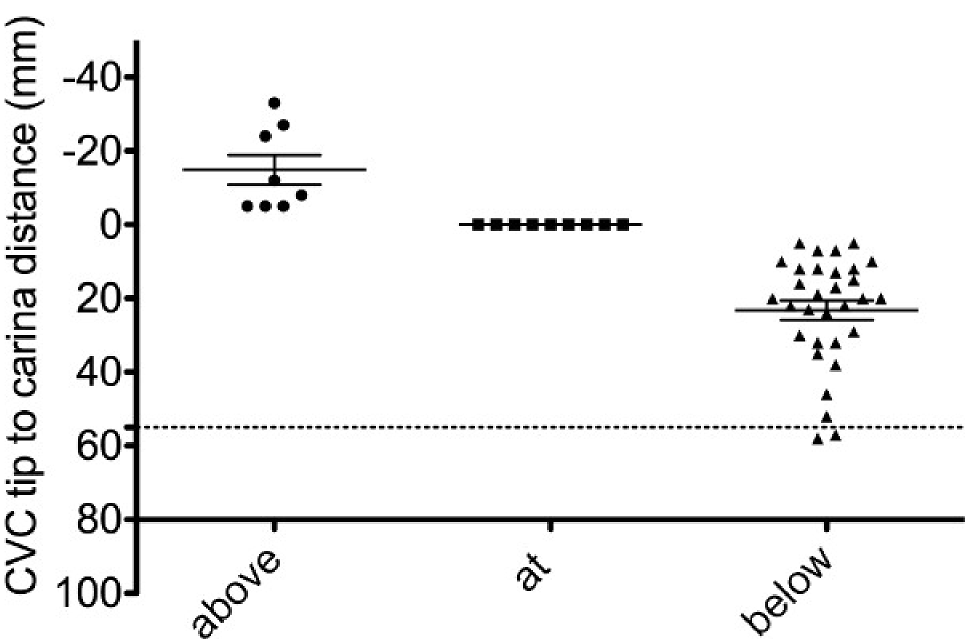

Figure 1: Distance of CVC tip to carina in mm measured in chest radiographs following ultrasound guided CVC tip positioning. This figure has been modified from Kim *et al.*[8]. Chest radiograph confirmed correct position in all patients with 90% of all tips within 35 mm distance of the carina.

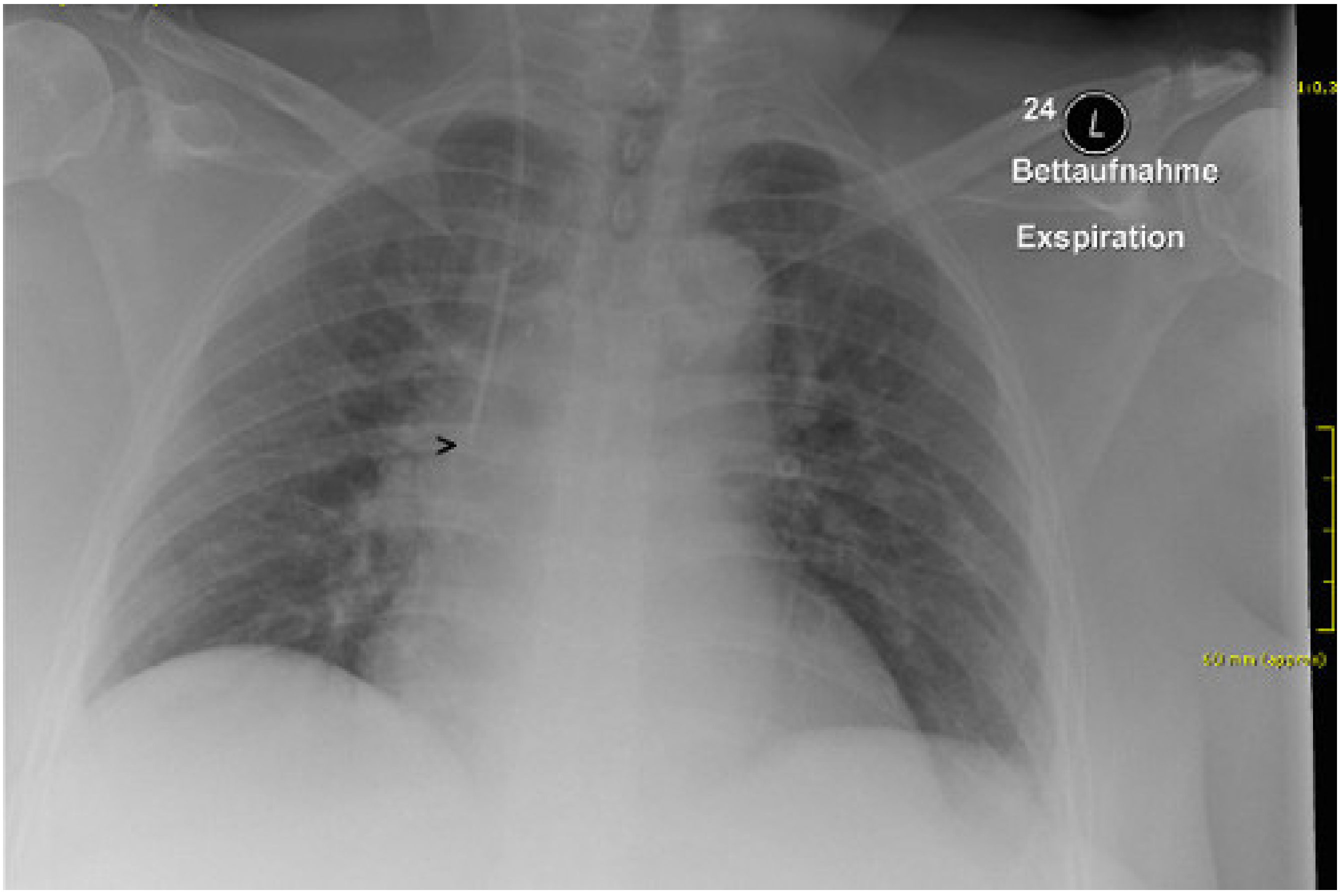

Figure 2: Representative chest radiograph following ultrasound-guided CVC tip positioning in supine position and exspiration. The CVC tip (arrow) is in projection of the distal superior vena cava.

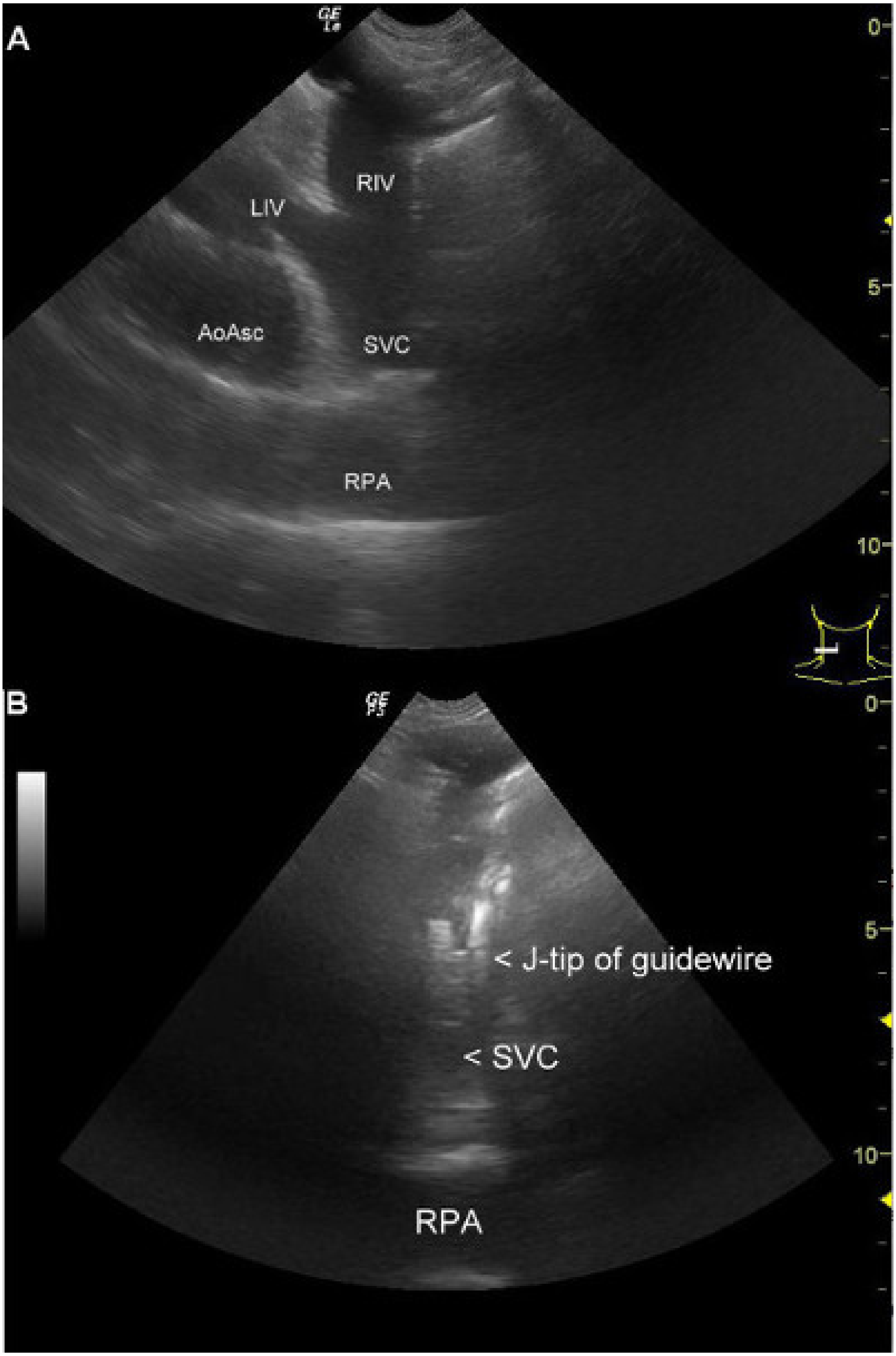

Figure 3: (A) Representative ultrasound image of the superior vena cava (SVC), right and left innominate veins (RIV/LIV), ascending aorta (AoAsc) and right pulmonary artery (RPA). **(B)** Representative ultrasound-guided guidewire advancement. J-tip of the guide wire is visualized in the mid-portion of the SVC. The RPA can be seen as a hypoechoic band in the far field.

Discussion

This procedure allows for visualization of ultrasound guided venipuncture and central venous catheter tip position in real time via the right supraclaviculare fossa view. In combination with a lung ultrasound scan, this approach could replace chest radiograph for confirmation of catheter tip position and exclusion of a pneumothorax.

It is critical for ultrasound trained operators to become familiar with the ultrasound anatomy provided by the supraclavicular fossa view and correctly identify the anatomical landmarks. Moreover, it is crucial to adjust the angulation of the ultrasound probe with respect to the neck to a very narrow angle which can be best achieved with small probes. Little adjustments need to be performed to achieve an optimal view of the long axis of the SVC. Furthermore, advancing of the guidewire with one hand while performing the ultrasound scan with the other hand, requires training. In some case, it is not possible to align the ultrasound beam with the J-tip and the right pulmonary artery which could be solved by turning the probe into a sagittal view.

Best results will be obtained by micro-convex and similarly by phased array ultrasound probes due to their small contact surfaces and high penetration depth when compared to linear probes[9]. Curved abdominal ultrasound probes may also be used but may be difficult to handle because of their large surface and body. As with every ultrasound image, settings like gain, depth and focus position have to be modified to achieve optimal results.

A micro-convex probe might not be available at every hospital since it is a pediatric ultrasound probe. Ultrasound presets should allow deep tissue penetration. Other ultrasound probe types are potentially feasible but the results might not be optimal. Currently, there is limited data on the feasibility of this approach in obese patients. In 8% of the study population the J-tip was not visible in proximity of the right pulmonary artery. However, we did not test if a sagittal view would allow a better visualisation[8].

Intra-cardiac ECG, transesophageal echocardiography and other transthoracic echocardiographic views have been suggested for confirmation of a central venous catheter tip. However, these approaches have limitations. Intra-cardiac ECG is restricted to patients with a p-wave cardiac rhythm while the incidence of patients with atrial fibrillation and atrial flutter is increasing. It is a highly sensitive, cost-effective method[5]. Some cases have been reported with intra-aortic central venous catheter tips and positive high p-wave. Furthermore, no change of the p-wave is suggestive for a misplaced catheter which can then only be verified by chest radiograph[13]. Furthermore, a chest radiograph is still necessary for exclusion of a pneumothorax if venipuncture was not performed with ultrasound. Transesophageal echocardiography is indicated in those patients who have a cardiac pathology and are undergoing cardiac surgery[4]. At the time of echocardiography, the position of a central venous catheter can only be corrected if the catheter is visualized, and was inserted deep enough to retract for a correct tip position. Catheters in other positions can only be changed over a guidewire under sterile conditions.

Using the right supraclavicular fossa view, chest radiography for confirmation of the correct CVC position may be redundant if in addition a lung ultrasound is performed to exclude a pneumothorax. Furthermore, ultrasound guided change of a misplaced CVC over guidewire is feasible without subsequent chest radiography.

Disclosures

The authors declare that they have no competing financial interests.

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