ULTRASOUND GUIDED PERIPHERAL VENOUS ACCESS USING THE BEVEL-GUIDE TECHNIQUE: DESCRIPTION OF TECHNIQUE AND BEST PRACTICES

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SUMMARY

Ultrasound guided intravenous (IV) catheter placement allows reliable, appropriate bore IV access in adult patients. This document describes the bevel-guide technique and best practices learned over 300 placements by the author. Bevel is the only part of the angiocath assembly that will reliably reflect the ultrasound beam directly back to the transducer and provide the 'brightest' image of the needle in relation to surrounding structures. The operator should use a high frequency linear probe with the lowest available depth setting. After applying a tourniquet on the mid-upper arm, scanning should start from the antecubital fossa, where venous anatomy is consistent, and proceed distally. Optimal location for IV placement is in the middle half of the flexor surface of the forearm. During the bevel's passage through skin and subcutaneous tissue the ultrasound probe should be tilted away from the IV apparatus to orient the ultrasound beam perpendicular to the plane of the bevel. After locating the tip of the bevel in the venous lumen, the angle of the needle shaft should be adjusted to place the tip slightly cephalad of the center of the lumen. The catheter and introducer assembly should be advanced in the lumen till the widest cross section of bevel is visualized. The ultrasound probe should be slid proximally to locate the tip of the bevel. The tip should be repositioned center-cephalad and advanced. This should be repeated till about 2/3rd of the catheter is in the vein before sliding it off the introducer followed by securement. Best practices and trouble shooting for the technique are described.

Keywords: Anesthesia, venous access, ultrasound, intravenous catheter, IV, large bore access

Ultrasound (US) guided peripheral intravenous (IV) access is a valuable primary and rescue technique for securing peripheral IV access. In experienced hands the first-pass success rate in unselected patients is almost 100%. This document describes the materials used for this procedure, detailed description of the bevel-guide technique, and best practices learned from 300 consecutive successful placements by the author.

MATERIALS USED FOR BEVEL-GUIDE TECHNIQUE

ULTRASOUND BASICS RELEVANT TO VASCULAR ACCESS

- **Linear array probe:** High frequency probes are ideal for imaging superficial structures such as veins and arteries in extremities. Pictured on the right are three of the linear probes that come with the Sonosite machines at MGH (fig 1). The 'hockey stick' probe on one of the cardiac ultrasounds also works well for this purpose. The GE machine has similar linear probes.

- **Depth setting:** Veins are superficial structures. Lower the depth setting, larger the structure of interest will show on the screen. Depth settings are the up and down arrow keys on the left lower side of the Sonosite Edge and the dial on the right lower side of the GE ultrasound.

- **Gain:** Higher gain is typically better to distinguish between the dark lumen of the vein and the lighter walls and surrounding structures (blood is hypoechoic). After initially locating the vessel, adjust gain as needed to optimize the image.

Figure 1: Three Sonosite linear probes available at MGH Anesthesia

STRUCTURE OF AN ANGIOCATH

An angiocath or peripheral IV placement device usually consists of a plastic catheter with a luer lock compatible screw preloaded over an introducer needle and hub assembly. The introducer needle consists of a shaft and a bevel. The hub may or may not allow unrestricted flashback flow. At MGH Anesthesia we have six sizes of IVs (Braun Introcan Safety® IV catheter 14G to 24G). There are other IV types and sizes that we occasionally see in our practice. RNs on floors and in the Endoscopy suite use winged catheters. Some IV catheter devices have a spring loaded shaft that withdraws when a button is pushed.

Figure 2: 14G angiocath (front) and introducer needle (back)

BACKGROUND AND DESCRIPTION OF THE BEVEL-GUIDE TECHNIQUE

IMPORTANCE OF VISUALIZING THE BEVEL

The operator's primary interest in ultrasound guided IV placement is to recognize the location of the IV relative to the vein and surrounding structures. The IV's bevel is its easiest part to recognize by ultrasound imaging. A simplified explanation of why the bevel is easiest to recognize with ultrasound is that a solid structure reflecting an ultrasound beam directly back at the probe will be seen brightest compared to surrounding structures (hyperechoic). This direct reflection requires a flat surface positioned directly perpendicular to the beam produced by the probe. The IV has only two parts that have a flat profile capable of reflecting a substantial portion of the ultrasound waves directly back at the probe – the bevel and the shaft in the longitudinal section (fig 3). This document focuses on using the bevel to place IVs using short axis (cross section) of vessels.

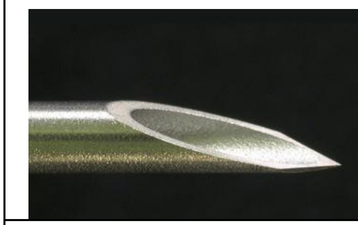

Figure 3: Magnified IV needle bevel

Using the bevel to accurately locate the IV tip in relation to surrounding tissue has two distinct stages that are briefly summarize below and detailed in following sections.

Figure 4: Drawing of plane of bevel perpendicular to plane of ultrasound beam

The first stage is from skin-prick to entry into the vein. In this part of placement, emphasis is on keeping the ultrasound beam perpendicular to the plane of the bevel. In order to this, the operator tilts the ultrasound probe as shown in fig 4. This allows significantly better visualization of the IV tip compared to relying on tissue movement.

The second stage of using the bevel for location is after entry into the vessel; the operator orients the ultrasound probe perpendicular to the skin to visualize the vessel in full cross section. The exact tip of the bevel is located with the ultrasound, adjusted with respect to the vessel walls, and advanced. This process is repeated until an appropriate length of the plastic catheter is in the vein and can be slid off the introducer. Tilting the probe is not needed for this step because of echogenicity of the metal bevel contrasting with the dark background of venous blood.

ERGONOMICS

The author's preferred setup is shown in fig 5. The operator sits on a chair or stool facing the ultrasound machine located beside the head end of the bed. Patient's arm is supported on one or two blankets to maintain passive extension at the elbow joint. The ultrasound probe is held in the left hand.

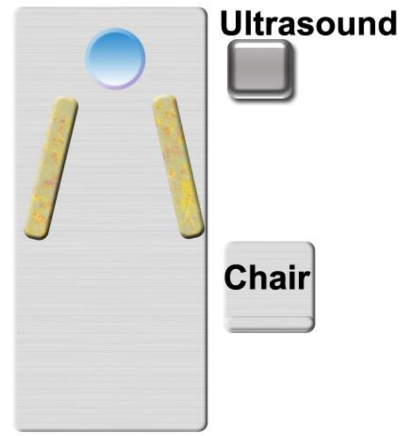

Figure 5: Set up for IV placement

SCANNING TECHNIQUE

After orienting the left and right sides of the probe with the screen, the operator scans the forearm with ultrasound to quickly map the venous anatomy. Starting from the antecubital fossa and scanning down towards the wrist, the operator should identify targets for IV placement. Veins in the antecubital fossa and their continuation, the basilic vein, are consistently present and are the most reliably identifiable venous features in the upper extremity (figure 6). This makes the antecubital veins good starting points for mapping. The operator should ensure that the probe is perpendicular to both skin and long axis of the target vessel being followed. This will allow the best short axis view of the vessel. Keep the vessel in the middle of the screen. Apply the least amount of pressure on the skin to maintain good probe-skin contact without compressing the vessel.

The operator is advised against initiating scanning in the middle of the forearm. Venous anatomy in this area is highly variable and the likelihood of quickly finding a good target is lower than starting in the antecubital fossa.

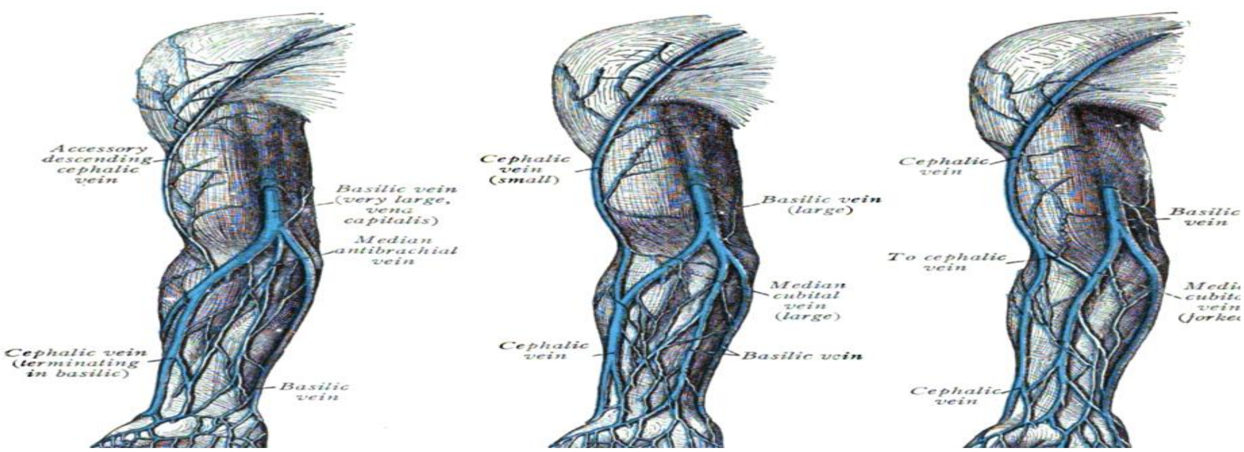

Figure 6: Venous Anatomy of the Upper Extremity and Common Variations

EVALUATION OF VESSEL STRUCTURE AND CHOICE OF PUNCTURE SITE

While scanning down the arm, the operator should visually evaluate the diameter, shape, wall thickness, course, variation in depth, and branching of veins. Larger, thin walled, superficial vessels with a straighter course are easier to cannulate than smaller, thick walled ones with repeated turns and branching. Ideally, the operator will be able to identify a 5cm or longer linear segment of vein to cannulate. Shorter linear segments require more skill and planning because the skin and vein entry points must be precise in order to avoid 'chasing down' the vein as it makes a sharp turn (see the section on 'Clinical Pearls/Troubleshooting' to learn more about 'chasing the vein').

Figure 7: Preferred location for upper extremity IV placement shown in blue

Preferred location for ultrasound guided IVs is the middle half of the forearm (fig 7). The operator is most likely to find a linear, relatively superficial segment of vein in this location. The author recommends not placing IVs with their tip or hub within 5cm of the wrist or elbow joint. IVs placed close to joints are more likely to be 'positional'. Patients are more comfortable when they can freely move their wrist or elbow joint without fear of disrupting flow into the vein. Whenever an IV hub moves, the tip will move inside the vein and can cause damage to intima that can be a nidus for thrombosis and infection.

SET UP

Recommended set up for IV placement is an open pack of Chlorhexidine or alcohol swab, syringe of local anesthetic with a 27G or 30G needle, and the IV apparatus taken out of its paper pack but still in the plastic sheath (fig 8). The operator should start with skin disinfection in the standard fashion: clean off the ultrasound gel, vigorously rub the skin at and around the planned needle entry site.

Figure 8: Set up for placement

INFILTRATION

US guided IV placement is a comfortable procedure for the patient if skin and subcutaneous tissues are well infiltrated with local anesthetic. Before injecting local anesthetic, center the vein under the black line or mark located on the probe. This black line denotes the center of the probe. Locating the vein under this line will allow the ideal angiocath skin entry area to be anesthetized. Enter the skin about 5-10mm from the probe, in-line with the black line. If the probe doesn't have a mark or line, use an approximate middle of the probe. Make a liberal wheal with local anesthetic.

SKIN ENTRY

Position the black line or approximate center of the probe over the center of the vein. Enter the skin with the tip of the angiocath needle, about 5-10mm distal to the probe, in line with the center. The bevel should be facing up. The shaft angle at skin entry is between 15-45 degrees depending upon the depth of the vein – deeper veins require a steeper angle. The angle should be adjusted to ensure vein entry within 15mm of skin entry.

Figure 9: Ultrasound image of the bevel entering the vein and corresponding drawing.

Keep visual track of the bevel of the angiocath needle as it goes through the skin. Stop advancing as soon as the whole bevel disappears below the skin. Tilt the probe away from the catheter entry site to make the beam approximately perpendicular to the plane of the bevel and sonographically locate the bevel in the skin (fig 9). Determine location of the tip and ensure the bevel is directly above the center of the vessel. If not, adjust location of the tip with small sideways movements of the hub. When in optimal position advance the angiocath needle forward by 0.5-1mm. Repeat this process until the tip of the bevel is directly over the top of the vein.

Figure 10: Ultrasound image of the center of the bevel in vein and corresponding drawing

Once the tip is positively identified to be exactly above the vein, introduce it into the lumen with a short 'jabbing' motion. This is similar to the action required to enter a central vein. IV needle bevels are not particularly sharp; a slow, gentle attempt at advancement through the vessel wall is likely to redirect the tip off center. Stop advancing the apparatus as soon as the tip of the bevel is recognized within the vessel lumen.

Position the ultrasound probe upright and perpendicular to the skin (fig 10). The objective of making it perpendicular to the skin and the vein's long axis is to ensure visualization of the vessel lumen in perfect cross section in relation to the bevel. It is important to scan and recognize the whole bevel and identify the exact tip of the bevel. The body of the bevel is seen as a bright white object in the lumen (fig 10). As the vein is scanned proximally, the size of the bright dot becomes smaller and smaller until it disappears. The smallest observable part of the bevel is the tip (fig 11).

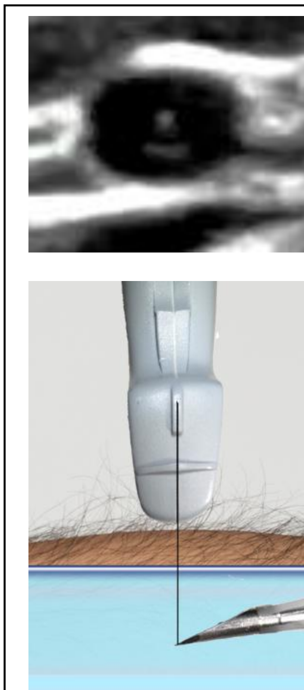

Figure 11: Ultrasound image of tip of the bevel in vein and corresponding drawing

With the tip in real-time view on the ultrasound screen, adjust the angle of the shaft. Manipulate the hub to ensure that tip of bevel is in the optimal position in relation to the lumen. The optimal position of the tip is just cephalad to the center of the vessel (fig 12). Once in position, advance the IV about 2 millimeters till the body of the bevel is visualized as an enlarging, bright dot.

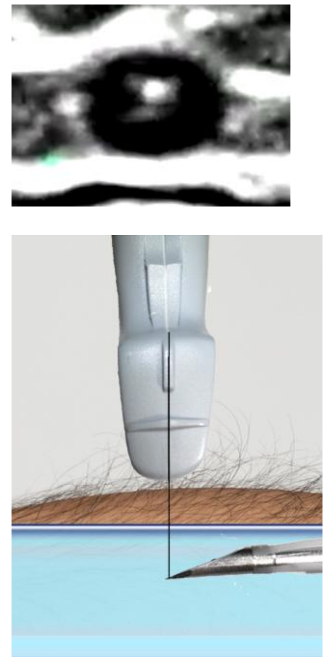

Figure 12: Ultrasound image of tip of the bevel in optimal location for advancement and corresponding drawing

The next set of actions allows real-time advancement of the IV apparatus inside the vein. Advance the IV apparatus in the lumen of the vein till the sonographic view in fig 10 is obtained (ultrasound beam cutting through middle of the bevel). Stop advancing the IV apparatus. Locate the tip of the bevel by scanning proximally (sliding the probe towards the patient's shoulder). Position the tip in the optimal position. Advance the IV apparatus in the vessel lumen till the view in fig 10 is obtained. Repeat this process till 2/3rds of the IV is in the vein.

If at any point during advancement the operator desires to ensure that the tip is in the true lumen and not snagged on a wall, first visualize the tip of the bevel; then give the hub a quick, small, sideways wiggle without advancing. Observe the tip move sideways in the lumen. If the tip wiggles freely in the lumen then it is not snagged on to a wall. If it doesn't move freely, pull the IV apparatus back 1-2mm at a time with real-time visualization of the tip of the bevel until the tip is free of the vessel wall. This can be verified by the 'wiggle' maneuver previously described.

Subtle resistance to advancement is often felt as the plastic catheter follows the bevel into the vessel lumen. This does not signify problems with placement as long as real-time confirmation of location of the tip and bevel in the vessel lumen is ensured.

Advance catheter over introducer once an adequate length of catheter is in the vessel lumen. This author recommends not sliding the catheter off the needle till 2/3rd of the angiocath apparatus has been advanced into the vein using real-time guidance. This will counter problems with venous valves because the sharp bevel can cut through valves that the soft plastic catheter usually can't go across. This also obviates the problem of blindly advancing a large catheter into a small branch coming off the main vessel.

The catheter should be attached to a leash and flushed to verify free flow. Thoroughly cleaning ultrasound contact gel from around the IV site is strongly recommended. Even a small amount of gel on the skin will not allow occlusive dressing (Tegaderm) to stick.

BEST PRACTICES & TROUBLESHOOTING

Patient selection: Patients with large, superficial, 'bulging' veins are typically not good candidates for ultrasound guided IV placement. Maintaining good contact between the probe and skin is often challenging in this patient population. In most other patients the bevel-guide technique allows experienced operators to secure reliable large bore IV access in less than 60 seconds.

Catheter size: The technique described in this document is most useful for catheters 18G and larger. These catheters have large bevels that are easier to visualize than smaller catheters. In figure 13, note the ¾ inch difference in length between the 18G and 22G catheter. The longer length of 18G and larger catheters provides a margin of safety against an inadequate length of catheter in a vein after a vein was 'chased' before entry. Not having enough catheter length in the vein can cause unrecognized extravasation and IVs 'falling out'.

Figure 13: Comparing lengths of 14G, 18G, and 22G catheters

Verifying IV location in vein: There are a number of different methods to verify intravenous placement. The author prefers injection of agitated saline and observation of it passing through the basilic-cephalic system on ultrasound.

No reasonable venous targets identified in forearm: Scan contralateral upper extremity if available. It may be that the only usable vasculature is in the basilic-cephalic system. These veins are typically larger and deeper than those in the forearm. Use of a catheter 18G or larger bore by an experienced operator is advised. Long 20G catheters may occasionally be appropriate; their bevel is smaller and more difficult to visualize when approaching a deep vessel. The author's practice is to avoid ultrasound guided IV placement in the antecubital veins for the following reasons: IV flow dependant on arm position (positional), patient discomfort in the postoperative period, and branching and debranching of veins as the cephalic-basilic system is formed proximal to the antecubital fossa, making real-time advancement technically difficult. Ultrasound guided saphenous vein IV placement is also possible. Its proximity to the bony prominence of medial malleolus which limits 'working space' can make it a technically challenging placement. The author does not have personal experience with ultrasound guided external jugular vein IV placements.

'Chasing' the vein: There may not be sufficient length of catheter in the vein to have reliable access (fig 14). This situation is common when the skin entry site is not directly on top of the center of the vein. In this scenario the operator follows a vein with the IV apparatus and is ultimately able to enter the vein some distance from the skin entry site. There may not be enough length of catheter in the vein as most of it is in the subcutaneous tissue/muscle. These IVs are prone to displacement out of the vein with patient movement and arm manipulation. This can cause unrecognized extravasation into deep brachial tissues that has led to compartment syndrome in some instances.

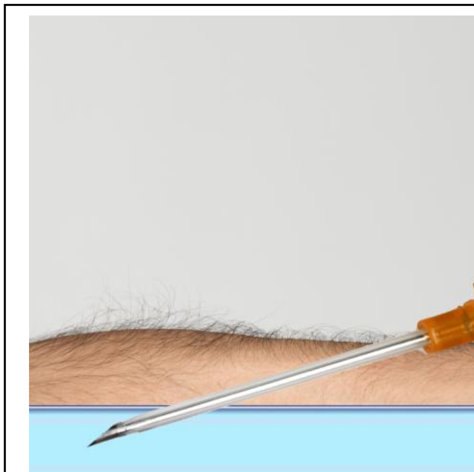

Figure 14: Insufficient length of IV catheter in the vein

Arterialized veins: Veins noted on ultrasound imaging looking like an artery – small diameter, completely round, thick walled – are associated with difficult ultrasound guided IV placement. These vessels tend to spasm upon contact with the bevel tip and the operator loses their image because the contrast between the darker center (blood) and lighter colored wall is lost – the vessel blends in with surrounding tissue (becomes isoechoic). These vessels also seem to extravasate quickly and further obscure sonoanatomy. This author has noted these vessels most frequently in obese and diabetic individuals. Usually, these individuals are a 'difficult IV stick' without ultrasound. Often they will inform you that their veins 'disappear'. In the author's opinion the 'disappearing vein' may be due to higher medial smooth muscle content causing these veins to spasm. In this author's experience there is no single technique to successfully secure IV access in these patients. Meticulous attention to visualizing the bevel usually leads to high first pass success.

Superficial veins and limited 'working space': Occasionally one encounters the thin patient requiring large bore IV access who has superficial vein(s) on ultrasound but no visible or palpable veins of adequate size. The operator may be hampered by the angle of advancement being so shallow and close to skin and joints that required correction of trajectory and advancement in the lumen of the vein becomes challenging. To counter this, after introduction into the vein and advancement to about 0.5-1cm in the vein, the operator should lift the whole IV apparatus up 1-2mm off the skin before repositioning the tip. This will allow the shaft to lift the vein off its bed and allow the operator more space between the hub of the angiocath and skin for adjustment of angle and position.

'Wiring' IVs into veins: In the author's opinion this should only be attempted when no other option remains to secure an IV. Wires can easily tunnel subintimally and create a false passage. A cross section view utilizing the bevel-guide technique is likely safer than blind advancement of a wire into a vein.

Using the 4Fr Micropuncture kit for short segments: Using real time ultrasound guidance and a 4Fr micropuncture kit for venous access is preferable if the length of visualized segment of vein on ultrasound is <2 inches. The micropuncture catheter can be safely left in the vein as an IV. The 4Fr catheter is a 17.7G IV.

Arterial line placements: Radial artery is on average ~2.4 mm in diameter with a lumen as small as 0.5-1mm. Often it is a smaller ultrasound target compared to veins. Arterial lines are typically placed using 20G or smaller IVs, the bevels of which are smaller and more difficult to see. While the author has experience 'floating' the arterial line by the techniques described in this document, the success rate is significantly lower than venous cannulation. It is preferable to use the 4Fr Micropuncture kit because the 21G micropunture needle is designed for ultrasound use and provides two points of confirmation of intravascular presence of its tip (ultrasound visualization of bevel and uninterrupted blood flow back from the hub).