

Sono-guided vessel access & intervention

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Introduction

- Mode: B-mode and Doppler mode
- Probe: Higher frequency probes (>7 MHz) are preferred over lower frequency probes (<5 MHz)
- probe orientation relates to the image display.
- Probe movement

Probe orientation

- structures beneath the left aspect of the ultrasound probe marker (denoted by a light or a notch on the side of the probe) are always displayed on the left side of the imaging screen.
- when working from the head of the bed, as is often done for internal jugular vein access, the probe marker should be oriented towards the operator's left (also the patient's left) for both right and left internal jugular vein access.

Probe orientation

- When working from beside the patient, as for femoral vein central line or peripherally-inserted central catheter (PICC) insertion, this marker should be oriented to the patient's right on transverse views. Using this orientation, the patient's right will be displayed on the left-hand side of the ultrasound monitor.



The center probe, a linear 12-5 MHz transducer, is most often used for peripheral vascular imaging. The left-hand probe, called a "hockey stick", can be useful in tight locations. The right-hand probe is a curved, lower frequency transducer that allows for greater tissue penetration in obese patients.

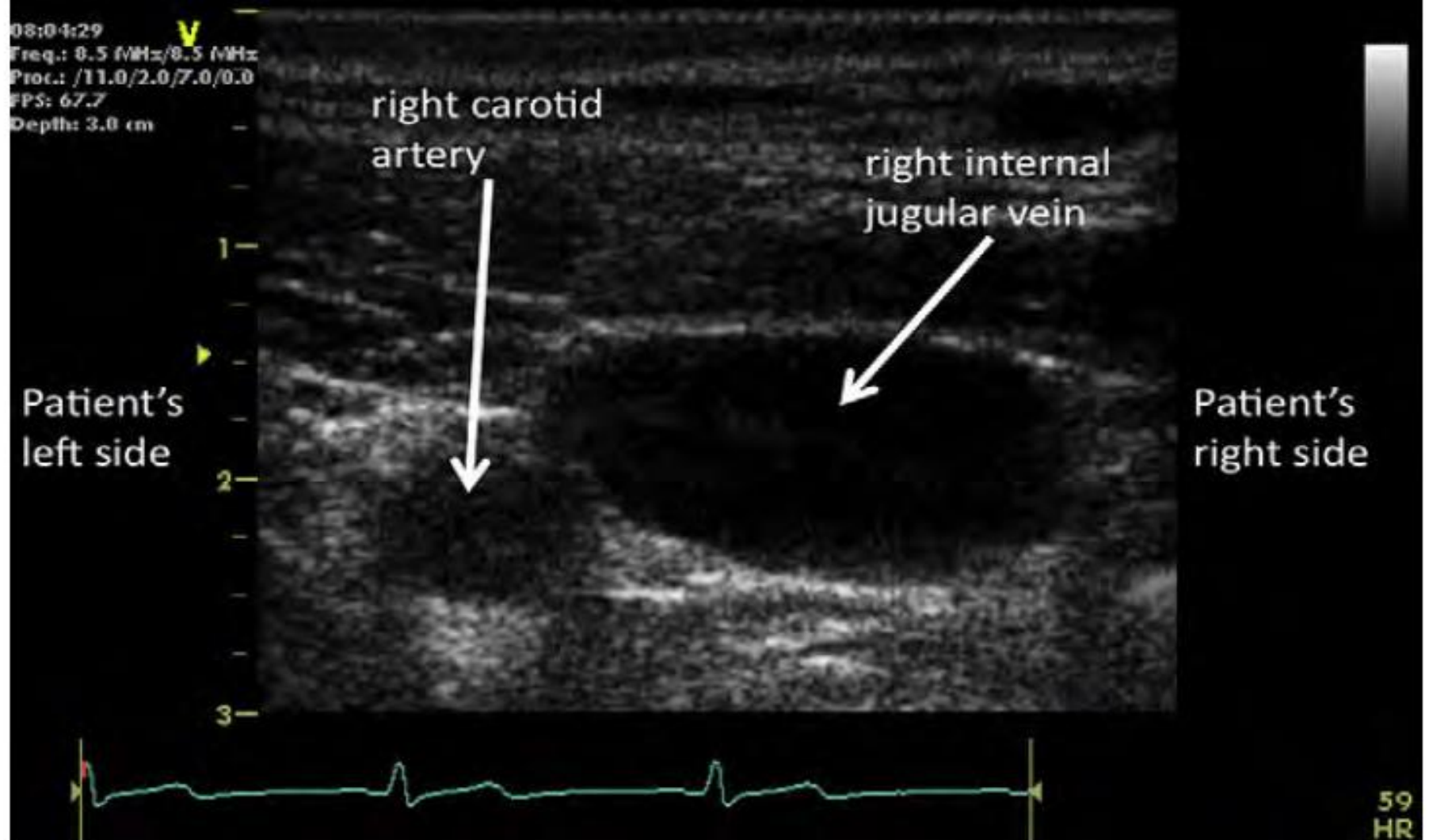


Figure 1 Right neck central vein cannulation. The ultrasound probe is held so that each side of the screen displays ipsilateral structures. With the probe mark placed on the upper left corner of the image, the displayed structures will move in the same direction with the probe.

영상유도천자 Vs 해부학적 천자

- Higher primary puncture rate
- Nearly 100% success rate
- Rare complication
- Shorter procedure time

Indications/Contraindications

- real-time ultrasound imaging during needle placement reduces time to venous cannulation and reduces the risk of complications during central venous and peripheral venous access.
- When used appropriately by qualified personnel, there are no absolute contraindications to using ultrasound as a procedural adjunct for vascular guidance.

Indications/Contraindications

- The subclavian vein is more difficult to localize than the femoral or internal jugular vein because of the proximity of the clavicle.
- Moderate to severe volume depletion may interfere with ultrasound localization of venous structures.

Qualifications of the Ultrasound User for Vascular Access

Table 2 Recommended training objectives for ultrasound-guided vascular cannulation

Cognitive skills

1. Knowledge of the physical principles of ultrasound
2. Knowledge of the operation of the ultrasound equipment, including the controls that affect the imaging display
3. Knowledge of infection control standards for performing vascular access and sterile preparation of the ultrasound probe for real-time use
4. Knowledge of the surface anatomy specific to the access site and ultrasound anatomy that allows identification of the target vessel and structures that are to be avoided
5. Ability to recognize the location and patency of the target vessel
6. Ability to recognize atypical anatomy of vessel location and redirect the needle entry to minimize complications
7. Knowledge of the color flow and spectral Doppler flow patterns that identify arterial and venous flow characteristics

Technical skills

1. Ability to operate the ultrasound equipment and controls to produce quality information to identify the target vessel
2. Dexterity to coordinate needle guidance in the desired direction and depth on the basis of the imaging data
3. Use of needle guides for coordination of needle insertion with imaging data when operator dexterity is lacking or clinical conditions make dexterity coordination challenging
4. Ability to insert the catheter into the target vessel using ultrasound information
5. Ability to confirm catheter placement into the target vessel and the absence of the catheter in unintended vessels and structures

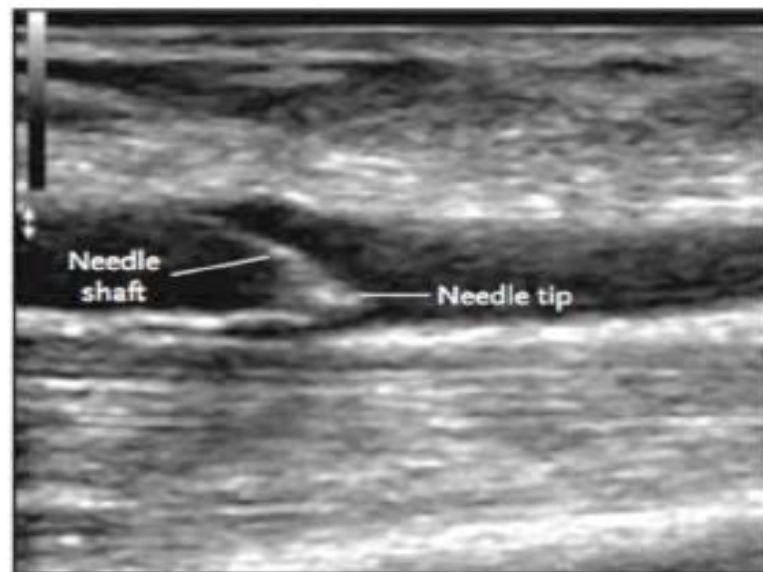
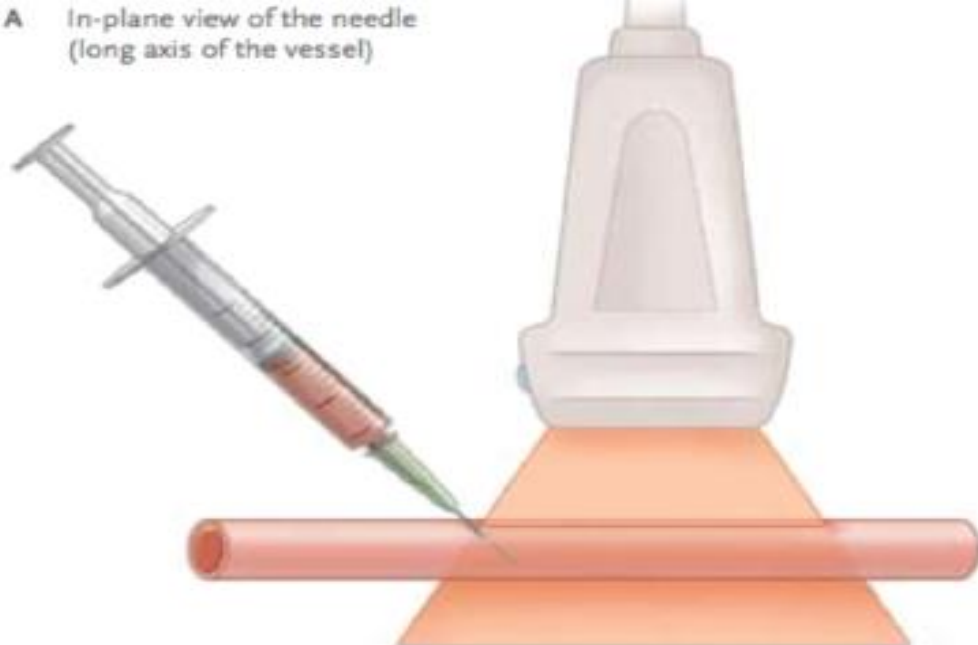
Short-Axis Vs Long-Axis Visualization

- Short-Axis: Out-of-Plane

Long-Axis : In-Plane

- The short-axis view allows the needle approach to be over the center of the vein.
- The long-axis view has the advantage of allowing visualization of the entire needle shaft and tip.
- No different in time and complications required for vascular access regardless of short axis or long axis technique

A In-plane view of the needle
(long axis of the vessel)



B Out-of-plane view of the needle
(short axis of the vessel)

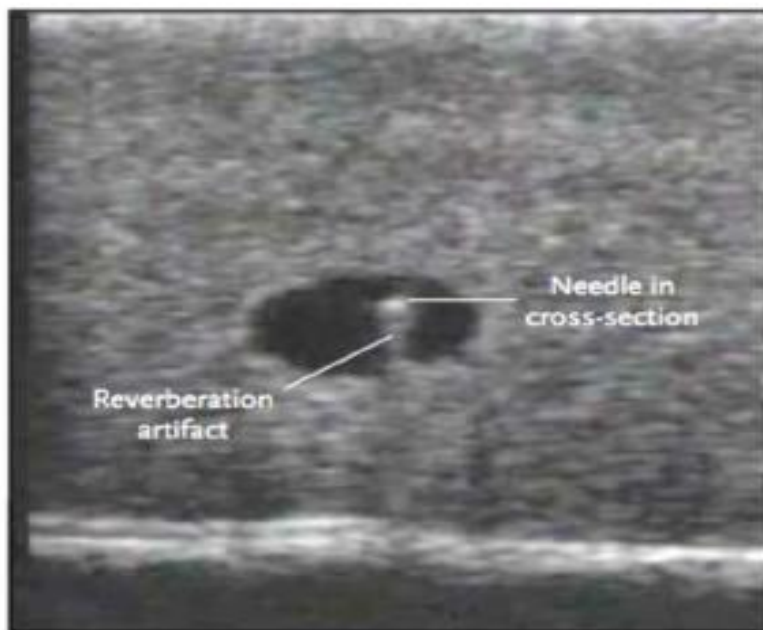
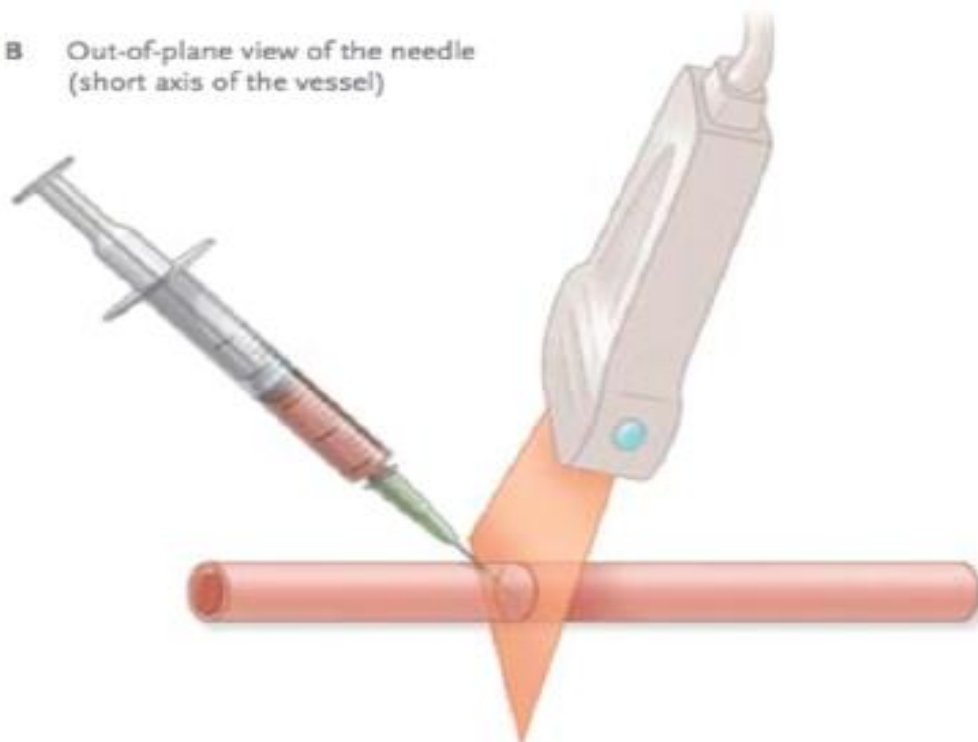


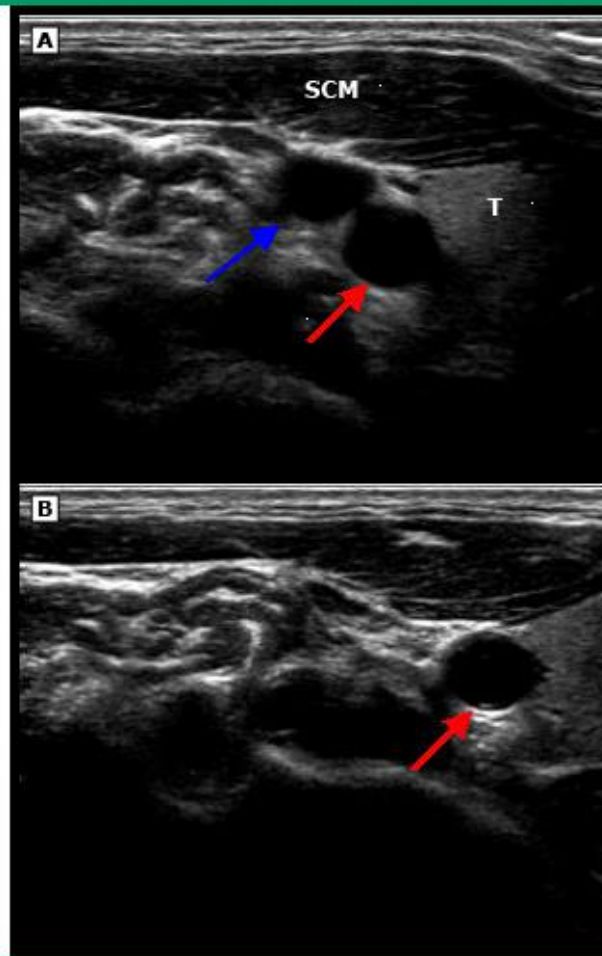


Figure 2. Linear array transducer with needle guide attachment¹⁰.

Differentiating Arteries From Veins

- Veins are distinguished from arteries on ultrasound because they have thinner walls, are more easily compressed, may have visible valves, and lack arterial pulsations.
- veins usually distend with maneuvers that impede or augment venous return, such as application of limb tourniquets, the Valsalva maneuver, and putting the patient in the Trendelenburg position.
- Doppler imaging may also be used to identify blood flow and to help differentiate arterial from venous flow.

Ultrasound of normal neck vessels



Transverse ultrasound images of the right neck demonstrate normal anatomy, including the internal jugular vein (blue arrow), common carotid artery (red arrow), sternocleidomastoid muscle (SCM), and thyroid gland (T). B shows collapse of the internal jugular vein when compression is applied with the transducer. The carotid artery is not easily compressed with light probe pressure.

Courtesy of Lauren W Averill, MD.

Static Vs Dynamic Ultrasound Guidance

- The static approach uses ultrasound to determine the vessel location and patency, assess surrounding structures, and mark the location to provide optimum placement for needle introduction. After determining this location, the procedure is performed without real-time ultrasound.

Static Vs Dynamic Ultrasound Guidance

- In a dynamic approach, the procedure is performed using real-time ultrasound observation of needle entry and placement.(with a sterile technique that includes sterile gel and sterile probe covers)
- The dynamic approach allows for real-time visualization of the needle tip placement and has been shown to be superior to the static approach in most situations.

One-Person Vs Two-Person Technique

- Using dynamic visualization, it is possible for one person to perform the ultrasound while another person performs the procedure ("two-person dynamic approach").
- In a one-person dynamic approach, the person performing the procedure holds the needle with one hand while directing the ultrasound probe in the other hand.(most advanced practitioners, as it allows for real-time hand-eye coordination)

Site Selection and Preparation

- 1st: USG for the choice of site should include factors such as vessel size, depth, course, surrounding structures, and adjacent pathology such as cellulitis. Also vessel patency, course, and other anatomic issues such as vein valves.
- 2nd: preprocedural local anesthesia
- 3rd: skin preparation and Maximal sterile barrier precautions with probe cover kits (include sterile cover for the probe and sterile gel)

Performing the Procedure

- Using ultrasound to identify the depth of the center of the intended vessel, the point of skin entry should be about the same distance from the probe, assuming an approximately 45° angle, set back from the probe a distance approximately equivalent to the depth of the vessel (“triangulating” the path of the needle toward the vessel lumen)
- Trace the catheter or needle
- Vessel puncture: target sign, Doppler mode, double puncture technique(only PICC)

Use of Ultrasound After the Procedure

- Catheter, guide wire
- “postprocedure flush”: injecting a small amount (<10 mL) of saline that has been agitated with air and then had large air bubbles removed from the syringe. When the catheter is properly placed, injection of agitated saline produces hyperechoic contrast within the lumen of the vessel, verifying the proper position.

Ultrasound-Guided Central Venous Catheterization

Advantages and disadvantages of central vein approaches

Approach	Advantages	Disadvantages
External jugular	<ul style="list-style-type: none">Superficial vessel that is often visibleCoagulopathy not prohibitiveMinimal risk of pneumothorax (especially with US guidance)Head-of-table accessProminent in elderly patientsRapid venous access	<ul style="list-style-type: none">Not ideal for prolonged venous accessPoor landmarks in obese patientsHigh rate of malpositionCatheter may be difficult to thread
Internal jugular	<ul style="list-style-type: none">Minimal risk of pneumothorax (especially with US guidance)Head-of-table accessProcedure-related bleeding amenable to direct pressureLower failure rate with novice operatorExcellent target using US guidance	<ul style="list-style-type: none">Not ideal for prolonged accessRisk of carotid artery punctureUncomfortableDressings and catheter difficult to maintainThoracic duct injury possible on leftPoor landmarks in obese/edematous patientsPotential access and maintenance issues with concomitant tracheostomyVein prone to collapse with hypovolemiaDifficult access during emergencies when airway control being established

<p>Subclavian</p>	<p>Easier to maintain dressings</p> <p>More comfortable for patient</p> <p>Better landmarks in obese patients</p> <p>Accessible when airway control is being established</p>	<p>Increased risk of pneumothorax</p> <p>Procedure-related bleeding less amenable to direct pressure</p> <p>Decreased success rate with inexperience</p> <p>Longer path from skin to vessel</p> <p>Catheter malposition more common (especially right SCV)</p> <p>Interference with chest compressions</p>
<p>Femoral</p>	<p>Rapid access with high success rate</p> <p>Does not interfere with CPR</p> <p>Does not interfere with intubation</p> <p>No risk of pneumothorax</p> <p>Trendelenburg position not necessary during insertion</p>	<p>Delayed circulation of drugs during CPR</p> <p>Prevents patient mobilization</p> <p>Difficult to keep site sterile</p> <p>Difficult for PA catheter insertion</p> <p>Increased risk of iliofemoral thrombosis</p>

US: ultrasound; SCV: subclavian vein; CPR: cardiopulmonary resuscitation; PA: pulmonary artery.
 With permission from: Factor P, Sznajder JJ. Vascular cannulation. In: Principles of Critical Care, Hall JB, Schmidt GA, Wood LDH (Eds), McGraw-Hill, New York, 1992. Copyright 1992 McGraw-Hill.

Sono-guided Vs intervention complication

- Immediate(mechanical)
 - pneumothorax
 - accidental arterial puncture
- Early (Infectious)
 - catheter related infection or sepsis
- Late(thrombotic)
 - Stenosis
 - thrombosis

Immediate complication

(Accidental arterial puncture, hematoma, pneumothorax)

- Accidental arterial puncture:
femoral > jugular > subclavian approach
- Pneumothorax, hemothorax: subclavian > jugular

Early complication (Catheter related infection or sepsis)

- Femoral vein > Subclavian vein
- Internal jugular vein = Femoral vein ?
- Internal jugular vein = Subclavian vein

Catheter insertion site는 contamination의 가능성이 적은 곳으로 선택되어야 한다.

- 가능한 femoral은 피한다.
- burn or infected skin, adjacent tracheostomy site, open surgical wound를 피한다.

Late complication (Stenosis/Thrombosis Incidence)

Subclavian vs Internal Jugular

	Subclavian	Internal Jugular
Cimochowski(1990)	50%	0%
Schillinger(1991)	42%	10%
Trerotoal(2000)*	13%	3%

*thrombosis

초음파 유도천자(천자 정맥 결정)

- 천자 정맥 종류

 - internal jugular vein : 가장 선호 (특히 우측)

 - > subclavian vein

 - > Femoral vein

- Right Internal Jugular Vein

 - larger caliber

 - shorter and direct course

 - easy approach

 - less complication

Ultrasound Guidance for Internal Jugular Cannulation (general)

- ultrasound guidance for IJ vein cannulation improves first-pass and overall success rates and reduces the risk of procedure-related complications.
- ultrasound guidance for IJ vein insertion using real-time guidance is recommended.
- one-person dynamic ultrasound guidance is recommended for a CVC at the IJ vein site.

Ultrasound Guidance for Internal Jugular Cannulation

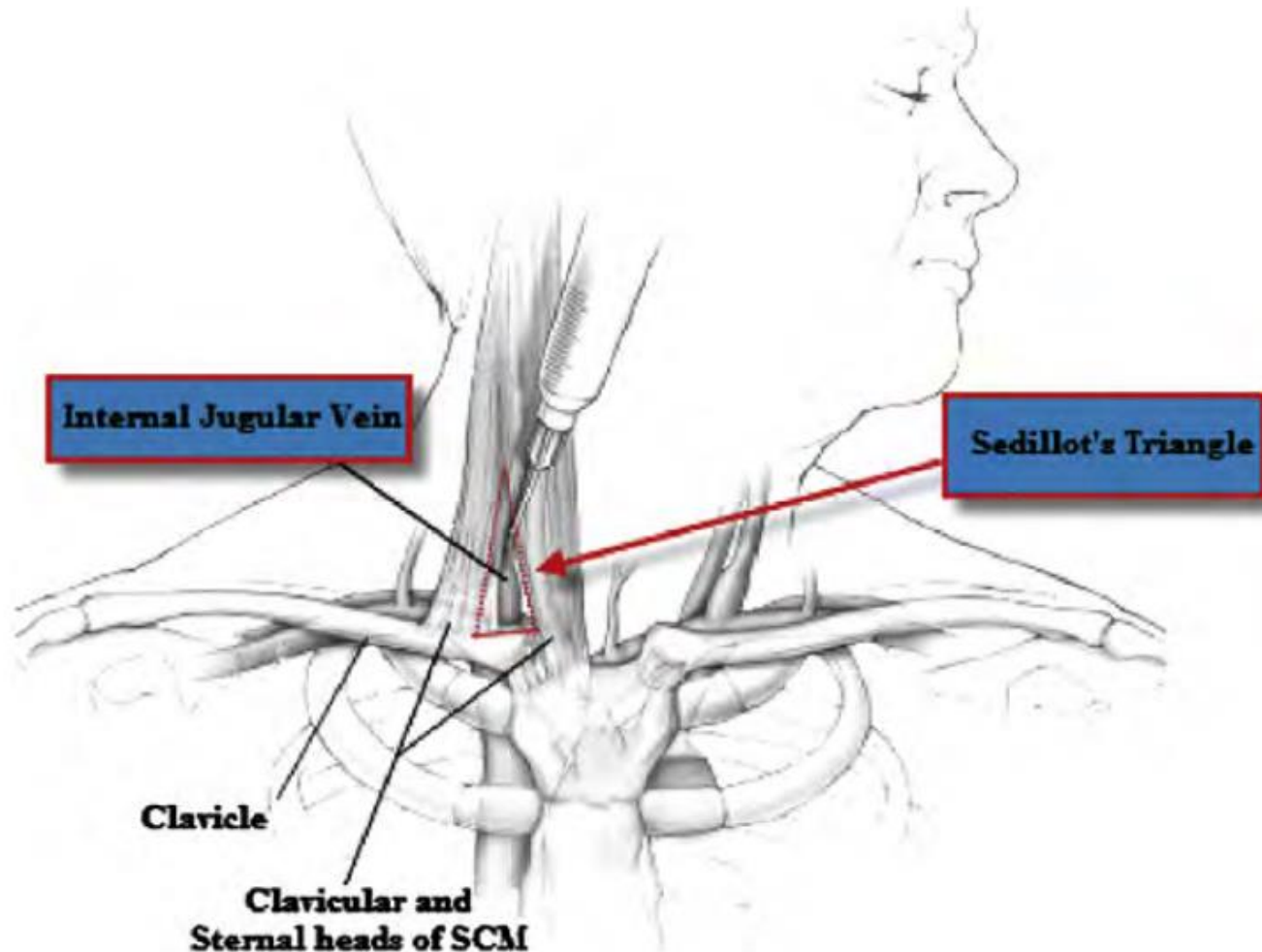


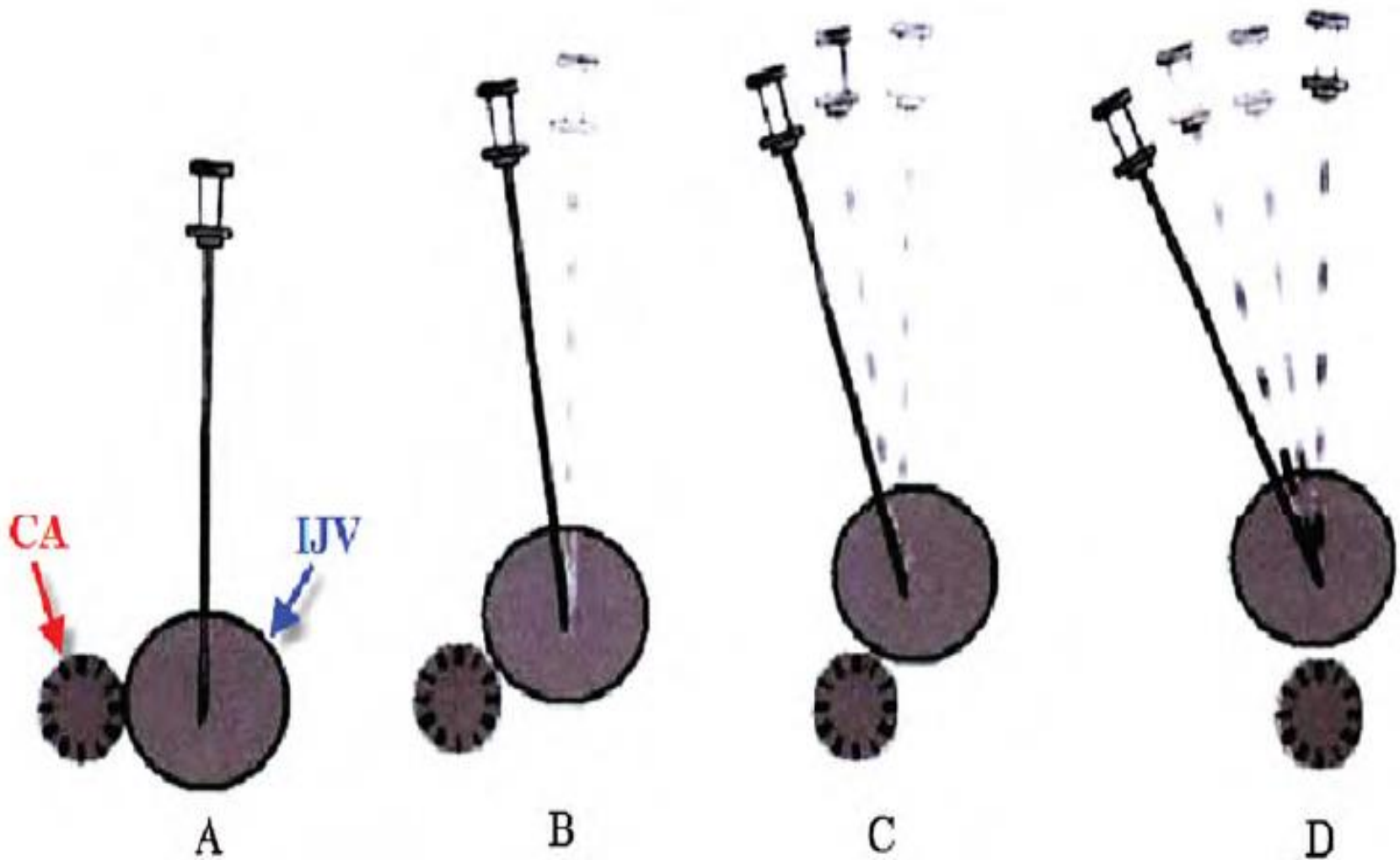
Figure 8 External landmarks for IJ cannulation. SCM, Sternocleidomastoid muscle. *Modified from N Engl J Med.*⁴

Ultrasound Guidance for Internal Jugular Cannulation



Figure 7 Variable overlap between CA and IJ vein. *RIJV*, Right IJ vein. Adapted from *J Vasc Interv Radiol*.²⁴

Ultrasound Guidance for Internal Jugular Cannulation



Ultrasound Guidance for Internal Jugular Cannulation (technique)

- Trendelenburg position to maximize the IJ vein size and minimize the possibility of air embolism.
- The operator should be positioned at the head of the bed, with the ultrasound screen facing the operator in a position where it can be easily visualized during the procedure.

Ultrasound Guidance for Internal Jugular Cannulation (technique)

- In a transverse or short-axis view, the probe indicator should be oriented to the operator's left, corresponding to the left of the patient and the left side of the screen as it is viewed.
- After procedure: Echo, Lung ultrasound for lung sliding

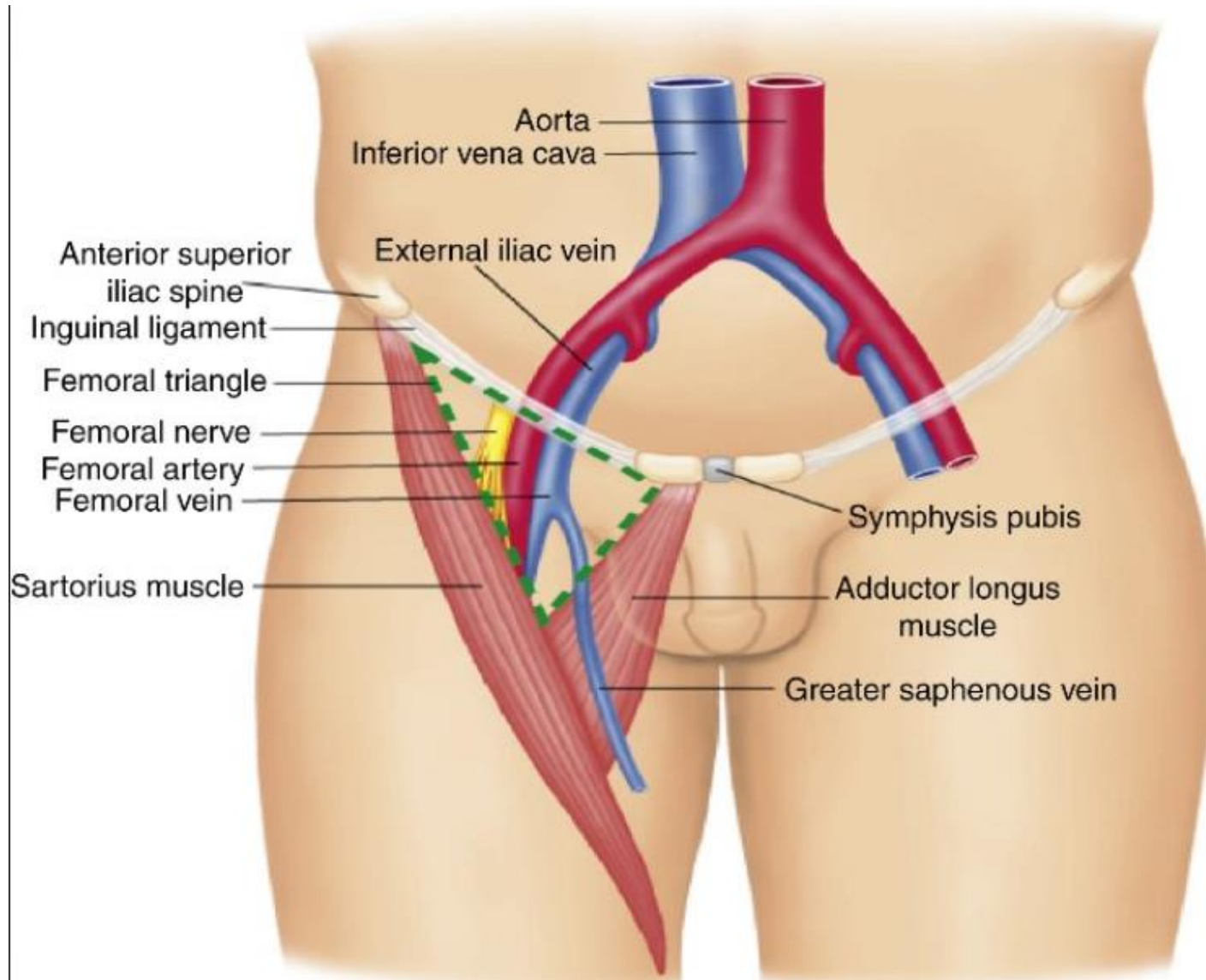
Ultrasound Guidance for Femoral Venous Access (general)

- not usually preferred because of higher infection rates.
- ultrasound guidance for femoral vein access may improve the success rate and reduce complications for femoral venous cannulation.(this benefit may be more important with novice operators, in pediatric patients, or in patients without adequate pulses for landmark guidance.

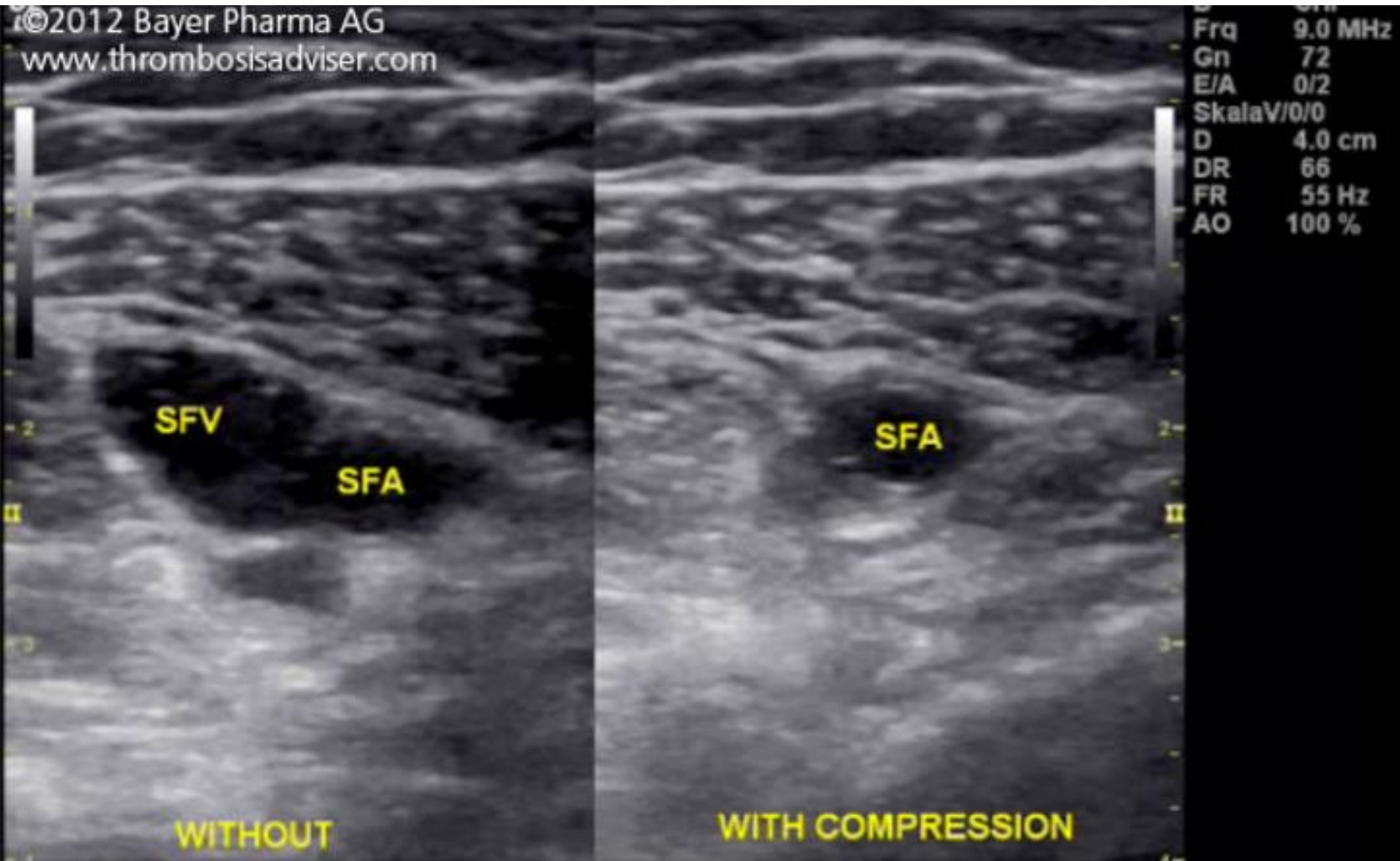
Ultrasound Guidance for Femoral Venous Access (technique)

- “frog leg” position : supine position with the leg slightly externally rotated.
- Because of the close relationship of the artery and vein in this area, it is particularly important that the guide wire is appropriately placed before advancement of the dilator.
- After securing the catheter, appropriate placement may be confirmed by visualizing the inferior vena cava and/or right atrium during a saline flush.

Ultrasound Guidance for Femoral Venous Access



Ultrasound Guidance for Femoral Venous Access



Ultrasound Guidance for Peripherally Inserted Central Catheters

- Instead of CVC
- Peripherally inserted central catheter lines should be avoided in patients with advanced kidney disease to preserve future dialysis access.

Ultrasound Guidance for Peripherally Inserted Central Catheters

- When using a “blind” approach to PICC line placement, most practitioners rely on a landmark such as an artery to find the adjacent vein (ie, the brachial artery and adjacent veins in the upper arm). In addition to clarifying the relationship of adjacent arteries and veins, ultrasound can find and guide access to veins that do not travel with arteries (such as the basilic vein), minimizing the risk of arterial puncture.

Ultrasound Guidance for Peripherally Inserted Central Catheters

- initial ultrasound examination of the upper arm to determine the best site(basilic, cephalic, or brachial veins) for needle puncture and PICC site location.
- recumbent, supine position with the extremity of choice extended on a flat surface, palm up.
- modified Seldinger technique

The many uses, the better.