Introduction to

Ultrasound Transducer and Needle Handling in Regional Anesthesia

Dr. Robert M Raw MD,
MBChB, MFGP, MPraxMed, DAFCA
Professor of Anesthesia to 2016
Editor of Journal of Regional-Anesthesia.Com (J-RAC)
Email: editor@regional-anesthesia.com

INDEX
A. Introduction.
B. Transducer adjusting movements.
C. Needle adjusting movements.
D. Transducer-to-nerve viewing positions.
E. Transducer-to-needle viewing positions.
F. Needle to nerve APPROACHES. (combinations of D. and E. positions).
G. Hot tips for handling the needle and the transducer.
H. Finding the lost needle tip with in plane views
I. 3-Dimensional spatial perception, and skills of the operator

-----------------------------------------------

A. INTRODUCTION

This lecture explains the HANDLING of both (1) the ultrasound transducer, and (2) the
needle, relative to each other and to the nerve. The final goal is injecting drugs for a nerve block.
The terminology in this field is evolving. UltraSound Guided Regional Anesthesia (USGRA)
implies directing the needle towards the injection target utilizing real-time sonographic imaging.

Ultrasound Aided Regional Anesthesia (USARA) uses the ultrasound to pre-scan for prior
anatomical information, to be marked onto the skin. The nerve block is then done without the
ultrasound. This is useful in epidural blocks in obese patients, to aid identify the midline and
interspinous spaces before inserting needles.

There will be 5 classifications related to ultrasound handing in USGRA.
1. Transducer-to-nerve positions.
2. Transducer-to-needle positions.
3. Needle-to-nerve approaches. (Combination of the needle and nerve positions, relative
to the transducer)
4. Needle position adjustments.
5. Transducer position adjustments.

To randomly jiggle a nerve-block needle about, whilst viewing everything aided by an
unsteady ultrasound transducer moved at random and with no objective, and then to
simultaneously have one’s eyes fixated on the ultrasound monitor far from one’s hands is a
strong formula to fail in performing the nerve-block, apart from seriously injuring the patient.
This lecture will fix that problem.
B. TRANSDUCER POSITION ADJUSTMENTS

There are 5 basic movements. Terminology and concepts are still evolving. There are few relevant authoritative texts on this. The following is popular teachings, with logical modifications rooted in hands-on clinical experience, and clinical teaching experience.

1. **ROTATE the transducer.**
   
   See figure number 1. It is used to correct misalignment of needle and nerve imaging planes, when using in-plane (IP) needle techniques, or In-Axis (IA) nerve techniques.

2. **TILT the transducer.**

   See figure number 2. With all Off-Axis (OA) views this is the single most critical adjustment to optimize imaging of the nerve, especially with the popliteal fossa sciatic nerve. Once ideal tilt is found it must be held constant throughout any other transducer adjustments. The OA nerve image is best when the image plane is a perfect 90° perpendicular to the nerve axis. If the transducer is glided proximal or distal along the course of the nerve, TILT may need to be adjusted as the nerve path turns deeper or shallower along the nerve’s course. Never look for the needle with this maneuver.

3. **GLIDE the transducer.**

   See figure number 3. Transducer gliding has three applications. (1) GLIDE is used to survey the nerve anatomy, in Off-Axis (OA) views, to choose the best point of injection, e.g. in the popliteal fossa and interscalene area. (2) GLIDE is also the MAIN maneuver to find the needle in the sonogram with In-Plane needle views. (3) GLIDE it is used to find the nerve with In-Axis (IA) views.

4. **SLIDE-to-side the transducer.**

   See figure number 4. The transducer is moved in its long axis, that is side-to-side. The first purpose of this is to center the target-nerve within the sonogram image, in an Off-Axis nerve view. The second purpose is to position the nerve to the one side of the sonogram image, when using the In-Plane Off-Axis approach. The nerve must be on the opposite side of screen to the side from where the In-Plane needle will enter view. This extra screen space in the image, helps viewing the needle image, as it will fill the major part of the screen as it advances towards the steady nerve on the other side of the screen.
6. **ROLL the transducer.** See figure number 6.

To ROLL, the transducer it is rotated or tilted sideways in its length. This causes the direction of the plane of sound waves into the flesh under the transducer, to be re-aimed at an angle away from that side, rather than be directed perpendicular to the skin in its normal position. The ROLL maneuver when using a linear transducer, has also been described as *digging the heel* of the transducer into the flesh.

![Figure 5](image)

**Figure number 5.** Rolling the transducer side-to-side.

![Figure 6](image)

**Figure number 6.** The linear transducer ROLLS to the side. The transducer-base to needle-shaft angle improves by 20 degrees. The needle shaft visibility in the sonogram improves.

![Figure 7](image)

**Figure number 7.** In picture “A” the needle passes steep relative to the sound waves. This produces a poor needle image in the picture “C” sonogram. In picture “B” the transducer has been ROLLED to look left, and the needle has been re-inserted from further away. That, with “retreat and look back”, improves the needle image in “D”.

See in figure 6, how digging the heel of the transducer into the flesh, can reduce the angle between the base of the transducer and the shaft of the needle. The closer those two surfaces become to being parallel, the more soundwaves that will be reflected off the needle shaft, and back to the transducer, to form a on screen.

Images “C” and “D” in figure number 7, show how the tissue in the image distorts. The distortion is the result of tissue compression under the part of the transducer pressing deeper into the tissues.
The ROLL transducer movement also shifts the sonogram image to the side, creating a tilting in the view. It is a method of “looking under” a structure if the structure obstructs placement of the transducer directly overhead of the targeted nerve. See figure number 8. It shows how the transducer vacates the center position directly over the target nerve, with a SLIDE maneuver, but how the simultaneous ROLL maneuver preserves the viewing of the nerve keeping the nerve centered in image. It is as if the transducer is looking back at the nerve, after the combined transducer ROLL and SLIDE. View this in figure number 9.

**Combined transducer maneuver. First SLIDE transducer to the right, and simultaneously ROLL the transducer, looking back to the left, keeping the nerve centered in the image.**

![Diagram](image)

A. Transducer held vertical direct over a nerve viewed In-Axis. (Needle inserted from the side.)

B. Transducer held to the side, and looking back at the nerve viewed In-Axis. (Needle inserted via shortest route to the nerve, from directly above the nerve.)

Figure number 8. Combined transducer maneuver. First SLIDE the curved transducer to the right side. Then, simultaneously ROLL the transducer to the side looking back to the left, with the sound beams. Keep the nerve centered in image the whole time. See how in the B-image the nerve-block needle can be inserted the shortest route to the nerve, from directly above the nerve.

SLIDE and ROLL allows an In-Plane needle to be inserted perpendicular from the skin to the nerve, for the shortest distance, but with a relatively side-view from the transducer that facilitates imaging of the needle In-Plane. The transducer sound waves meeting the needle surface are sufficiently perpendicular to at least part of the needle to make that part visible. It is the rear part closest to skin. That is enough to facilitate the block, by letting the needle be pointed towards the nerve, even if the needle-tip is unseen. Nerve stimulation is needed to confirm final needle-tip to nerve contact. This is very useful with the deep lying sciatic nerve in the buttock, as illustrated in figure number 9, which uses actual sonogram images.

This ROLL movement also has great utility with a linear transducer and the TAP block. This is a fascial plane block with invisible nerves. The technical challenge is to see the needle tip very precisely, and position it very accurately in order to open a potential cavity with fluid injection between a muscle layer and a single fascia layer. See figure number 7. The ROLL maneuver is added to, the reinsertion of the needle from further away from the transducer. That makes the needle track less perpendicular to the skin. That combined transducer ROLL, with the needle being less steep within the tissues, can nearly produce a horizontal needle within the sonogram image. Conversely this can be described as maximizing the angle of the sound waves so that they meet the needle-shaft near perpendicular. This maximizes the amount of sound waves bouncing back to the transducer, to form a brighter bigger needle image. Soundwaves from curve transducer radiate outwards like wheel spokes from the wheel axil center, while linear transducer sound waves travel parallel to each other.
**Start.** Transducer lies over shortest route of skin to nerve. The long arrow is the needle route.

**Transducer SLIDES**
- to right on skin. Nerve moves to left in image.

**Transducer SLIDES more**
- to right on skin. Nerve moves to more left in image.

**Transducer ROLLS**
- facing to left. Nerve shifts in image back to right.

**Finish.** After final ROLL movement, the needle can now pass along the shortest route of skin to nerve.

Figure number 9. The SLIDE and ROLL maneuver using a curved transducer, over the transgluteal sciatic nerve, at the GT-IT line.
6. PRESS the transducer

This movement is very tiring to hold. When using it, it is desirable to complete the nerve block within 1 to 2 minutes and preferably within 30 seconds. In the early days of evolving ultrasound-guided regional anesthesia techniques, there were a few teachers who taught that pressing the transducer down hard was always a “good thing”, but they offered no rationale or evidence of that claim. This teacher generally discourages PRESSING down hard, as a sustained routine transducer handling technique while performing nerve blocks.

PRESSING down with the transducer does have the following uses:

i. It is used briefly as a diagnostic maneuver to assess compressibility of a structure. If it compresses easily, it is a vein. If it compresses partially only with more pressure, it is an artery. If the structure is approximately round, hypoechoic and uncompressible, it is potentially a nerve.

ii. Pressing the transducer modestly with some side ROLL, may be a way to get a linear transducer to look under a structure. This is sometimes needed in the infraclavicular region to look more to posterior under the clavicle.

iii. It can be used to approach a poorly imaging structure a bit closer, in order to see it better, purely for diagnostic purposes to obtain a photo. This shorten the skin to nerve distance.

iv. It can be used to smooth out an undulating skin field that is causing transducer-skin contact breaking, e.g. in the lateral neck of very thin old wrinkled patients.

C. NEEDLE POSITION ADJUSTMENTS.

The hand holding the nerve-block needle, must generally only be moved in one of three ways. Also, the movements must also only be done one at a time. The three movements are;

1. Inwards, or outwards.

2. Aim the needle shallower within the sonogram, or deeper within the sonogram.

3. Side-to-side movements. This is used only with Off-Plane approaches, after first withdrawing the needle tip from the image by 1-2 cm. Push the needle hub to the side, as needed, and re-advancing the needle-tip to re-enter the sound-wave plane, and image in a new position.

When making the OP needle-tip image position adjustments, the needle-hub outside the tissues must be moved in an opposite direction to where the needle is to go in the image. Where the needle punctures the skin is the pivot-point for the needle.

- For the needle to advance deeper into the tissues, that is further from the skin, the hub of the needle must be moved closer to the skin insertion point, which advances the needle deeper into the patient.
- The needle-tip may need to aim, shallower within the image. That means the needle-tip must be lifted upwards in image. To achieve that the needle-hub must be depressed downwards, outside of the patient. The opposite movements apply too.

With IP nerve block approaches, keep needle movements simple. Leave complex image adjusting to transducer position adjustments.
D. TRANSDUCER-to-NERVE VIEWING POSITIONS

The ultrasound emits sound beams in a 2-dimensional plane, and senses reflected beams within the exact same 2-dimensional plane, in order to generate an image. That sound-wave plane can be orientated in a few ways relative to the 3-dimensional structures of the procedural nerves and needle. Each orientation position will produce very different sectional views of the nerve-block tissues.

CLASSIFICATION OF TRANSDUCER TO NERVE POSITIONS.

There are three possibilities;

(i.) **In-Axis (IA).** The transducer is held so that the sound-beam plane and the resulting image plane, is parallel to the axis of the nerve. A portion of the nerve is seen in its length. See figure number 10.

(ii). **Off-Axis (OA).** The transducer is held so that the beam plane and the resulting image plane, cross the long-axis of the nerve. The nerve is seen in cross-section. Figure numbers 11.

(iii). **With-Axis (WA).** The transducer is held so that the beam plane and image plane, face the nerve in its axis. This is only feasible when a nerve turns, and the transducer is held in a position the nerve would have intersected with, had it continued straight. This is commonly seen in the neck when viewing the C5 brachial plexus root as it exits the intervertebral foramina before turning caudad and joining the C6 nerve root to form the upper trunk. See figure number 12.
Detailed discussion on transducer-to-nerve orientation views.

- **IN-AXIS NERVE VIEWS**: In figure number 11, the transducer is held over the nerve parallel to its long axis.

  The In-Axis (IA) view produces a sonogram image of the nerve, in its length. Typically, the multiple fascicles form multiple parallel hyperechoic lines within the nerve. This becomes the tissue-signature identifying the structure as a nerve, as opposed to being a tendon, or fascia. A fascia has only a single or a double-line appearance, and is thinner than the nerve typically being searched for. A tendon does not have continuous linear hyperechoic-structures within it.

  *Gliding* movement of the transducer back and forth across the nerve can cause loss of the nerve image on sonogram, or recover a lost image. *Gliding* is thus, the critical movement to keep the image optimum. *Tilting* of the transducer in small degrees, especially with deeper nerves, also causes loss of the IA nerve image on sonogram. Avoid *Tilting* the transducer during In-Axis nerve viewing as it is confusing. Slight *rotating* of the transducer may diminish the length of nerve visible on the image. Fine adjustment of rotation keeps the maximum length of the nerve in view, by correcting for the view cut-off phenomenon. *Sliding* the transducer side-to-side will not substantially alter the nerve image, as long as the sound wave plane remains parallel and aligned to the nerve.

  Importantly, this view sometimes produces a recognizable good nerve image, when a deep nerve would otherwise be invisible on OA view, e.g. the transgluteal sciatic nerve in large buttocks, in the GT-IT line position. See figure number 13. The deep transgluteal sciatic nerve in an obese buttock, might not be instinctively recognized on sonogram by an anesthesia novice with inexperienced eyes. The multiple fascial surfaces create a confusing array of similar looking lines. The deep transgluteal sciatic nerve in an obese buttock however still has a sufficiently subtle unique tissue-signature and brightness in IA views to be always recognizable, with expertise. The fascicles form multiple long linear echogenic structures within the nerve. The superficial and deep perineural surfaces frame the fascicles with two slightly brighter layers. This is distinguished from tendons which have internal structural markings that are more fine and shorter.
- **OFF-AXIS NERVE VIEWS**: In figure number 10 the transducer is held across the length of the nerve in the OA view. There are three types of nerve appearances in OA views: see them in figure number 14.

  - **Type-I Off-Axis nerve images** have a hypo-echoic center, that is dark, and homogenous. It is surrounded by a well-defined hyperechoic layer. Type-I is commonly seen in shallow large nerves, while using very high frequency probes. An example are the nerve roots of the brachial plexus, and especially where the nerve root has not split up much into well-defined fascicles.

  - **Type-II Off-Axis nerve images** tend to be seen in nerves lying deeper that Type-I image forming nerves. The image is also only typically seen with linear ultrasound transducers. The nerve image is characterized by having a dark structureless center with fuzzy edge surrounding it.

  - **Type-III Off-Axis nerve images** are hyperechoic. They stand out visually very starkly from the darker surrounding tissues. They are also typical of nerve images seen using low frequency, low-resolution, but deep-penetrating curved ultrasound transducers. See figure number 14. A very good reason to use curved transducers for popliteal fossa sciatic nerve blocks, is because the then hyperechoic sciatic nerve, is so easy to identify.

The OA view is very popular because the image tolerates a moderate amount of transducer movement without any loss of nerve image within the sonogram. **GLIDING** the transducer back and forth only alters the relative position of surrounding structures and does not affects the ability to see part of the nerve. **SLIDING** from side to side alters the relative position of the nerve on the sonogram without loss of sight of it. **SLIDING** is useful to center the target with OA views. **ROTATING** the transducer slightly has no benefit, and causes no problem. **TILTING** the transducer so that the angle that corresponds with exactly 90 degrees to the axis of the nerve will produce the best nerve image. **TILTING** is particularly important in the popliteal fossa where the sciatic nerve deceptively does not lie parallel to the skin. When holding the transducer perpendicular to the posterior popliteal fossa skin, no nerve may be seen at all. Then tilting the transducer about 15-degrees to aim more caudal, suddenly produces a large starkly hyperechoic sciatic nerve image impossible not to notice within the image. See Type-III nerve image in figure number 14. Nerves often don’t run parallel to the skin or even the long axis of the neck or limb. Therefore, a transducer perpendicular to the skin seldom obtains an optimum image. A change of only one or two degrees of tilt, may render a nerve dramatically visible or totally invisible. After the nerve is visualized it is critical to maintain this exact angle of tilt whenever varying the other transducer movements. OA is a simple only one-movement only needed view, hence its popularity in the popliteal fossa.
When nerves are not readily recognized with this view because optimum tilt is not feasible (e.g. in the infraclavicular zone) the adjacent structures like an artery can be used to locate where to inject local anesthetic drug. For example, in the infraclavicular and axillary regions. Note however, that not all nerves close to an artery share the same fascial compartment of the artery, for example the femoral nerve. A perivascular infraclavicular injection produces a nerve block, while a perivascular block of the femoral artery in the groin, will totally fail to produce a femoral nerve block.

- **WITH-AXIS NERVE VIEW (WA):**

  See figure number 15. This WA view is obtained at the intervertebral foramina of the roots of the brachial plexus. It is best recognized during a sliding scan from cephalad to caudad along the lateral neck over the interscalene groove. As the sound-beam plane glides caudad off of a pure bone section view, onto the first large nerve root of C5, emerging from the intervertebral foramen, a nerve with a type-II Off-Axis image appears. The nerve appears as a hypoechoic structure with a dark fuzzy edge. The nerve in a WA view, is being viewed along its length with the sound beams passing parallel to the nerve axis, before the nerve path curves more towards caudad. When the transducer is shifted more caudad along its glide path, the nerve image then moves more superficial. The nerve image then changes into a Type-I image in an OA view. Brachial plexus blocks are seldom done specifically in this WA view, as that is unsafe being within the intervertebral foramen. This view is only recognized incidentally when initially inspecting the interscalene brachial plexus sonographically.

![Figure number 15. With-Axis (WA) nerve view. Note how the nerve image outer edge is fuzzy dark.](image)
E. TRANSDUCER-TO-NEEDLE VIEWING POSITIONS.

There are two basic approaches; In-Plane (IP), and Off-Plane (OP).

1. **In-Plane (IP)** approach in figures Image number 16 and 17. The needle is passed parallel to the plane of the sound beams and fully within the sonogram view. The needle is potentially visible in its entire length. This is a hard view to hold because various tiny transducer movements corrupt the image. Gliding the transducer back and forth by more than 1 mm will result in loss of view of a 1.5 mm wide needle. Tilting the transducer by more than 1 degree will cause loss of view of the needle. Rotating the transducer by one degree will cause loss of the view of the needle-tip, and preservation of only a length of the middle section. The “end” of the middle section in view may be misinterpreted as being the needle-tip. That is the needle cut-off phenomenon. Advancing the needle in the presence of needle cut-off phenomenon could be dangerous because the true needle tip will be 1 to 3 cm or more, deeper than expected and may penetrate dangerous tissues out of image. Sliding the transducer slide side-to-side keeps the needle in image and may help center the target tissue-point in the sonogram. The image of the needle is best when the needle is parallel to the surface of the transducer and increasingly steeper needle directions than 30 degrees from the transducer surface will render the needle near invisible to fully invisible. The In-Plane (IP) approaches works best when a needle insertion towards a nerve can be achieved that keeps the needle shaft parallel to the transducer. The best example is a lateral approach to the popliteal fossa with the transducer held posterior in the fossa. With the superior approach to the cords of the brachial plexus, one is dependent on seeing tissue movements to locate the needle on a dynamic sonogram image. This is due to the steep angle of the needle insertion and the resulting poor needle images formed.

This is a conceptually attractive view that novices like, although it is the hardest one to “hold steady”. It works best with a shallow nerve that allows the use of a high frequency transducer. A low frequency transducer can barely resolve the deep lying needle image in its length.
4. **Off-Plane (OP)** approach in figure number 18 and 19. The needle path crosses the plane of the sound beams at right angles, and only the cross section of the needle-shaft or tip, appears in the sonogram, or the tissue distortion that the needle-tip induces.

*Gliding* the transducer back and forth does not cause loss of sight of the needle. *Sliding* of the transducer from side-to-side does not cause loss of sight of the needle. *Tilting* of the transducer does not cause loss of sight of the needle. *Rotating* of the transducer does not cause loss of sight of the needle. This makes this, a very easy needle approach in terms of maintaining needle view. This view is best with high frequency transducers and shallow needle approaches. With steep approaches and low frequency transducers the needle is often not seen, although some needle induced tissue distortion may be visible.

The maximum tissue distortion that the needle can produce is when the needle-tip just penetrates the sound-wave plane for the first instant. Once the tip has fully passed through, the shaft produces less tissue-distortion, as seen on sonogram. The distortion from the shaft may only be fleetingly visible, and if the needle ceases moving the tissue distortion may become invisible. Accordingly, OP views are best
seen in *dynamic* images, where the needle can be jiggled back and forth by one or 2 mm in order to keep the tissue distortion active. The exact needle location is hard to recognize in static image prints in a document.

This OP approach may also be best used with high frequency transducers and *steep* needle approaches, e.g. the trans-sartorius saphenous nerve block. Then the sonogram hyperechoic spot representing the needle tip, is more related to the distortion of fascial tissues that the needle causes, than the needle itself. Look for how the needle pushes the deep center part of the Sartorius muscle fascia downwards. OP needle approaches are the favorite approach of experienced USGRA practitioners (e.g. Dr. Chan) because the transducer is easy to hold, and the technique is a very flexible. Low frequency transducers do not resolve 1.5 mm wide needle-tip cross section views very well within the sonogram. The OP needle approaches are this author’s, and many experts, first-choice approach for the femoral nerve in the groin, the obturator nerve, some saphenous nerve approaches and many abdominal wall approaches. Key to its safe use, is to never advance the needle further than the first point the needle is recognized in image.

Finally, if one sees much complex tissue disturbance in an image, perhaps 3-4 mm wide, a lot of image artifact extends deeper, and the actual needle is in the very most superficial part of the image “disturbance”.

Operators should have the concept that there is a *safe invisible zone* for the needle tip, and also a *dangerous invisible zone* for the needle tip. See figure number 19. The *safe* invisible zone lies between the point of skin puncture by the needle, and the point the needle-tip just touches the ultrasound transducer sound-wave plane. The *dangerous* invisible zone is when the needle has passed beyond the ultrasound transducer sound-wave plane. Typically, an inexperienced practitioner does not recognize that fact and keeps advancing the needle. The needle could then penetrate pleura, an artery, or other dangerous tissue lying within the dangerous invisible zone.

### F. NEEDLE TO NERVE APPROACHES.

For visible nerves, the combination of one nerve-view, and one needle-views produce four combinations of ultrasound guided nerve block, called APPROACHES.

For blocks of invisible nerves there are three nerve-block approaches. Invisible nerve-blocks are blocks where the goal is to inject local anesthetic drug into a fascial compartment known to reliably contain the target nerves, even though the nerves are invisible on ultrasound viewing. Invisible nerve blocks include many recently described fascial plane blocks, but the concept is actually very old.

<table>
<thead>
<tr>
<th>Classification of USG nerve-block approaches;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nerve visible</td>
</tr>
<tr>
<td>i. In-Axis in plane. (IAIP)</td>
</tr>
<tr>
<td>ii. In axis off plane. (IAOP)</td>
</tr>
<tr>
<td>iii. Off axis in plane. (OAIP)</td>
</tr>
<tr>
<td>iv. Off axis off plane. (OAOP)</td>
</tr>
<tr>
<td>2. Nerve invisible (NI)</td>
</tr>
<tr>
<td>v. In plane (NI-IP)</td>
</tr>
<tr>
<td>vi Off plane needle far (OP-NF)</td>
</tr>
<tr>
<td>vii. Off plane needle close (OP-NC)</td>
</tr>
</tbody>
</table>

1. **In-Axis In-Plane (IAIP) approach.**

This is a rarely used approach as it is hard to keep all three of the transducer, needle and nerve within one image plane. See image number 20. *Gliding* the transducer loses both needle and nerve in image. *Sliding* the transducer keeps both
needle and nerve in image. Rotating causes loss of the needle tip in image and shortens the visible length of nerve. Tilting the transducer causes both needle and nerve to be lost in view.

The best maneuver to find both needle and nerve is to glide and tilt simultaneously, so that the center axis of the transducer movement coincides with the nerve and the nerve stays in image throughout the movement. This coordinated double movement is only mastered by very experienced USRA practitioners. The movement is steadily done back and forth until both the needle and nerve are seen in image.

The IAIP approach is best initiated by finding the nerve on image then inserting the needle studiously ensuring the needle is exactly parallel to the transducer sound plane.

The needle must NOT be moved side to side, and only one of two needle movement should be used. The permissible needle movements are in or out, and redirection to deeper or shallower WITHIN the sound beam plane.

This author only has found one nerve-block indication use for this approach. It is with deep sciatic nerve approaches in the transgluteal region where the sciatic nerve may not be recognizable at all, in Off-Axis (OA) views. Sciatic Nerves as deep as 12 cm below skin in the transgluteal region at the GT-IT line is this teacher’s sole indication for this technique. In that situation, the sciatic nerve is only recognizable with an In-Axis (IA) view. It remains a challenging approach because it is deep, and the large distance from the transducer amplifies the consequences of unintentional tiny transducer movements.

Note; the needle may not be visible across its full length. Enough proximal needle shaft will usually be seen though, to still be able to point the needle towards the nerve. Nerve stimulation final verification of needle-to-nerve contact, is absolutely needed as well.
2. In-Axis Off-Plane (IAOP) approach
This is a very rarely used approach. It has been used by some exponents of the interscalene block wanting to view intentional intraneural injections best. See figure number 22. Introduce the needle very shallow into the image to find it, then serially withdraw it and incrementally redirect it deeper again each time. Keep doing that until the needle makes contact with the nerve. This is described as *walking the needle down the image*.

![Figure 22. Off-Plane In-Axis nerve block approach.](image)

One only has to keep the transducer aligned and parallel with the nerve. The needle is then very easily independently manipulated in and out of the image. The limitation of this approach is that generally, recognizing the nerve and keeping it in image is harder that with of an Off-Axis view. The exception is the interscalene brachial plexus upper trunk which is so large and so shallow, that it is very easy to keep it in view within the image.

Unfortunately, although an In-Axis view can reveal a deep transgluteal sciatic nerve, the very poor resolution of the deep image areas when using a low-frequency curved transducer, makes seeing Off-Plane needle impossible. In that situation, only use of in In-Plane needle technique (IPOA) is feasible.

3. Off-Axis Off-Plane (OAOP) approach. See figure number 23.
This popular and basic approach is mainly used with femoral nerve blocks, but is a highly flexible approach adaptable to many relatively shallow nerve blocks. Practitioners who work predominantly with children, where their thin skin and shallow nerves form sonogram images much easier than adults, tend to strongly favor this approach. It can be performed very fast. It is best used with high frequency
transducers, and shallow nerves. It is also relatively favored when the Off-Axis In-Plane view is limited by having not a suitable needle insertion site.

Although this approach is easy to keep a stable image with, and to re-direct the needle, novices conceptually struggle to understand the concept of walking the needle down the image. One needs to move the hub of the needle in the opposite direction to that, that one wants the needle tip to re-direct on the screen image.

This technique once mastered become a favorite and practitioners of it typically place the needle precisely onto the nerve within 5 to 10 seconds of puncturing the skin with the nerve-block needle. Its handiness is that the technique tolerates some amount of patient movement, without forfeiting ability to see the nerve or the needle.

Its limitation is that physicians with inherent poor 3-D spatial perception have difficulty relating what their unobserved hands are doing, with what the subtle screen images mean.

The first key principle is to immediately stop advancing the needle the moment any disturbance is seen on image from the needle within the tissues. The second key principle is to withdraw the needle-tip from image plus 1 to 2 cm more, before redirecting the needle. The third key principle is that the part of the needle-tip best seen on image is the actual tip. If the needle-tip is advanced beyond the image plane (e.g. 1 cm too deep) then the needle shaft which is then within the image plane image is often not seen.

Sometimes an image artifact suggestive of the needle may be seen lower in the sonogram image. The operator if then withdrawing the needle only 1 cm and redirecting its tip, will do so without altering the needle position on the image. The needle-tip will be in the dangerous distal blind zone of an Off-Plane needle approach.

Best blocks for OAOP approaches are femoral nerve, and the trans-sartorius saphenous nerve block.

GOLDEN RULES;
- Don’t ever advance the needle 1 mm beyond first sighting in image.
- Withdraw the needle entirely from the image and then an extra 1 – 2 cm, before redirecting the needle and advancing again.
4. Off-Axis In-Plane (OAIP) approach. See image number 24.

This is probably the most popular nerve-block approach. It is relatively easy to maintain the nerve view with the transducer, and seeing the entire needle is conceptually appealing. The challenge is to keep the entire needle in view and to recognize when the true needle-tip is not in view.

Rotation of the transducer will trim the most-close, and most-far parts off the needle in view. It is not obvious that the end of the needle in view, is not the true needle-tip. This is particular dangerous with the supraclavicular block, because of the inherent pneumothorax risks. NEVER advance the needle unless one is fully confident the true needle-tip is in view with the supraclavicular block. Injection of 1ml of 5% DW can be used to visually confirm needle tip is in view. If the Dextrose water is not exactly seen in image, and the needle tip is not in image and will be probably deeper and possibly in an unwanted place like the pleural cavity. Withdraw the needle to near the skin puncture point and start again.

5. Nerve-Invisible In-Plane approach (NIIP)

This is used a lot with the infraclavicular block where the brachial plexus cords have a well-known and constant relationship to the axillary artery. See figure number 25. It is not necessary to see the nerves in order to do the block. The nerves can be precisely searched for within a small zone with a nerve stimulator or the local anesthetic can be injected in fixed positions relative to the axillary artery, with similar success rates.
The NIIP approach is also most useful with USG blocks of the lateral cutaneous nerve of the thigh, ilio-inguinal nerve, ilio-hypogastric nerve, and the transversus abdominis plane (TAP) blocks. Figure number 25, illustrates a NIIP block of the lateral cutaneous femoral nerve of the thigh (LCFN) over the sartorius muscle. The precise needle-tip position is confirmed on image with injection of fluid (L.A. or 5DW). The fluid is seen to lift the fascia iliaca up above the sartorius muscle, which itself gets pushed slightly downwards. That confirms the needle tip is between the two fascias. The LCFN is known to cross through that fascial interspace, and can thus be nerve blocked, even though the nerve is invisible.

The drug is injected in between the two imaged fascias.

6. Off-Plane Far-Needle approach (OPFN). (Figure number 26.)

The ultrasound image is held to clearly identify a facial plane, and the needle is introduced into the image from Off-Plane. It is useful if the needle approaches from a short distance from the transducer to aid keeping the needle parallel to the transducer surface, as this will aid seeing the needle tip enter the image. It can be used identically for most of the uses of the NIIP approach and simply offers an alternate needle insertion site. The precise needle tip position is confirmed on image with injection of fluid (L.A. or 5DW) which widens the fascial space, in which the invisible targeted nerve lies.

7. Off-Plane Needle-Close (OPNC) approach. (Figure number 27.)

This variant of nerve block approach, is used when a nerve lies within a deep but identifiable fascial compartment, and one wishes to avoid the lengthy needle tract required to bring the needle sufficiently parallel to the transducer to make it visible. The needle with an OPNC approach, is inserted about 2 cm from the transducer in its mid-position. The needle descends very steeply, and near vertical. Inserting the needle closer than this is awkward, as the needle hub then encroaches against the transducer. Use intuition and angle the needle slightly off vertical towards the beam plane anticipating it reaching the target fascia as it enters the beam plane.

Typically, one easily learns to feel the needle edging against the fascia, or penetrating the facia with a “popping” feel at the needle-hub. In addition, one swiftly learns how to reinsert the needle so that the needle-tip tests the fascia precisely within the image plane. The final goal is to have the needle be felt to “pop” through the fascia in vision, and then inject all of the drug deep to the deep-fascia of the sartorius muscle. This is instinctive for persons with high levels of 3-Dimensional spatial perception. See later discussions. Using small, one ml, injections of contrast (5DW) every 1cm the needle advances, greatly aids “seeing” the depth the needle is at. One never sees the actual needle. Avoid injecting too much contrast fluid, as it ultimately contaminates the sonogram.
image diminishing its quality. The visual image’s subtle changes correlate perfectly with all the feelings experienced through holding the advancing needle. This is very easily learned technique.

The best use example is, the trans-sartorius muscle approach to the Saphenous nerve, near the knee medial side.

See in figure number 27, the triangular Sartorius muscle is seen in the middle of the image. The red arrow in picture A is pointing to the deep surface of the muscle just before the descending nerve block needle reaches it. With further descent of the needle it pushes the fascia downward and this is felt in the hand holding the needle. The moment the needle penetrates the fascia it is seen to spring back on image and the needle is felt to offer a feeling of a “pop”. Test fluid (L.A. or 5DW) can be injected to see if it spreads in the correct sub-sartorius muscle plane, as seen in picture C of image number 14.

The technique is easy and utilizes; (1) the feeling of the needle passing though the tissues, (2) the visual image of the tissue being pushed by the needle, and (3) the use of contrast injections.

### HOT TIPS for HANDLING the NEEDLE.

With **IPIA needle-nerve approaches**, NEVER move the needle side-to-side, only in-out or deeper-shallower. Side-to-side needle-hub movements will lose the needle in image.

With **IPOA needle-nerve approaches** NEVER move the needle side-to-side, only in-out or deeper-shallower. Side-to-side will lose the needle in image.

With **OPIA needle-nerve approaches**, the needle may be moved in any plane that will visually walk the needle-tip down or across the image to the target. NEVER advance the needle further, once it is first seen on image.

With **OPOA needle-nerve approaches**, the needle may be moved in any plane that will walk the needle tip down or across the image to the target. NEVER advance the needle further, after it is first seen on image.

### G. FINDING THE NEEDLE, and NEEDLE CUT-OFF PHENOMENON.

With in-plane needle views, a drift of only 1-2 mm of the transducer, or side twist of a few degrees with the needle can remove the needle entirely from view. There are then a few ways to “find” the needle again.

1. **Glance at the needle in your hand** to check you have not twisted it to the side. Typically, this is the first mistake novices make, moving the needle 90 degrees in the wrong axis, when they are looking on screen and not looking at their hands. Remember the rules;
   - To redirect the needle **tip deeper** in the tissue, move the needle-hub **towards the transducer**. Or phrased differently, lift the needle-hub higher above the skin.
   - To redirect the needle **tip shallower** in the tissues, move the needle-hub **away from the transducer**. Or rephrased differently, lower the needle-hub towards the skin.
2. Do a very tiny transducer GLIDE “North” and “South” adjustments, along the axis of the nerve under examination. See figure number 28. Important rules are;
   - Do not alter the optimum TILT one has established, to try imaging the nerve better.
   - Do not alter the transducer SLIDE position, that centered the area of interest within the image.

3. Turn the needle and transducer to face each other. See figure number 29. If the needle direction and transducer plane have lost being parallel, “turn them to face each other”. This is particularly useful in nerve block positions, where the transducer has limited ability to glide due to sitting in a tissue trough with firm boney boundaries, e.g. supraclavicular. Keep the same angle of tilt to retain best nerve image and keep the same side-to-side position to keep the area of interest centered in image. For all other blocks, keep the needle still and adjust the image by only using the transducer.

Keep correcting the needle view all the time so as not to lose it fully. Keep all movements small scale and perform them in slow motion.

Figure number 28. This shows in line “A” how despite having the transducer being parallel to the needle shaft, no image is produced. In line “B” a transducer gliding maneuver is used seeking alignment between the needle and the transducer. In line “C” the needle and transducer are both parallel and aligned, and the full needle shaft is seen in image.

Figure number 29. It is generally advised never to use a side-to-side movement of the needle when attempting In-Plane views of the needle. Confine all alignment corrections to transducer position adjustments. The one exception however, is when performing the Supraclavicular block of the brachial plexus. Maneuvering space for the transducer is very limited, by all the boney structures of the neck. In that case BOTH the needle and the transducer can be manipulated to correct parallelism and alignment. Quickly look at the transducer and needle to determine how they lie. Then, use very small rotating movements, turn them each to face each other, in their long axes, as shown in image “B” above, to produce image “C”.

**Needle Cut-Off phenomenon** occurs when using an In-Plane needle nerve-block approach under ultrasound guidance. See figure number 30. This means the most front part of the needle, the true needle-tip, is invisible in image. The last part of the shaft that is imaged, tapers to a fine point on screen, within the sonogram image. That fine point part of the shaft then seems to be the needle-tip, but is a false needle-tip. If the operator then advances the needle the true, but unseen, needle-tip advances dangerously further into the patient tissues. Depending on the nerve block, that can cause serious injury such as, puncture of large artery, the pleura, or the bowels.
Needle cut-off phenomenon must be continuously looked for all the time, during In-Plane (IP) nerve-block approaches. Needle cut-off phenomenon must be diagnosed when any of the three signs is present:

1. The needle-tip tapers to a thin point.
2. The needle tip does not advance proportionately in image when the needle is advanced into the patient’s tissues.
3. The length of visible needle on screen seems disproportionately short, for the length of needle already inserted into the tissues.

---

**Figure number 30.** Images A. and B. illustrate the concepts of parallelism and alignment between the ultrasound transducer, and the nerve block needle-shaft. Image C. demonstrates needle cut-off phenomenon, and how it creates false needle-tip on image. Image D. shows how rotation of the transducer can be used to correct needle cut-off phenomenon, by correcting parallelism and preserving the alignment.

---

**H. Three-dimensional spatial perception, and operator skills.**

This subject relates to the highest technical skills and abilities of humans. The ability to perform an ultrasound guided nerve-block requires that a person be able to operate two devices simultaneously held, but separately one per hand. Each of those devices, needle and transducer, has to be simultaneously operated in high-precision 3-dimensional (3-D) planes within the uncontrolled biological living milieu of a moving breathing patient. All of that is done blindly, as the operator’s eyes cannot observe their own hands. The operator has to
study the 2-dimensional low quality black and white dynamic image, far away from their hands. Operators who continuously look back and forth between their hands and the monitor cannot perform Ultrasound Guided Regional anesthesia (USGRA). The reason is that they then fail to notice subtle images changes corresponding with subtle hand position adjustments. Single one-time glances at the hands is acceptable. A strong marker of a trainee with poor prognosis to mastering USGRA, is one who repeatedly glances up and down between their hands and the monitor screen. It requires a confident and accurate perception of how an approaching sharp needle-tip under operator control, is placed in precise proximity to a delicate neurological patient structure, the nerve, utilizing only the 2-dimensional image as guide to controlling the hands operating the two devices, needle and transducer, in two coordinated 3-dimensional (3-D) fashions.

Rephrased, the dynamic 2-Dimensional video before the operator’s eyes, has to guide the 3-Dimensional adjustments of the two instruments in the operator’s hands, when any instrument movement has influence on the effects of the position of the second instrument, as well as on the anatomical structures within the patient, and all of that is done without the operator looking at their hands.

3-D spatial perception is the ability to manipulate an object unseen, as a needle inserted into tissues, and utilizing intellectual knowledge of the complex multiple tissue structures within that body segment, and fully form an accurate sense of where the needle tip is relative to the deep unseen body parts. With zero 3-D spatial perception a person cannot see deeper than the skin surface, within their minds. With good 3-D spatial perception the person is able to accurately fantasize where the needle-tip is, and how to manipulate the needle-hub to position the needle-tip where desired. 3-D spatial perception is the ability to have a COGNITIVE PROPRIOCEPTION for the boundaries of inanimate objects which one only touches part of, with one’s fingers, and that one cannot see.

The following are facts:
1. This task is performed by thousands of physicians on a regular daily basis, with great acumen, accuracy, safety and efficacy.
2. Individual physicians learn these skills individually with them having a very wide disparity in technical learning abilities.
3. The principle skill required is for the operator to have 3-dimensional spatial perception.
4. Human intelligence is incredible.

Studies have shown that simulations resembling this complex procedure can be mastered by some individual physicians, within one single experience. The vast majority of the other physicians master the complex procedure within a very small number of repetitions. Finally, a very tiny number of physicians required up to 20 repetitions of the simulation before achieving a rating of being skilled at the procedure. The final observation, was that every individual who had had the ability to qualify as a physician, within the study groups, was ultimately able to demonstrate competence performing a complex procedure requiring functional 3-dimensional (3-D) spatial perception skill.

Other studies have shown individuals who suffer from dyslexia, are equally poorly skilled at tasks requiring high 3-dimensional (3-D) spatial perception ability. Dyslexia is a marker of having low 3-D spatial perception ability. Important note; dyslexia is not a marker of one having zero 3-D spatial perception ability.
The following possible conclusions can arguably be drawn from all the above discussion on 3-D spatial perception and ultrasound guided nerve blocks.

- Candidates for entry to medical school must in addition to being subjected to measures of intelligence, such as exam scores, should also be assessed for ability to perform complex technical tasks. Tests for dyslexia, might be a simple sifting test.
- Qualified physicians, who do suffer from low 3-D spatial perceptions skills, and dyslexia, can all finally achieve sufficient skills to all perform good ultrasound guided regional anesthesia procedures.
- Educators and teachers must be skilled in recognizing individuals in need of extra training to acquire the technical skills to perform ultrasound guided regional anesthesia. The educators and teachers, must in themselves, be trained and skilled to providing the necessary and appropriate training, to the needy trainee.

The full and final decisions on these above three points, will depend upon philosophical views of life and humanity, and will be complex.

In this teacher’s view, society functions best, less when trying to mold all individuals into a stereotyped corporate mold, or to select only individuals fitting some arbitrary stereotyped mold. Society function’s best, more when it embraces individuality and focusses on each individual’s personal stand-out talents, and less upon their lesser rated talents. Furthermore, the best team is not one with uniformity of individual members, but one with disparity of individuals who hold hands and jointly solve novel challenges, that individually some of them would have failed to solve if alone. To emphasize this point. This teacher has recognized some trainees who were slow learners graduated to become phenomenal teachers themselves, because in their struggles to achieve technical mastery they learned how to verbalize and elaborate on the steps of the complex skills they had personally labored to learn. Conversely, this teacher has seen that some individual trainees who near instantly could master a complex skill, were themselves poor at guiding their first own trainees towards mastering the same skills. This teacher has in a personal life-time journey of parallel self-learning and teaching, acquired great respect for the individuality of all physicians. This teacher has also observed how, overwhelmingly, individuals ultimately gravitate towards their own personal best-fit situations in medicine, with respect to intellectual, interpersonal, and technical skills.

Accordingly, this teacher is not in favor of selecting candidates for medical school to also be ones also with innate high 3-D spatial perception ability, in addition to high intelligence. It is however, important to do more research into 3-D spatial perception to find ways to optimize learning that skill, best ways to teach procedures which are very dependent upon having that skill. Finally, general knowledge about 3-D spatial perception skill should be made common. It will help individuals each find their own best niches in the very diverse world of a medical career. Very different types of persons make for one being a best regional anesthesiologist, a best orthopedic surgeon, a best neurologist, a best family physician, and a best laboratory basic science researcher.