Curriculum one lecture 3

Basic in plane needling

Ultrasound guided TPVB

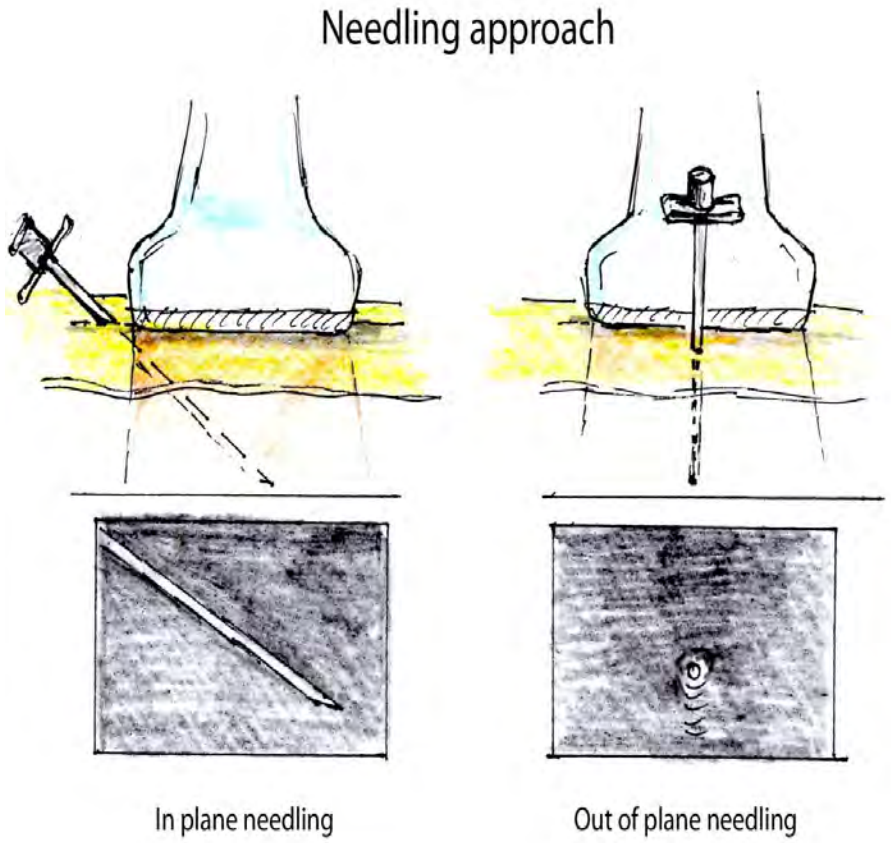
(in plane from lateral to medial, probe axial, patient prone)

Most common techniques of TPVBs

- **US assisted TPVB (previous lecture)**
- **Pure Landmark based techniques (bonus lecture)**
- **Ultrasound (US) guided TPVB (this lecture)**

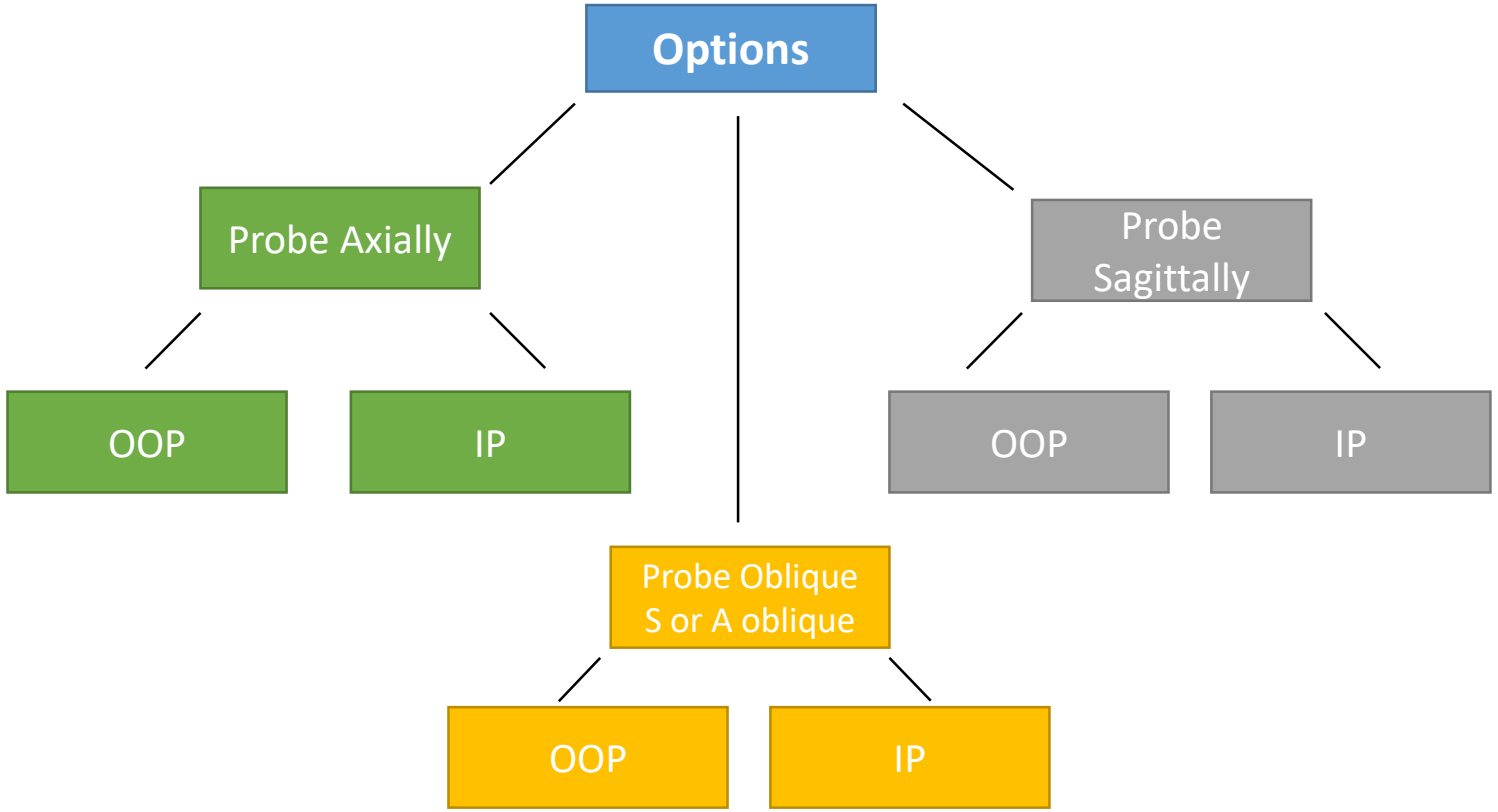
- **In US guided technique** one utilizes US in real time during needling. We visualize TPVS and advance needle into TPVS while watching needle tip entering the space. Seeing needle tip in TPVS or spread of LA in TPVS is our ultimate end point for correct needle position.

Needle to probe (ultrasound plane) orientation for US guided techniques. (*or simply needling approaches)*



Classification of US guided TPVBs
There are many options for live US guided TPVB

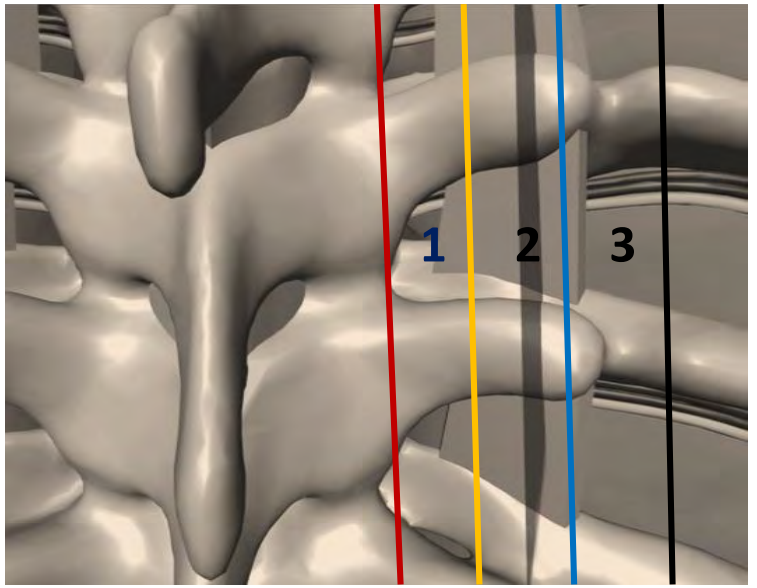
3 options based on TPVS space visualization (probe axially or longitudinally or oblique)
2 options based on needle approach (OOP or IP) for each option above if live guidance is used
Theoretically, the needle can be advanced either from lateral or medial (IP) or above or below (OOP)

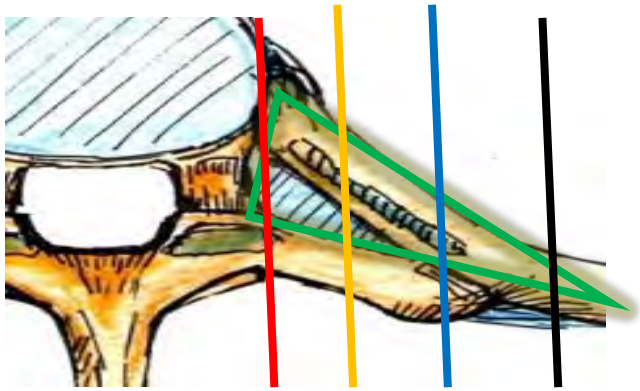


For all options patient could be seated, lateral or prone
There are many different approaches and endpoints

Another classification of TPVB: **medial vs lateral approaches** (based on targeted zone of TPVS)

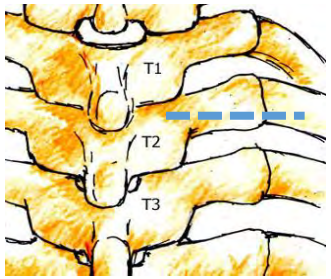
- In anatomy lecture we outlined 3 anatomical zones of TPVS: **middle**-around tip of TP(2), **medial** –adjacent to IAP (1) close to intervertebral foramina , and **lateral**(3) –lateral to TP tip
- From a clinical stand point, dividing them into **medial** (1) and **lateral** (2+3) is probably enough
- **WE advocate lateral approaches and warn about risk of neuraxial complications with medial techniques**
- **In this curriculum we focus on TPVB with probe axially**



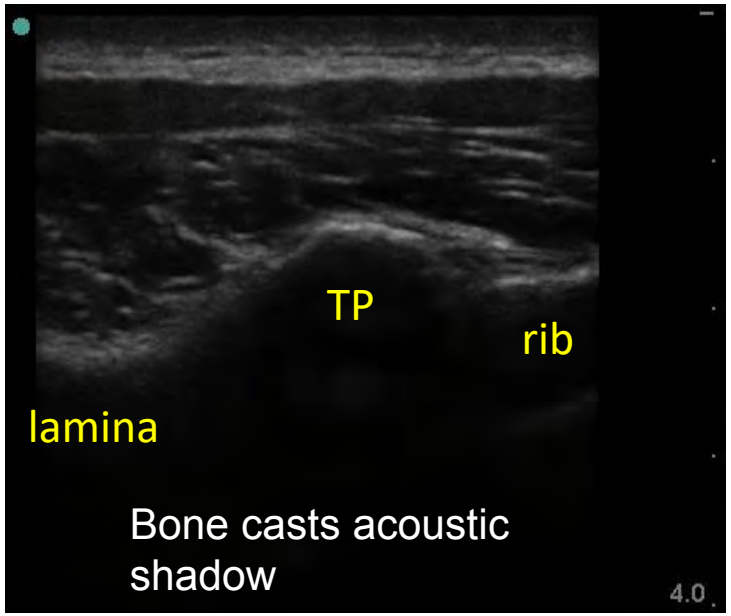


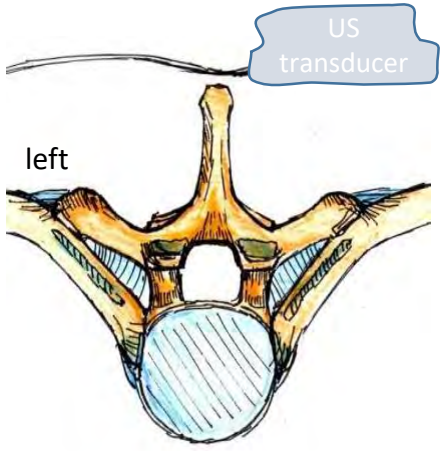
Sonoanatomy of TPVS

Standard axial TP scan: over costotransverse junction (blue line on the sketch)

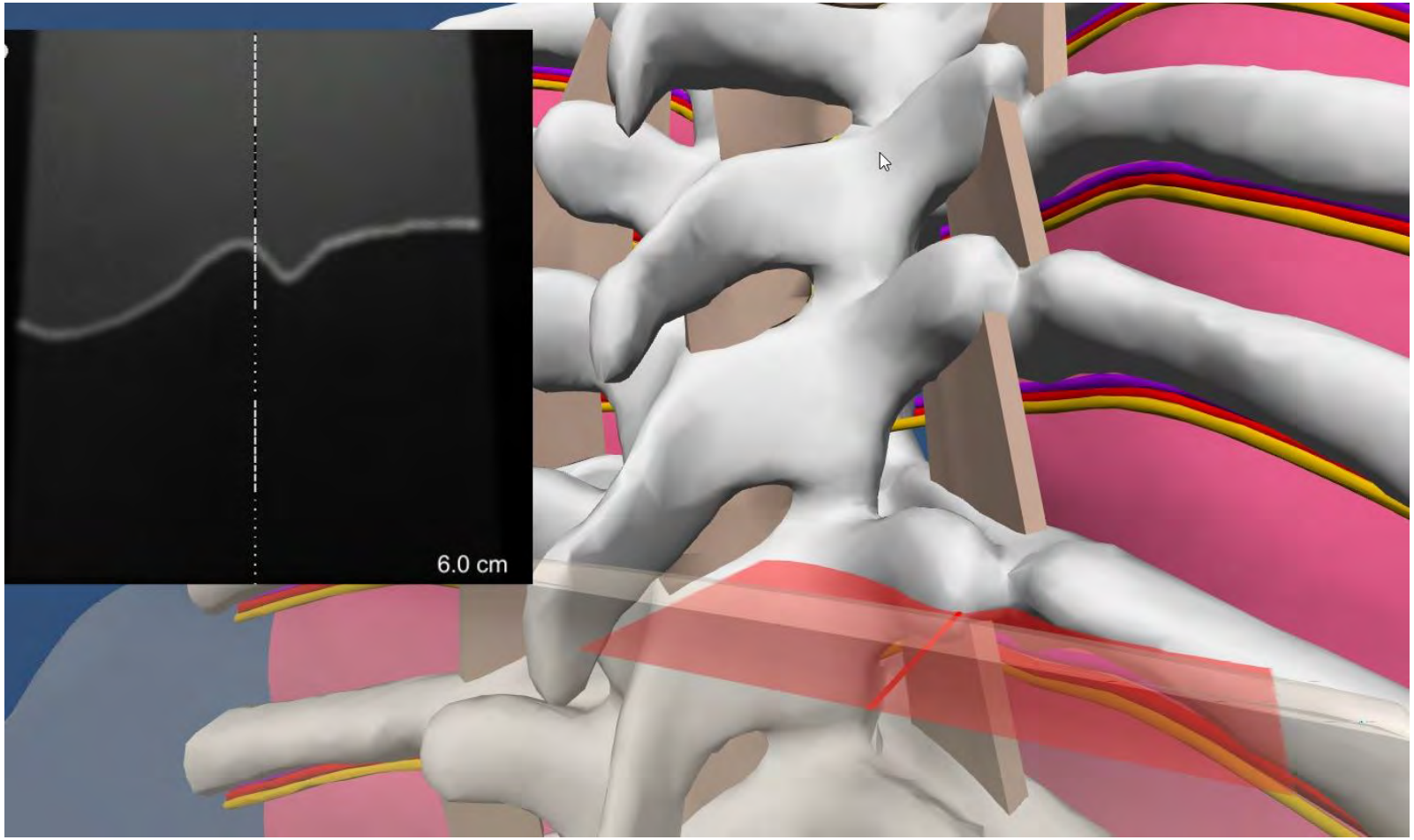


The ultrasound probe is positioned at the same level as the blue line on the skeleton sketch





Same axial/transverse scan over the costo-transverse junction on the simulator (muscles excluded).
It helps to follow with your eyes the interface between virtual US plane (red) and 3D anatomy to better understand the virtual US image (black and with on the upper left).

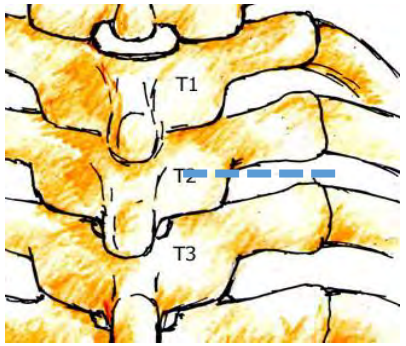


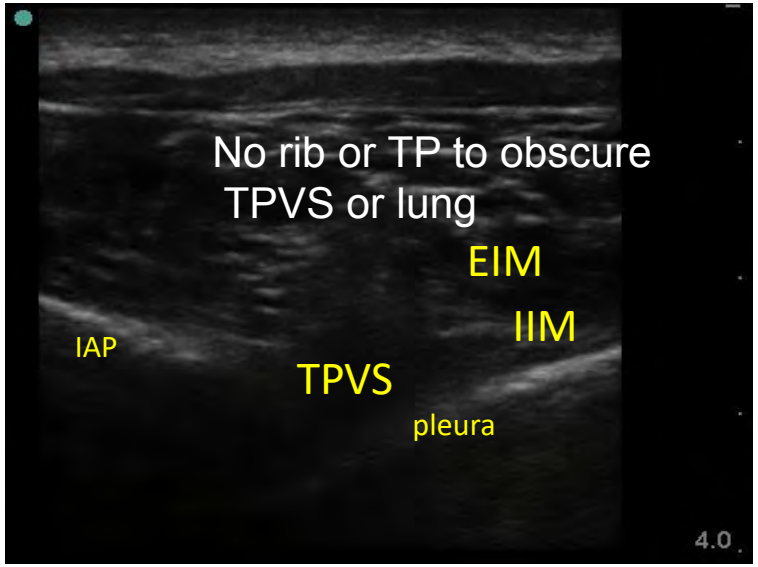
If we follow bone line from medial to lateral we will see: lamina-root TP-tip of TP-costotransverse junction-rib

Sonoanatomy for TPVB

Standard axial TPVS scan : off TP/rib only IAP medially , TPVS just below TP and rib (blue line on the sketch)

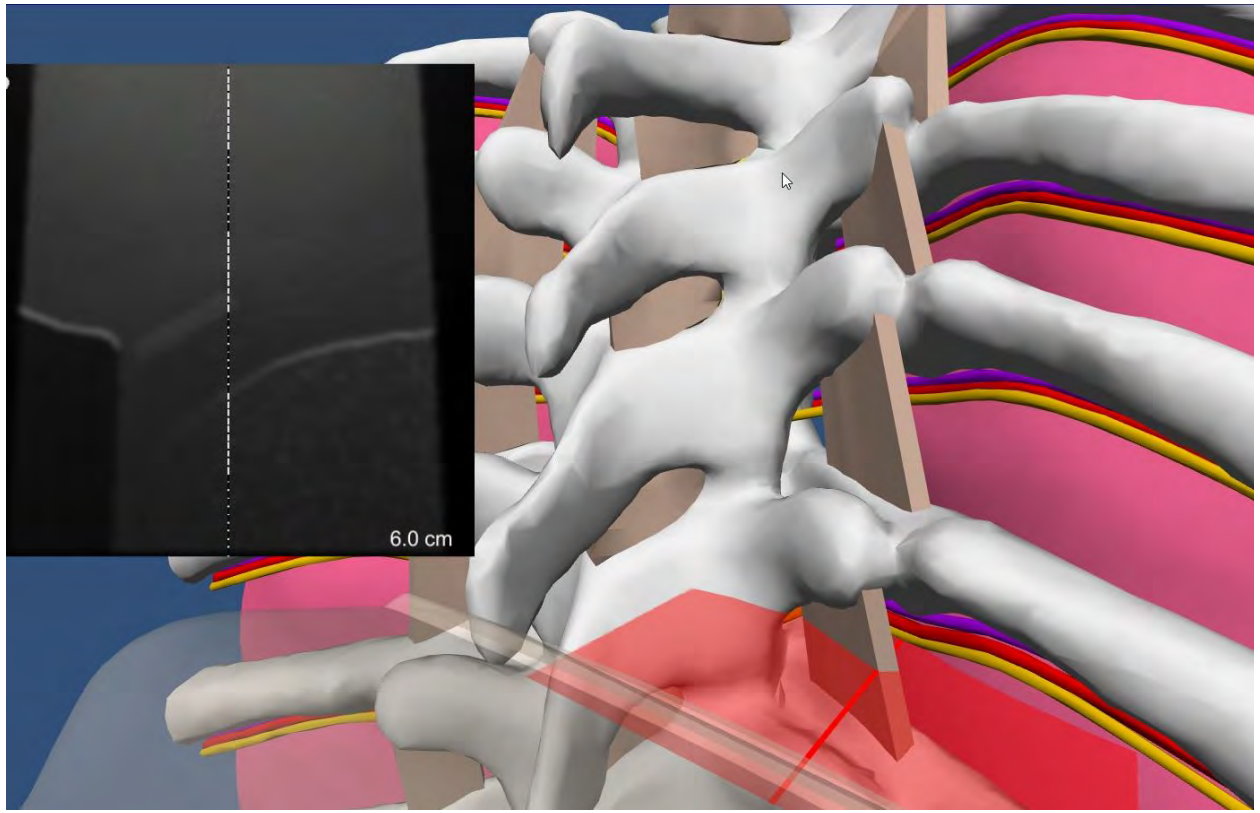
Tilt or slide the probe caudally to “move” the US beam off the TP or rib





The ultrasound probe is positioned at the same level as the blue line on the skeleton sketch (between TPs and ribs).
IIM-internal intercostal membrane, EIM-external intercostal muscle
IAP –inferior articular process

Transverse scan over TPVS between ribs and TPs. This model does not have muscles but you can still see IAP and pleura (note that pleural reflection fades medially). If we had muscles on our model we would see internal intercostal membrane and external intercostal muscle immediately behind it right over TPVS in its lateral part (dorsal to it).



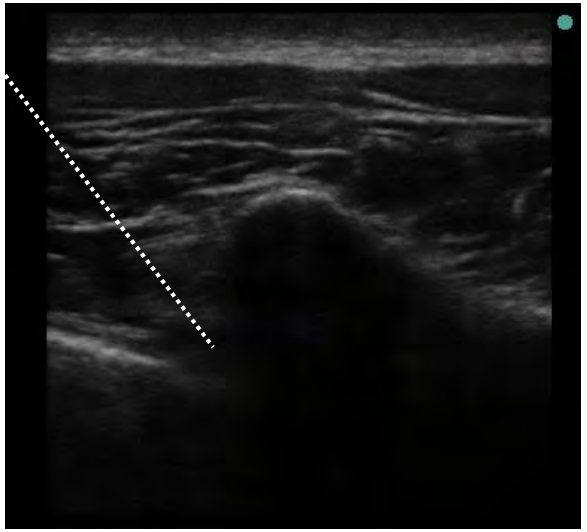
If you look at 3D anatomy and imagine the ultrasound plane is moved up and down, then you should predict how the virtual ultrasound image would change.

Moving probe UP: reflection of the bone (here IAP) should get wider (extend more to center) and up -transition into lamina and root of TP; TPVS should get a bit wider in AP dimension.

Moving probe Down: medial part of the head of the rib should start appearing in the view, TPVS get more narrow in AP dimension.

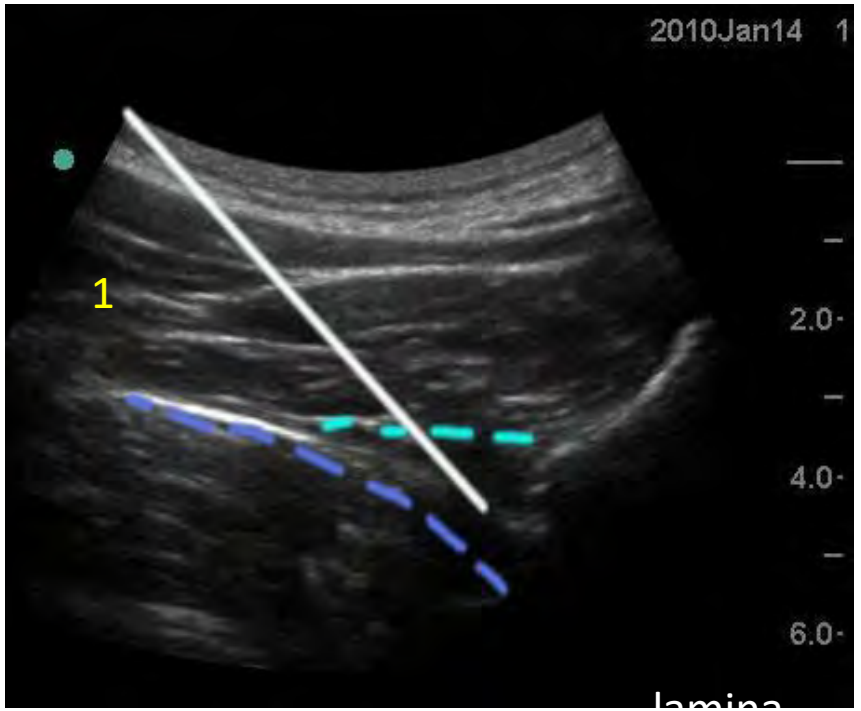
Our practical recommendation on choice of US guided TPVB for this curriculum

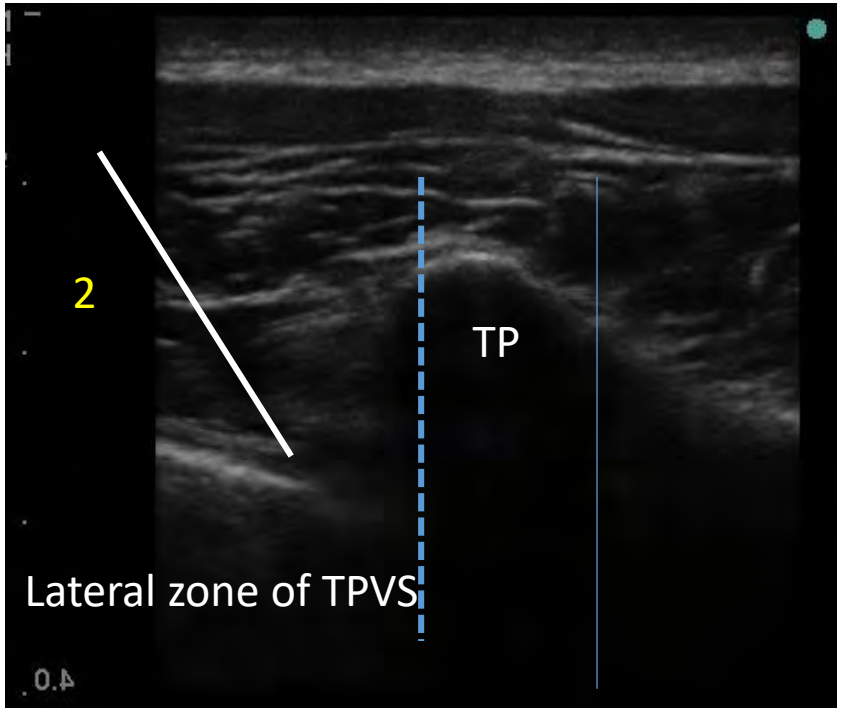
- We recommend **Probe axial, in plane needling from lateral to medial** targeting **lateral zone of TPVS with the patient prone (Shibata; Renes; Cowie technique)**
- It is probably the easiest technique with small drawback of **more lateral skin entry than alternative options** (may be less suitable for posterolateral thoracotomy for example)-For those cases one can use US assisted TPVB.
- **See all other techniques in bonus lectures**
- In order to teach this technique, we will cover fundamentals of in plane needling and details of the technique next. Sonoanatomy in more details was covered in first lecture.



2 slightly different versions of above mentioned approach

(1:deliberatly targeting true **medial zone** of TPVS or 2:targeting **lateral zone**)





It is not proven that a more medial block is better than more lateral so it makes sense to avoid too medial needle placement due to risk of neuraxial complications. Version 1 was popularized by Gautier (needle is likely to penetrate SCTL) and 2 by Shibata (needle is likely to penetrate internal intercostal membrane IIM). Ben-Ari performed a similar block but even more lateral (intercostal approach) and demonstrated spread into TPVS comparable to more medial approaches . Version one is still acceptable if one has good control of the needle tip and does not push it too medially towards the vertebral foramina. We will practice a version that is between 1 and 2 (we do not have IIM on our simulator, so we will advance the needle in TPVS through SCTL or lateral to it and stop it just below the tip of TP.

Review questions

- What are the 3 main available options for TPVB? What is the essence of US guided technique?
- Name 2 ways of needling based on needle to probe orientation.
- What are the 2 ways to give as classifications of US guided TPVB?
- What are the advantages and disadvantage of the axial in plane from lateral to medial approach with patient prone? What are 2 versions of that approach based on targeted zone of TPVS?

The big picture of any US guided block (part one and part two)

1. Acquiring a **proper image** with **adequate acoustic window** and estimating future **needle angle** (with **proper view point** and **US probe position)**
2. Needling
   - **Initial advancement** of the needle under the probe based on external alignment and estimated angle of needling
   - **Optimizing needle view after looking at US screen**
   - Further needle advancement based on **US guided alignment**

Part one (before actual needling)

(details with separate slides will follow)

- Good ergonomics always facilitate a successful procedure and bad one makes it difficult (US machine, patient and operator should be ergonomically aligned)
- Start with optimal view point and adjust it again before needling to avoid parallax error
- Know your probe/screen orientation, surface landmark (where to put the probe on the skin) and know the targeted sonographic image and sonoanatomy of the area around . Know the required probe adjustment to optimize the targeted sono image.
- It is ok to use both hands to move the nose and heel of the probe separately for better control.
- Avoid probe tilt during image acquisition if possible (use slide instead). Deliberately switch your eyes from US screen to the probe to assess (if you have a target image but the probe is tilted see if you can make adjustments to get one without a probe tilt)
- Some pressure frequently improves the image, and some forward probe rocking helps with angle of incidence and needle visualization (this is especially important when target is deep)
- Hold the probe low close to the patient, bracing your hand on the skin for stability
- Make sure you have an adequate acoustic window to accommodate future mini slides of the probe.
- Estimate angle of the needling based on the image before starting

Part two (basics of in plane needling)

(details will follow)

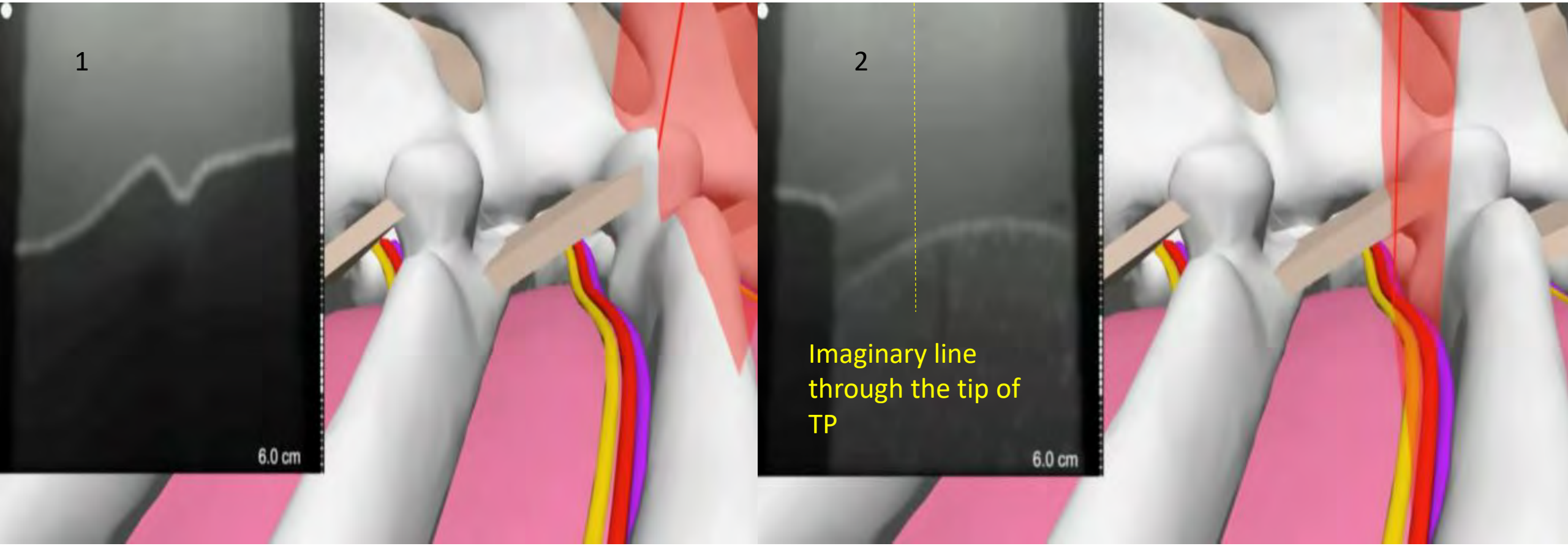
- Start initial needle advancement based on excellent external alignment: looking at the probe/needle/skin interface not at the US screen. Enter skin 1 cm away from heel of the probe and advance 2-3 cm of the needle in with the previously predetermined angle (use distance between needle and probe as a surrogate marker of the angle). Then shift your attention to the US screen (next steps are US guided alignment)
- Remember 2 types of US guided alignment (while looking at the US screen): needle and US plane alignment (NUSPA) first and then needle target alignment (NTA) later
- Use mainly 2 moves: 1-moving the probe (mini slides) and 2- moving the needle (horizontal hub push) to correct misalignments. Minimize/avoid tilting the probe. Use small correcting movements. Occasionally you may need to shift your attention back to needle and probe (external alignment)
- Use incremental advancements of the needle (1-2 cm at a time) with clear tip visualization at each step and adjust after each step if needed
- Focus on the tip of the needle (know its unique appearance). If the tip is lost from the view during advancement – stop, do not advance the needle further until you get it back into view
- Use other maneuvers such as hydrolocation when visualization is poor to help with needle guidance

Review questions

- What are the two parts during US guided in plane block that we covered in the previous 3 slides?
- Name at least 5 important points of the first part of procedure?
- Name at least 3 stages of the second part of US guided block?

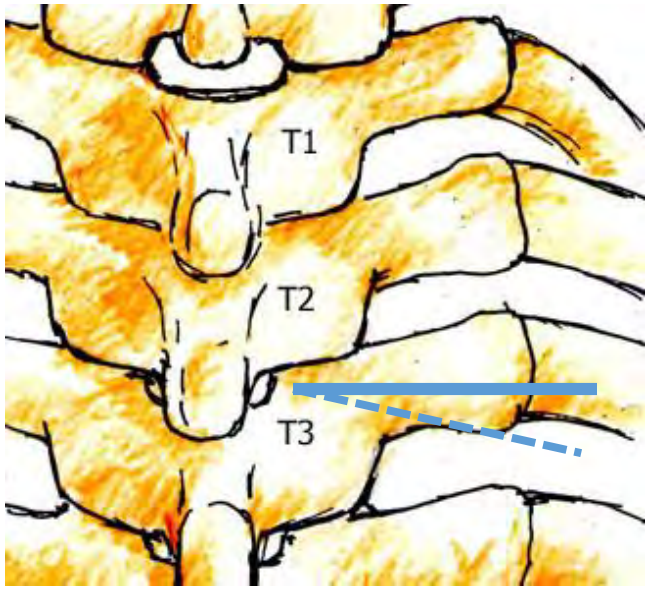
US image of the TPVS right below TP

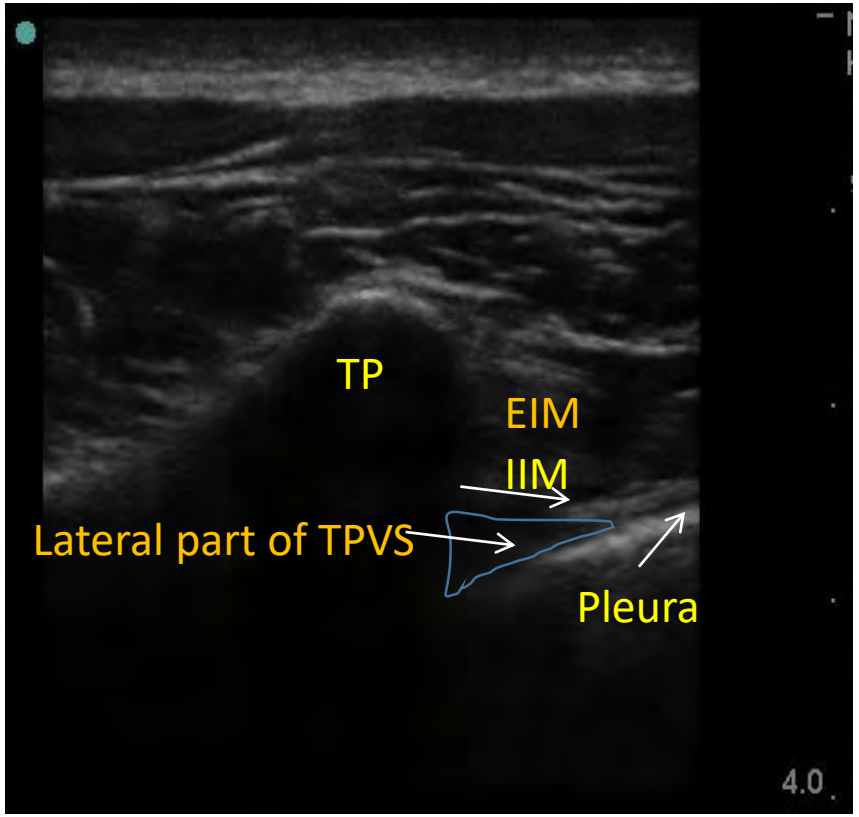
Image 1: Tip of TP serves as a marker of the future medial border for correct needle tip location.
Image 2: is the image obtained when the probe is moved about 5-15 mm caudad from image 1.
Do not advance the needle too far medial past the imaginary vertical line through the tip of TP to decrease the risk of neuraxial complications.



Some mild rotation of the nose or heel of the probe is occasionally needed to clean the image

Axial oblique : over tip of TP but off rib

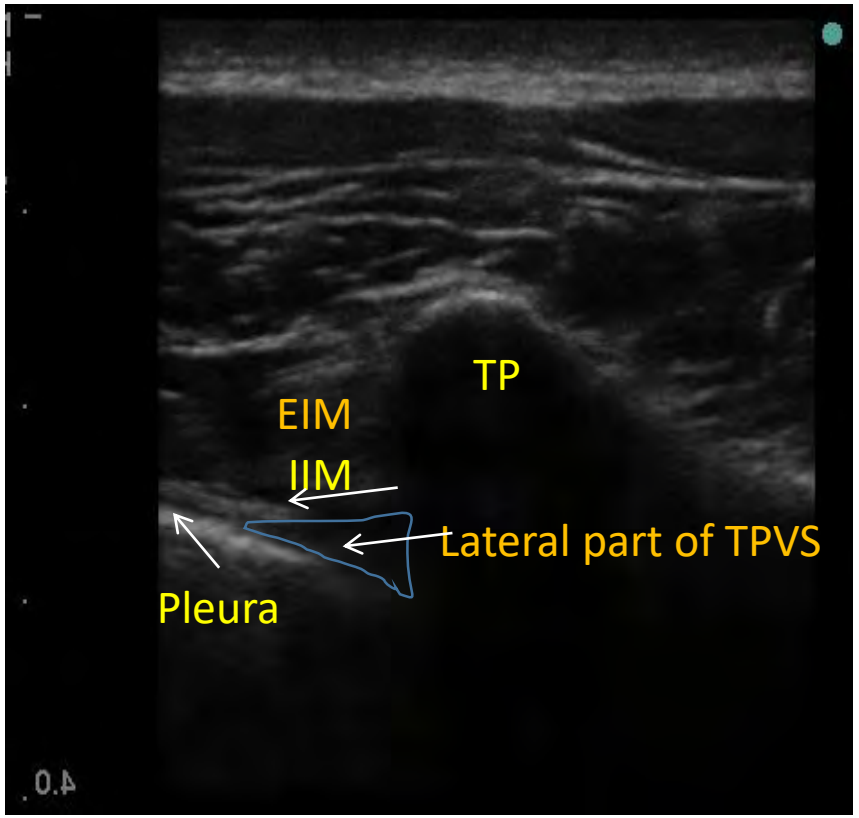




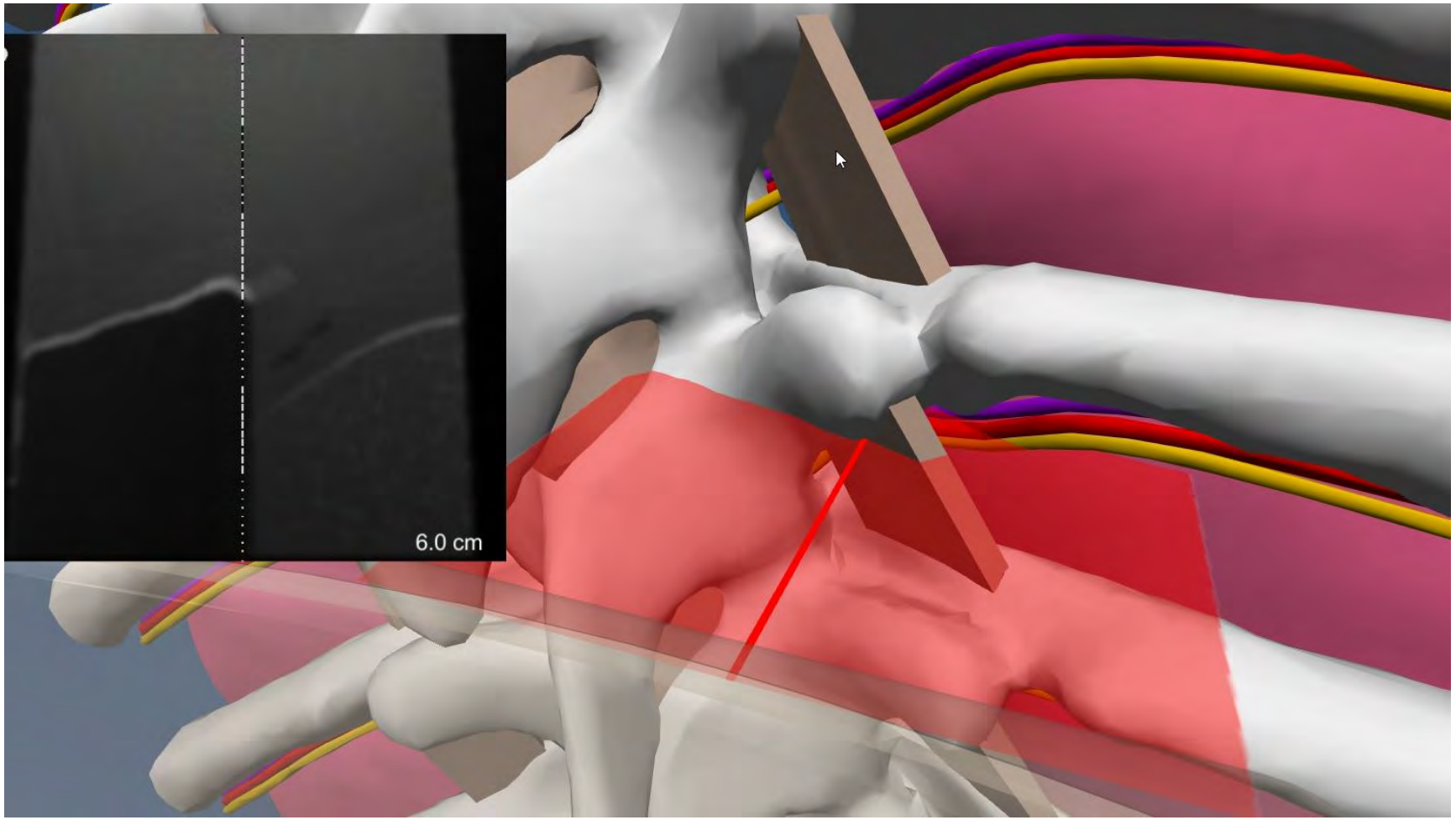
One can can rotate the probe slightly from a standard axial scan so the medial pole of the probe remains on the same spot while the lateral pole moves down (dashed line here). Seeing the lateral tip of TP helps to pinpoint only the lateral zone of TPVS, medial and intermediate zones are in the acoustic shadow of the TP.

Another version of the same view

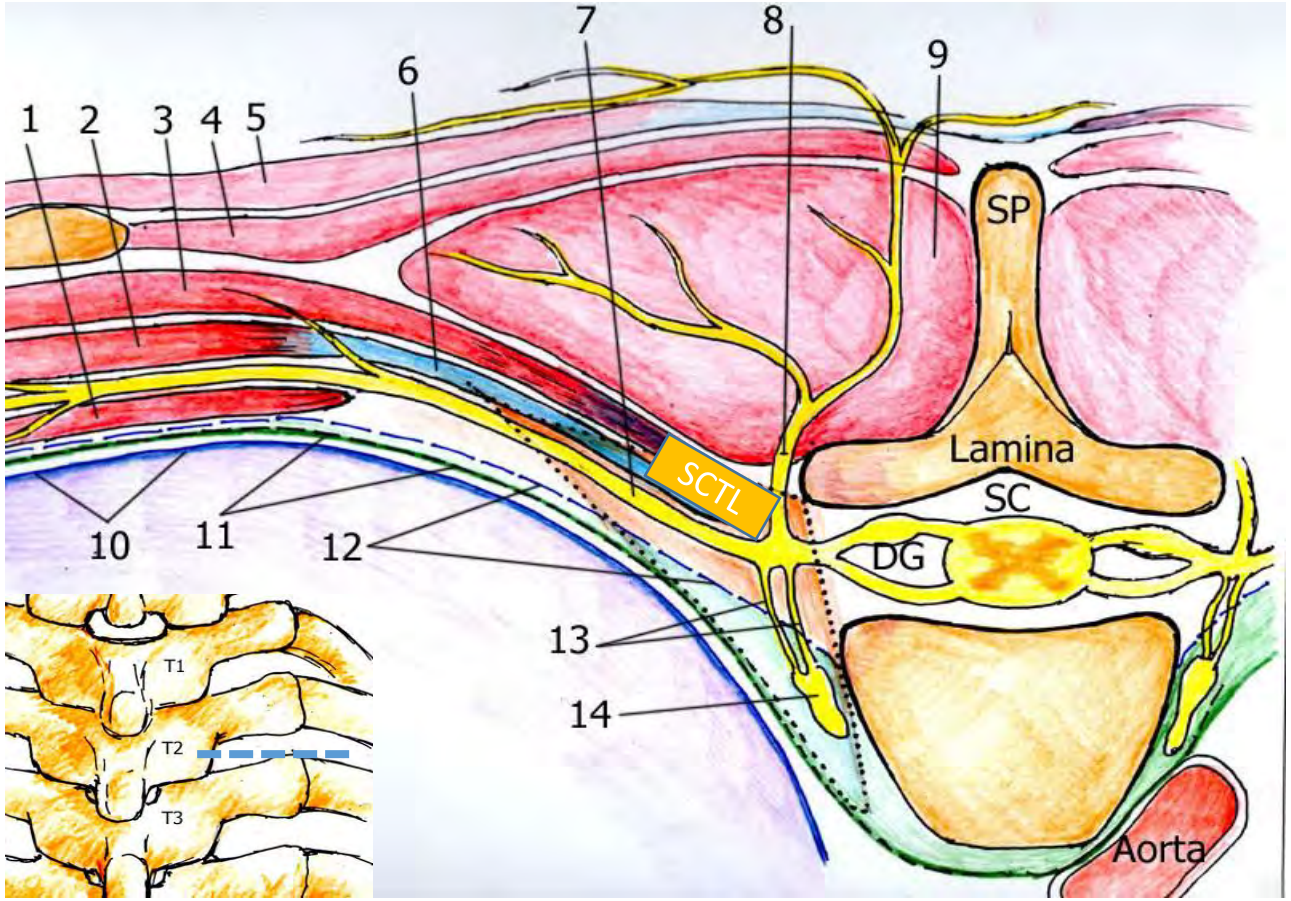
Blue line on the skeleton sketch represent position of insonating plane. If the lower edge of the rib is higher (cephalad) than the lower edge of the TP, one may not need to position the probe obliquely to avoid acoustic shadow from the rib while keeping tip of TP in the view

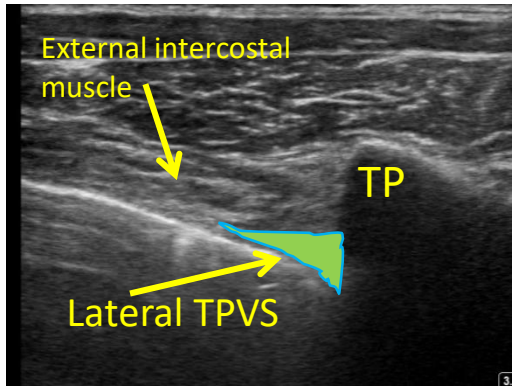


Similar view on the simulator (lateral part of US plane is off the rib while medial is over TP

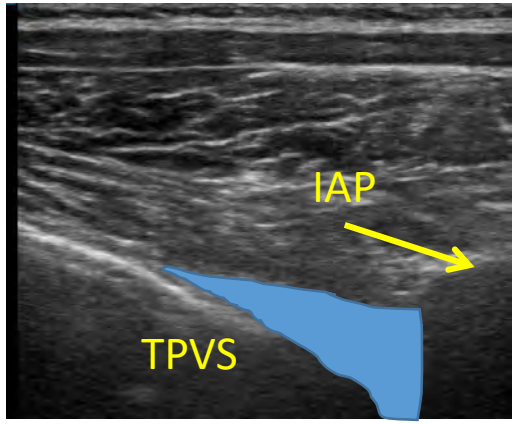


Note the difference between this view and one that is taken at the level of IAP on the next slide. In the future we will add external intercostal muscle and internal intercostal membrane so it is more realistic, for now just imagine those structures





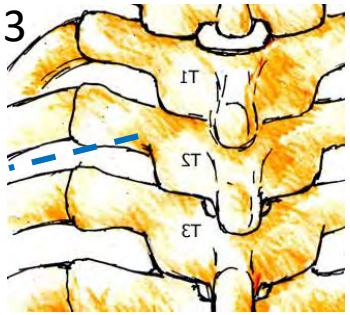
Axial oblique



Axial off TP/rib

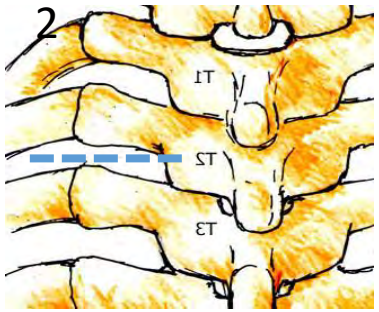
Schematic axial view (between ribs and TPs)

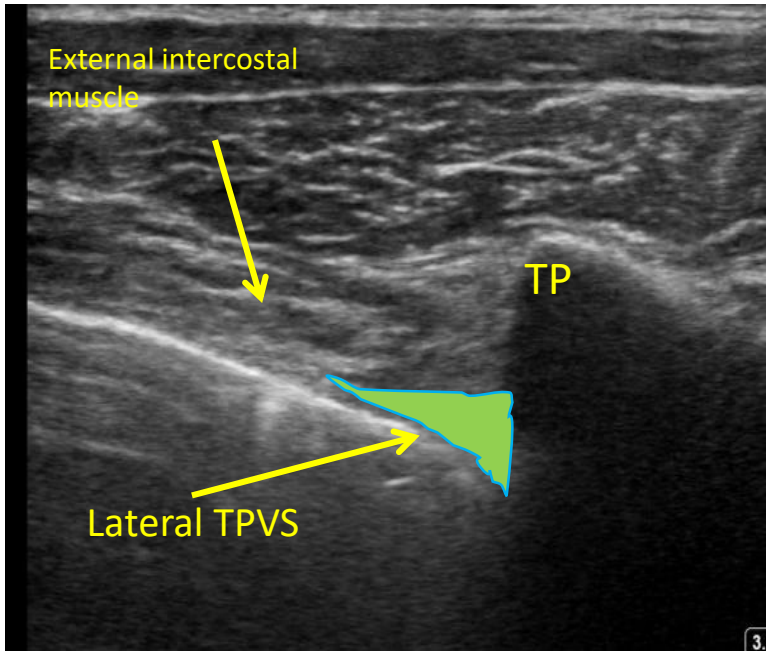
1) innermost intercostal muscle 2) internal intercostal muscle 3) **external intercostal muscle** 4) rhomboid muscle 5) trapezius **6) internal intercostal membrane** (medially fuses with SCTL) 7) intercostal nerve anterior rami 8) posterior rami of intercostal nerve 9) paraspinal muscles 10) visceral pleura 11) parietal pleura 12) endothoracic fascia 13) rami communicants 14) sympathetic chain

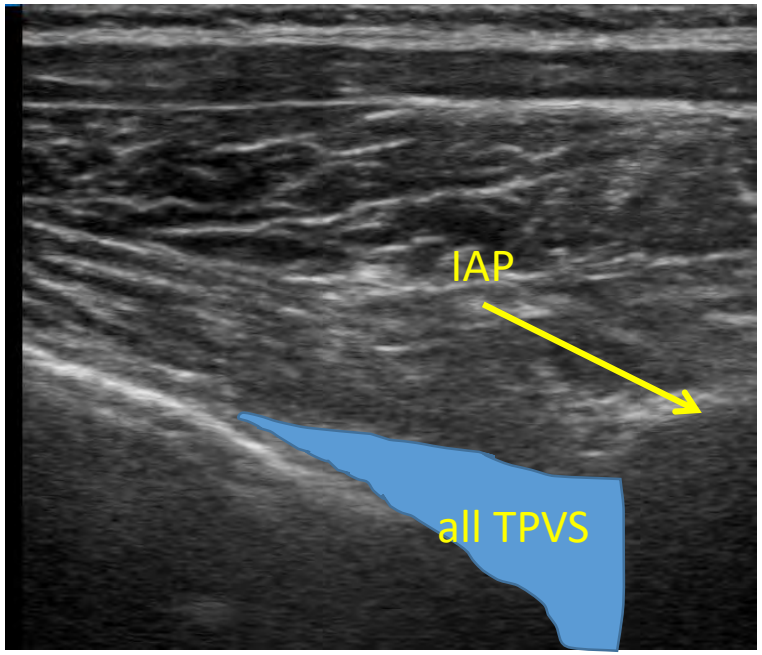


Difference in axial scan at the level of TP tip versus one at the level of IAP

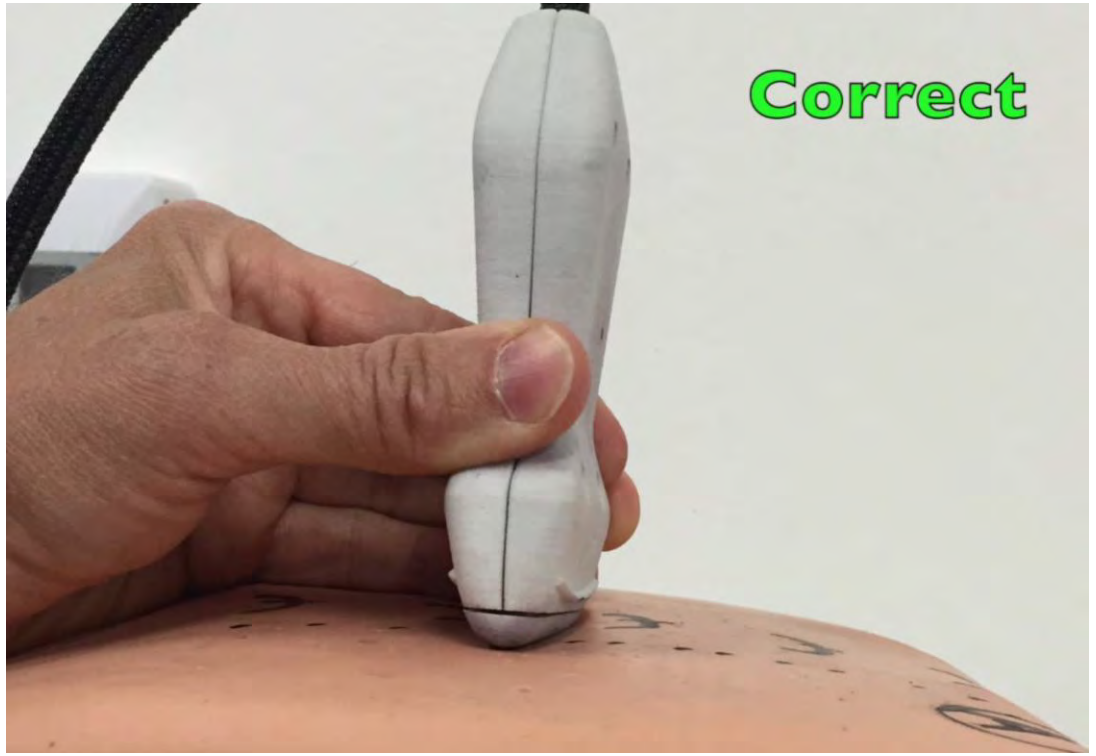
(one at IAP exposes medial zone of TPVS while another at TP- only lateral zone)







It is not proven that a more medial block is better than a more lateral bock, so it make sense to avoid medial needle placement due to risk of neuraxial complications, especially for multiple single injections when one does not need to rely on the craniocaudal spread (it is likely a more medial catheter position improves the spread)

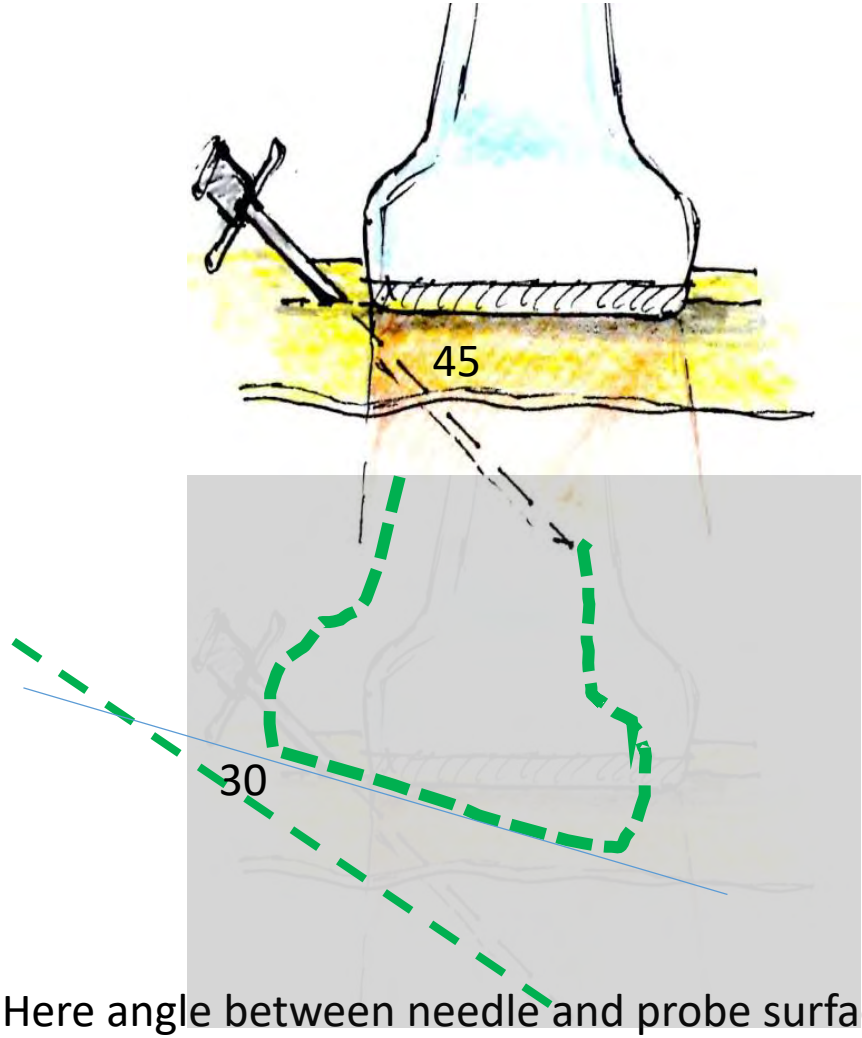


Strive to get a targeted image while the probe is not tilted. This will make needling much easier later. Occasionally, due to anisotropy of nerves we need to tilt the probe for better image. It is still easier to needle in plane when we have just an OK image but the probe is not tilted. Try to find a compromise.

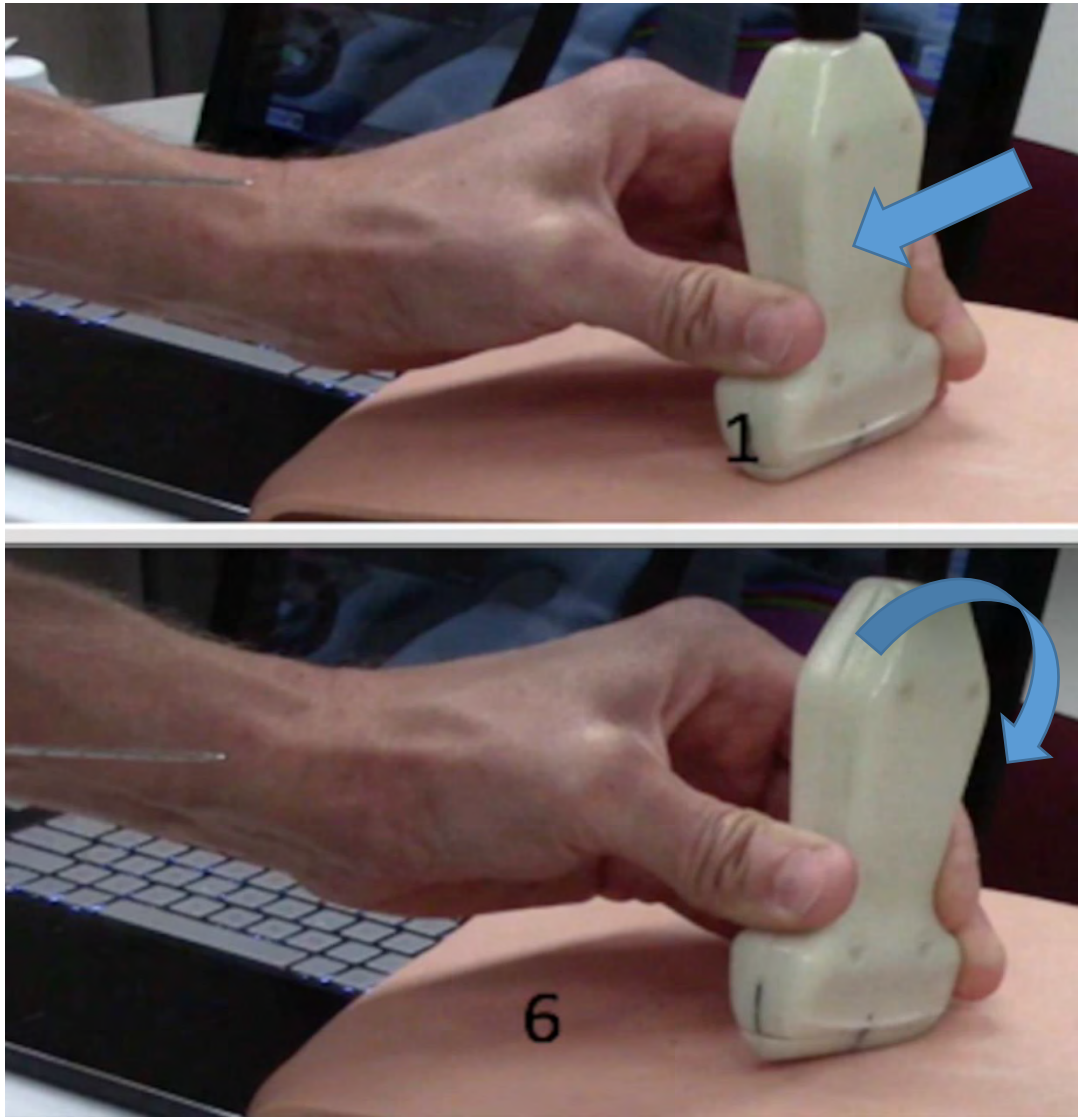
We frequently tilt the probe subconsciously while acquiring the image and do not realize it. Make an effort to shift your attention from the screen back to your hands and confirm correct probe position and adjust it if needed.

“Angle of incidence”

- **The angle at which the US waves encounter the surface of the structure (for example needle or pleura line).**
- If the angle is perpendicular or close to perpendicular, more US waves will be reflected back to the transducer and less will be “scattered” away resulting in a better image.
- The best angle between US waves and the needle is therefore 90 degree. For good needle imaging try to keep it at least 60 degree or higher. This translates into less than 30 degree angle between the needle and US probe surface (skin surface). New probes and needles may make this rule a bit softer (45 degree and even higher could still be reasonable especially with curved probes).
- Unfavorable angle of incidence may be responsible for **disappearing needle phenomena** as well as **disappearing pleura or other anatomical structures** from the screen.
- Angle of incidence with the anatomical structure or with the block needle could be improved by manipulating the US probe 1) sliding it back and 2) rocking it forward for example) or by using a 3) slightly different needle approach(entering the skin further away from the probe for example)



Here angle between needle and probe surface is about 45 degree on the top image. To make it less (30 degree would be better) one can 1)slide the probe back so the target is in the lateral part of the image, 2) rock probe forward and 3) enter the skin further from the current spot



Sliding the probe first slightly laterally (away from midline) and then rocking it forward, helps to improve the angle of incidence between US waves and pleura/needle. This improves the visualization of the needle and the lung when target is deep. When patient is skinny we may need those last two maneuvers

Changes in the image with previous maneuver (slide lateral and rock forward)

The target (yellow oval here) - lateral part of TPVS is moved from the middle into the left thirds of the image (yellow dash line is a border of the middle and lateral third of the screen and is also now right below the projection of the tip of TP). All these improve the angle of incidence with the needle and lung. We will not advance the needle further than 5-8 mm past that line to decrease the risk of neuraxial complications.

One can ignore the rib that got into the view on the right side of the image after lateral slide or one can rotate heel of the probe slightly caudad to “get rid of the rib” if needed.

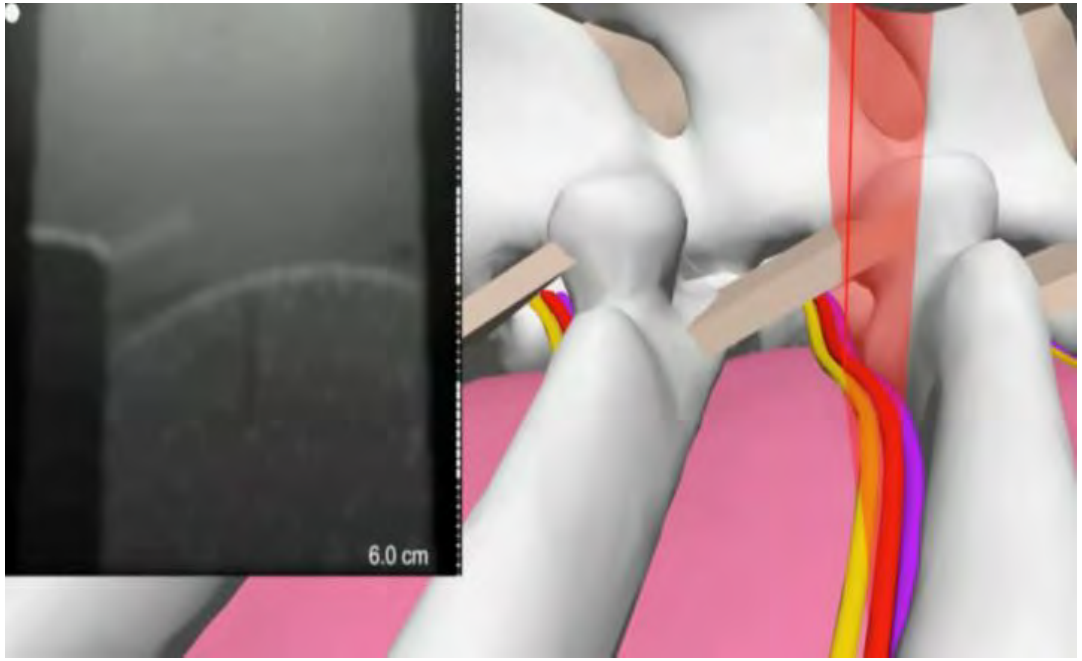
Other ways to improve the needle visualization

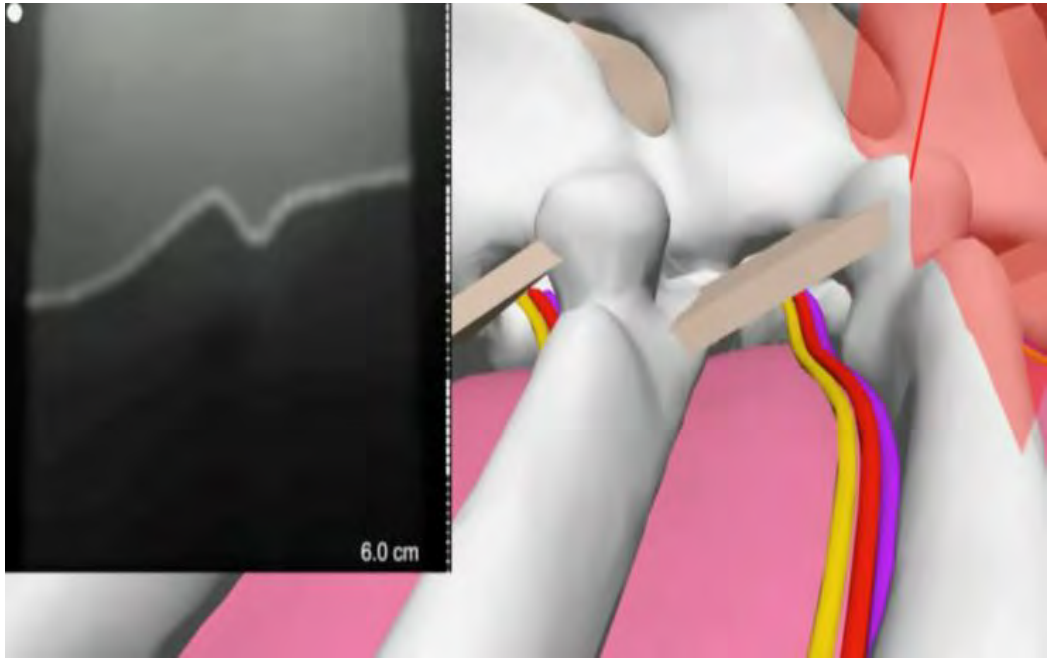
Besides **keeping the needle perfectly in plane** with US beam and utilizing the **best angle of incidence**, one may improve needle visualization by:

- Using a **larger bore needle and/or** by using **special echogenic needle**. Also remember that **bevel should be always up.**
- Placing stylet, fluid or air inside the needle does not affect quality of the needle image.
- **Newer US machines and probes** as well as needles make it easier to see the needle on the screen.
- Using **optimal gain setting** (too much gain may make it more difficult to see the needle).
- Remember that a **curved probe** may be better than linear when you can not get an optimal angle between needle and skin and/or target is deep.
- When needle visualization in a particular case is not great, **use hydrolocation early** or consider switching to US assisted technique that does not depend on good needle visualization. With hydrolocation, we confirm needle position by seeing spread of LA or Normal Saline during injection even if we do not see needle tip itself (remember ventral pleura displacement during US assisted TPVB). Consider the use of other end points like **nerve stimulation if needed.**

Make sure that you have a **reasonable acoustic window** for future mini slides of the probe in case you need them

During initial image acquisition (when you slide probe caudad) make sure the final image of TPVS will not be lost during mini slides of the probe caudad or cephalad from current position

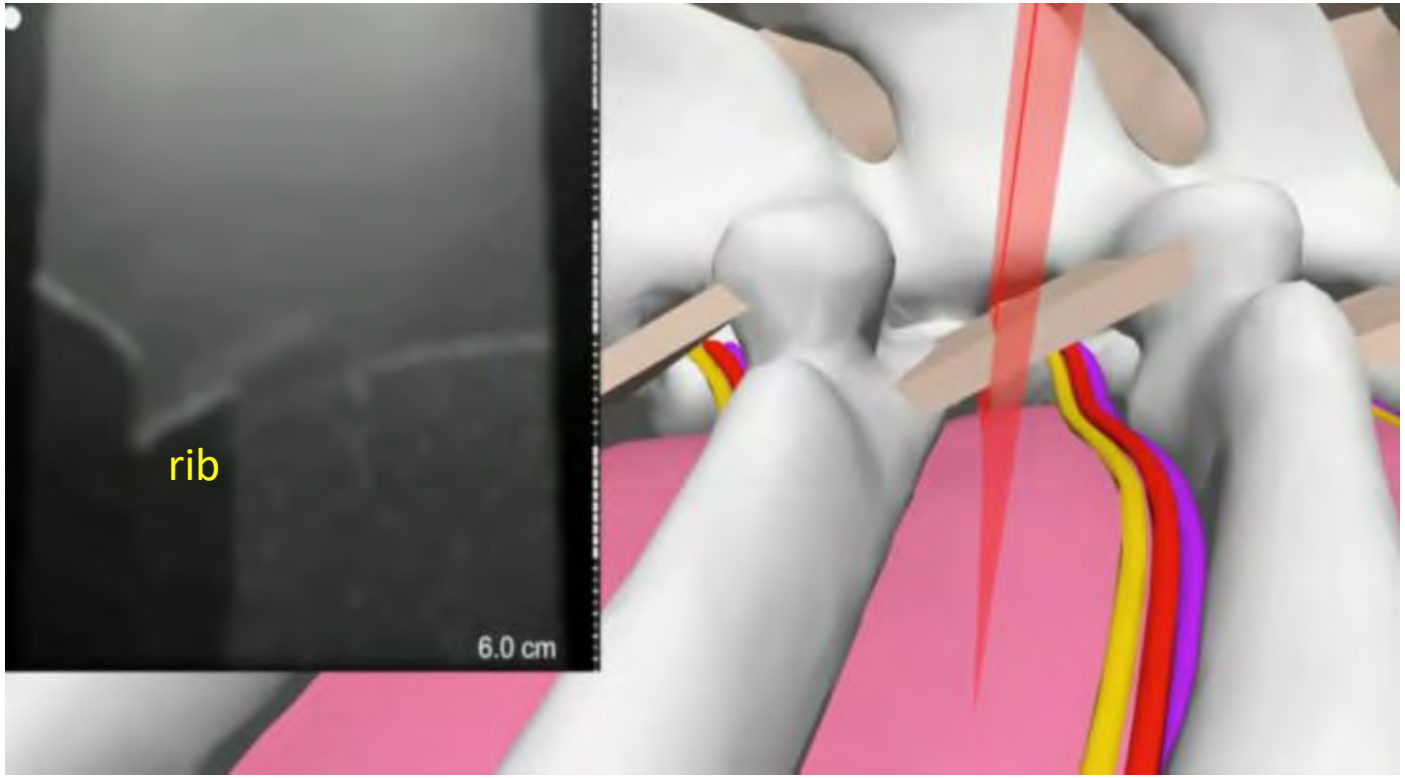




Here mini slide cephalad gets US plane over the costo-transverse junction and we are loosing a view of TPVS due to acoustic shadow from the bone. In such case, if the needle tip starts to deviate to the right of the US plane we can not use mini slide to the right. Theoretically, we can still push the needle hub to the right to keep the tip in plane with US probe, or we can tilt probe right (less effective). It is better to have a reasonable acoustic window from the start.

Next slide demonstrate the view after mini slide of the probe caudad when probe was originally more caudad that should be

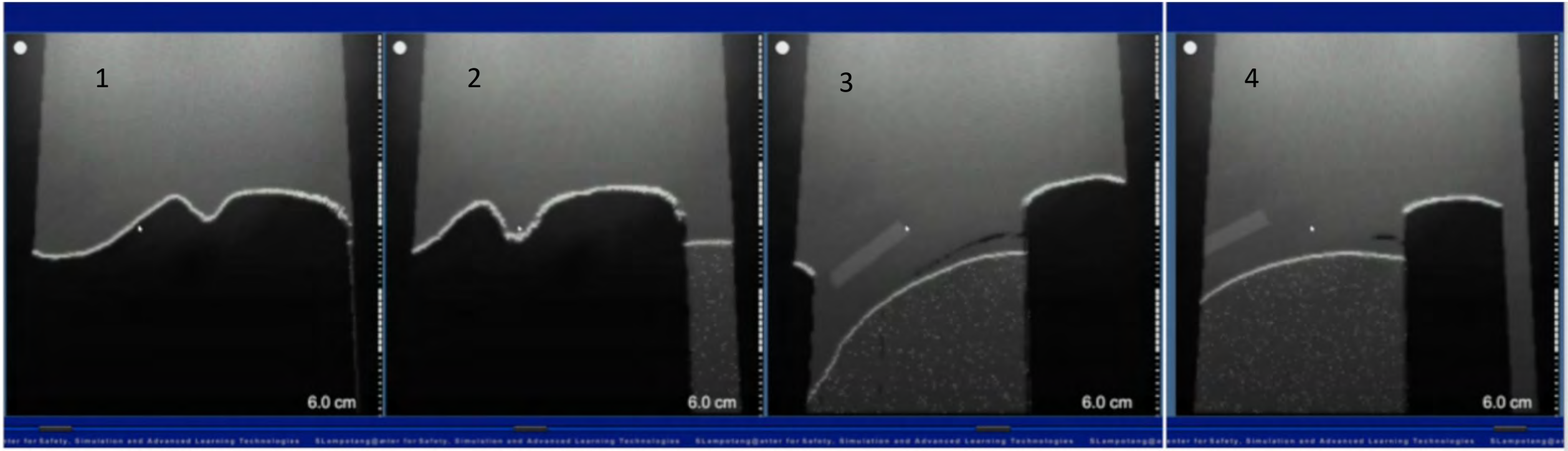
TPVS axial view in its lower (caudad) third that is closer to rib below



- Note on the medial side of the image the shadow of the head of the rib below (just lateral to the lower part of the IAP)
- Note that the AP dimension of the TPVS is slightly less here than in the cranial part of the TPVS

Review of probe manipulation during acquisition of the required image

Get a standard axial image of TP Slide probe 1.5 cm laterally Slide probe 1.5 cm caudad Rock probe forward

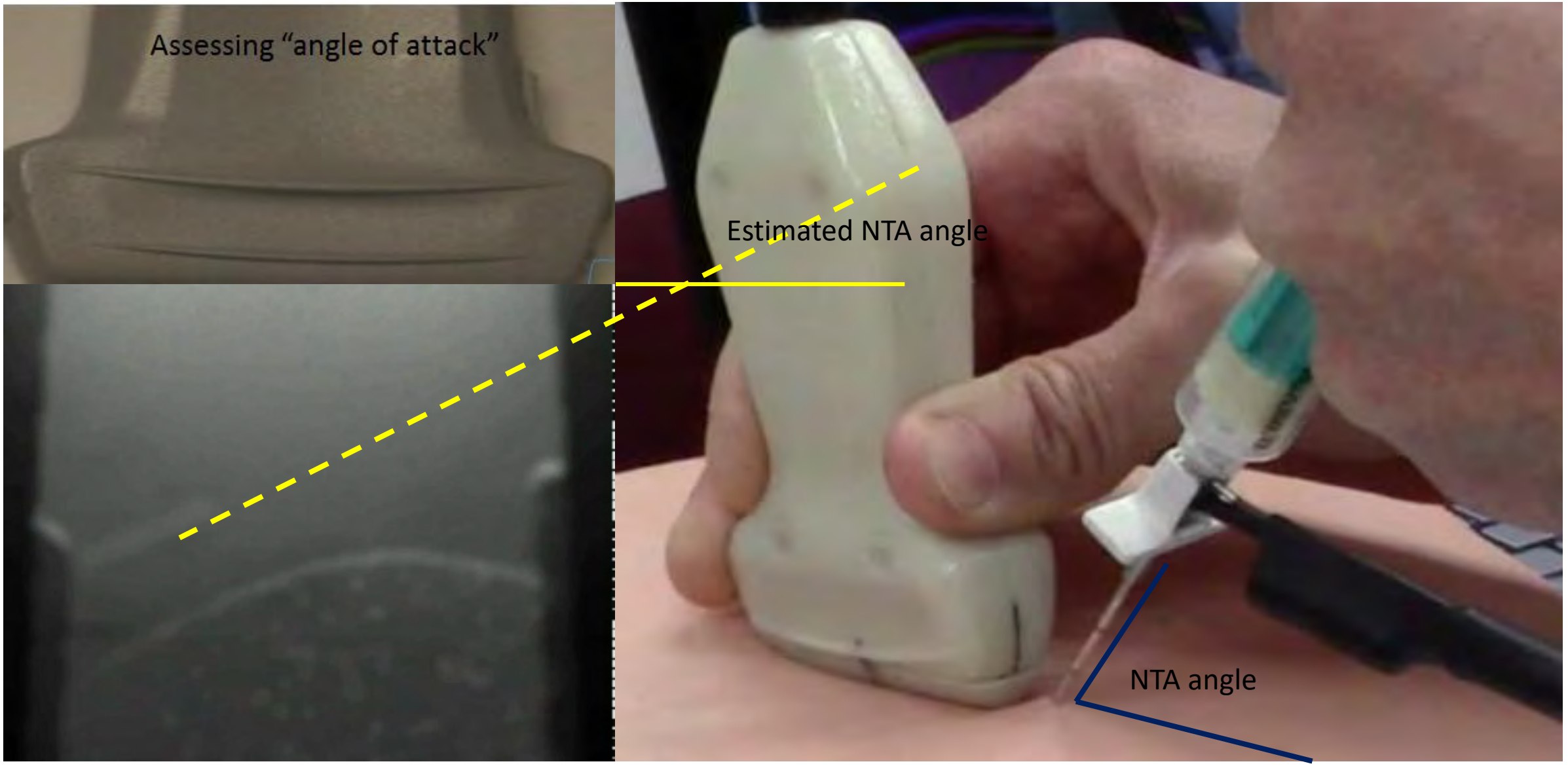


Once again, one can ignore the rib that gets into the view on the right side of the image 3 and 4 or one can rotate the heel of the probe slightly caudad to “get rid of the rib” if needed. By rotating the nose of the probe one may optimize the US plane position over the TPVS (moving it from the caudad part for example to more cranial and more spacious part of TPVS). It is OK to use two hands during image optimization. **Lastly check with mini slides to confirm the presence of the wide enough acoustic window** and **look back on the probe to confirm the absence of the tilt.**

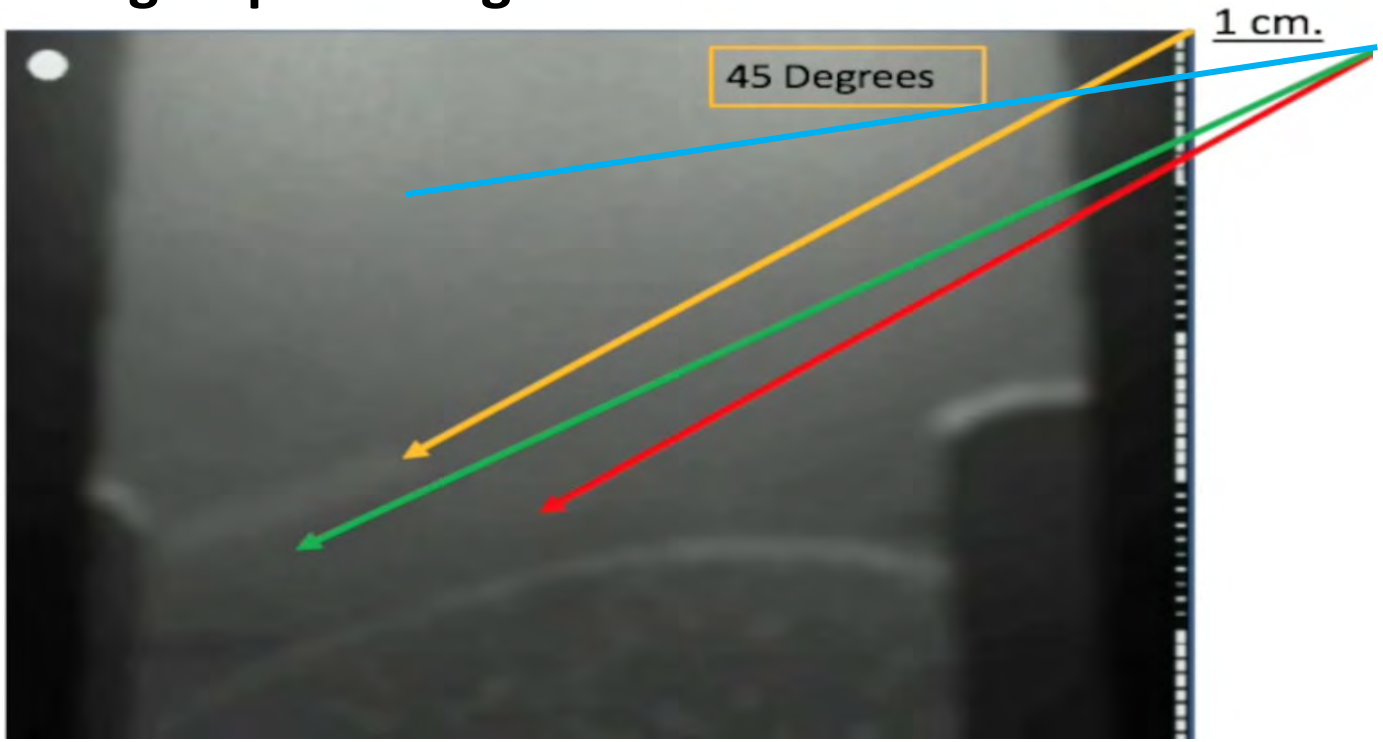
Review questions

- Name 3 maneuvers that may help improve the angle of incidence between the needle and US waves.
- The bevel of the needle should be up or down?
- What else could be used to improve needle visualization?
- Does tilt of the probe make needling easier? What can we do to avoid inadvertent tilting?
- Explain the concept of “reasonable acoustic window”.
- Visualize in your mind the series of US image changes as you acquire the final one for the US guided block (starting from the standard axial view of TP).
- How far should one advance the needle if we target lateral zone of TPVS? What if we target medial zone?

We estimate **Needle target alignment (NTA) angle** based on the image before we start needling, then set it at the beginning of needling and adjust later during live US feedback.



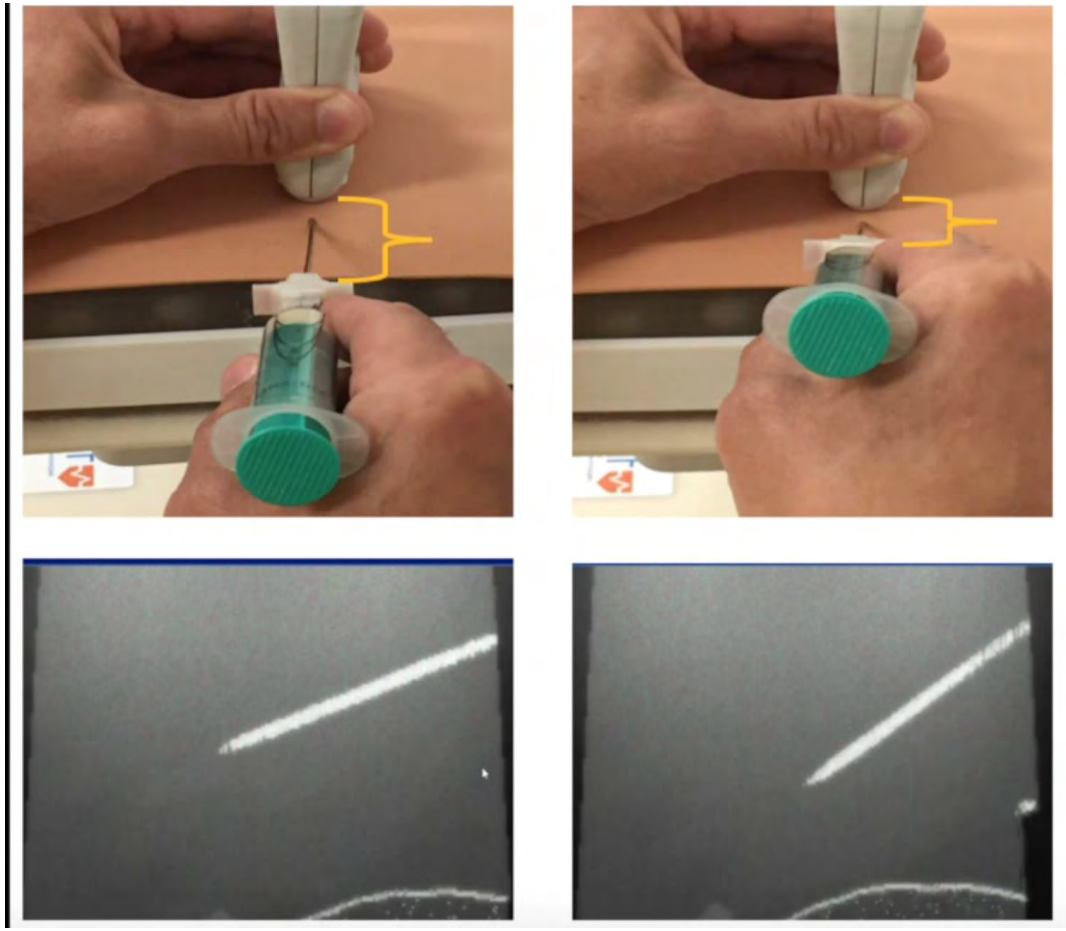
Estimating required angle of the needle based on the image



It is helpful to imagine the desirable trajectory of the needle pass on the screen (green) and compare it to an easily imaginable reference line of 45 degree (yellow). Imagine the desirable trajectory provided that the needle enter the skin 1-1.5 cm away from the transducer. The Red line is parallel to the yellow line, but starts from the same point as the green line and is here for better illustration that desirable trajectory angle in this particular case is 5-10 degree less than 45 degree.

For novices, it could be prudent to start with conservative angulation (away from pleura- here is way less than desirable angle-a blue line) and then adjust it with visual feedback from US. This will decrease a risk of lung injury if initial advancement is too deep at a too steep angle (it would be easier to notice the needle at such angle due to more favorable angle of incidence).

Setting earlier estimated angle of needling based on the distance between hub and the probe

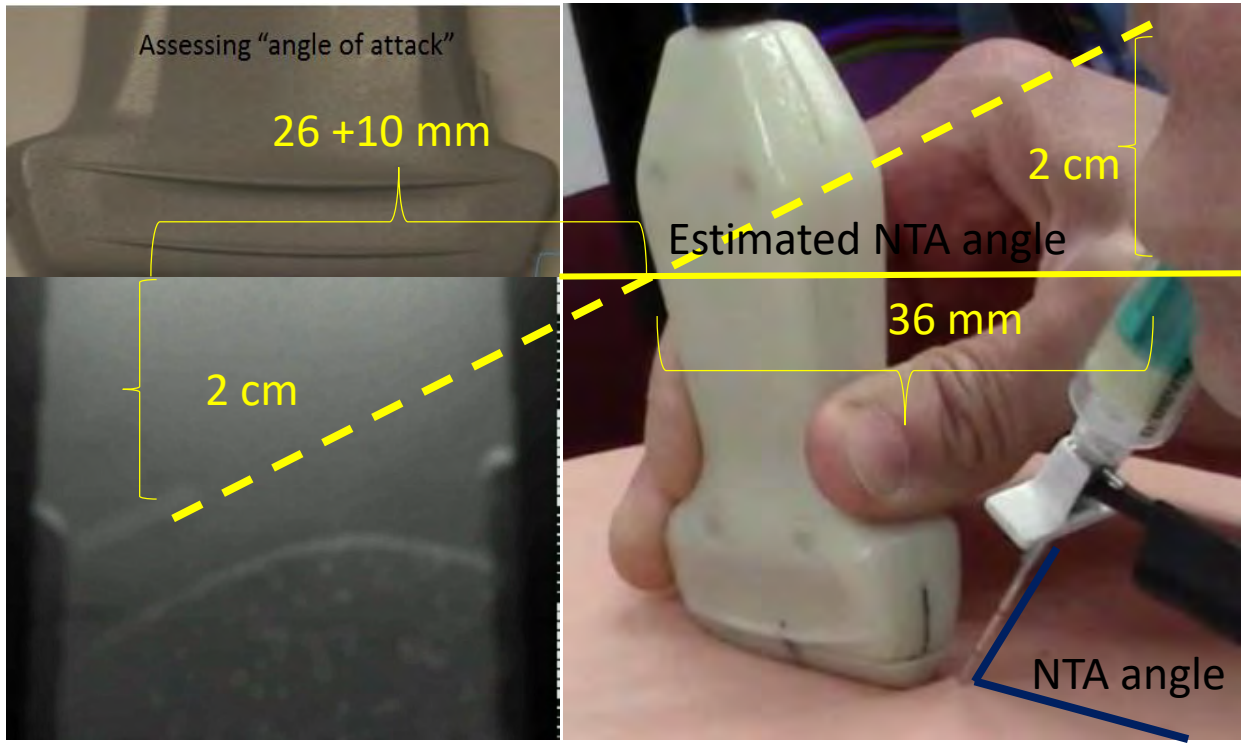


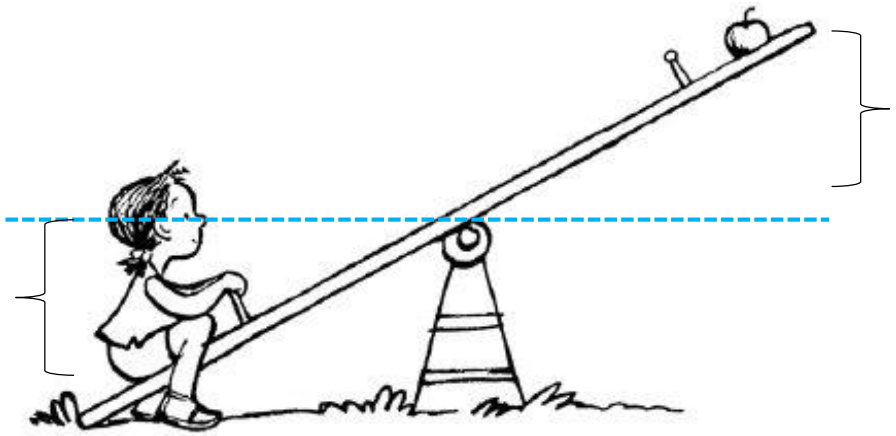
In order to correctly set the estimated the angle between needle and skin, we recommend to use a surrogate marker of the distance between needle hub and the US probe (see picture above). To establish those relationships (what distance correspond to an angle of 45 degree for example) one should practice inserting the needle at different angles while paying attention to that distance at the particular point of view (eye level).

It is logical that different points of view (scanning surface is at very different levels) will produce different distances, fortunately in our clinical practice we can control the level of the surface by adjusting bad level for example.

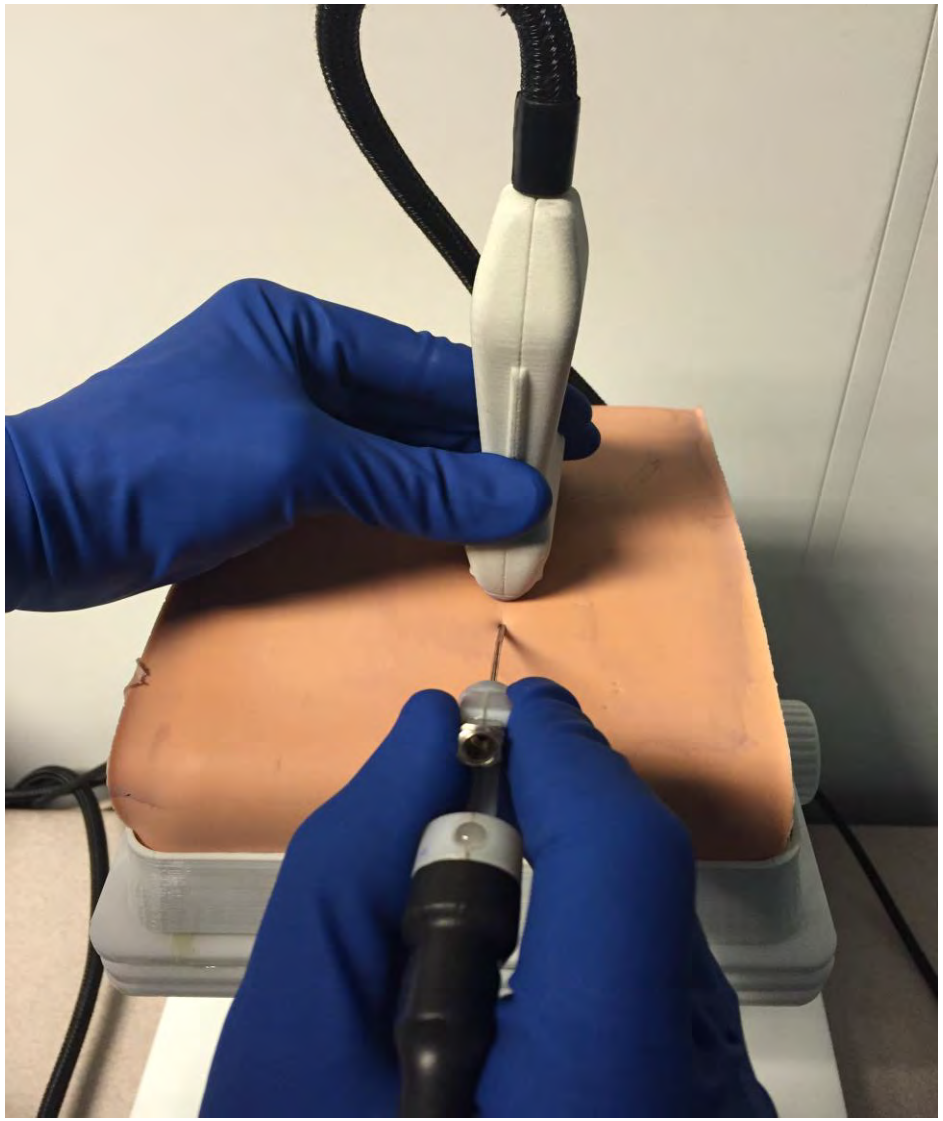
Alternative technique to estimate and set initial needle angulation

- One can use a “seesaw” principle to do this
- First look at the US screen and see how deep from the surface and how far from from the future needle entry the target is
- To estimate the distance from the needle entry point to the target, one needs to know the dimension of the transducer foot print and the distance of the future needle entry to the scanning surface
- If we enter the needle 1 cm away from the transducer and our target is located at the border between outer and middle thirds of the screen, than if we use 38 mm transducer then 26 mm (approximately 2/3 of 38 mm) plus about 10 mm is equal 36 mm
- If the target is 2 cm deep than we place the needle flat with tip 1 cm from the probe and note where the 36 mm marking is on the needle. Then we start lifting needle hub up to the point the 36 mm mark is approximately 2 cm from the skin





Assume the **good point of view** to avoid parallax error before you start the needling



Parallax is a difference in the apparent position of an object viewed along two different lines of sight.

During in plane needling, start with the best external alignment of the needle and US plane, and then add slight adjustments to alignment based on the US image.

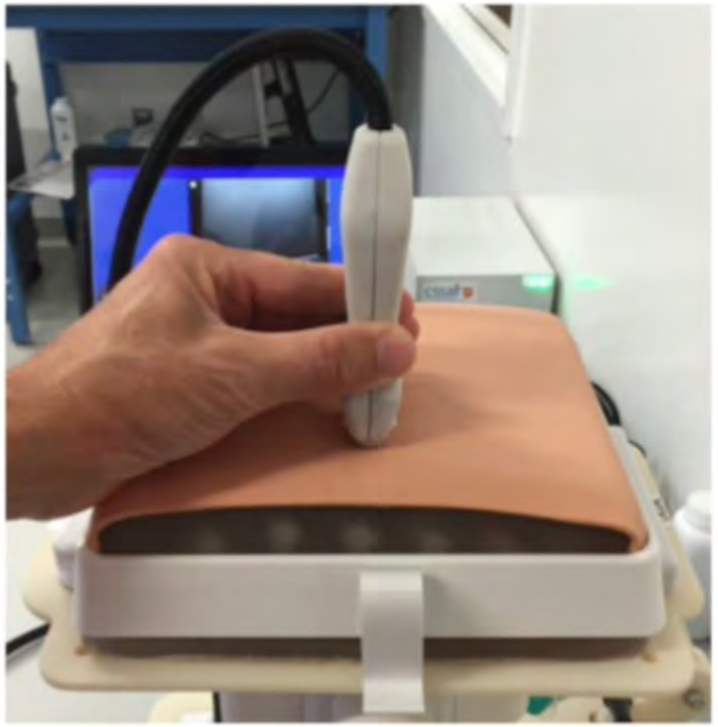
To do this correctly, one must assume a position with the line of sight as closely aligned with the long axis of US probe as possible . During needling, the needle hub, the needle tip, and both middles of US transducer edges (proximal and distal) must be aligned.

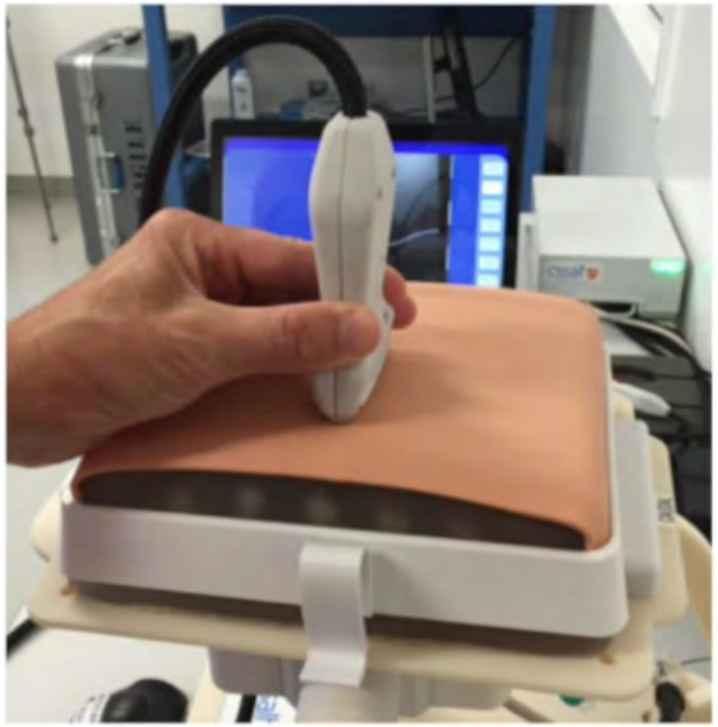
If one has a less optimal point of view, there is a chance to make an error where it will appear to you that the needle is perfectly aligned while in reality it is not. If the needle is not aligned from the start, it may require multiple adjustment to keep it in view during advancement.

Try to move your line of sight so when you look at the probe you do not see its lateral sides. On illustration, we see the right side of the transducer more than the left, so we should adjust our position slightly to the left.

Avoiding parallax error by optimizing our point of view of the probe

See to much of the left side of the probe.





See to much of the right side of the probe.

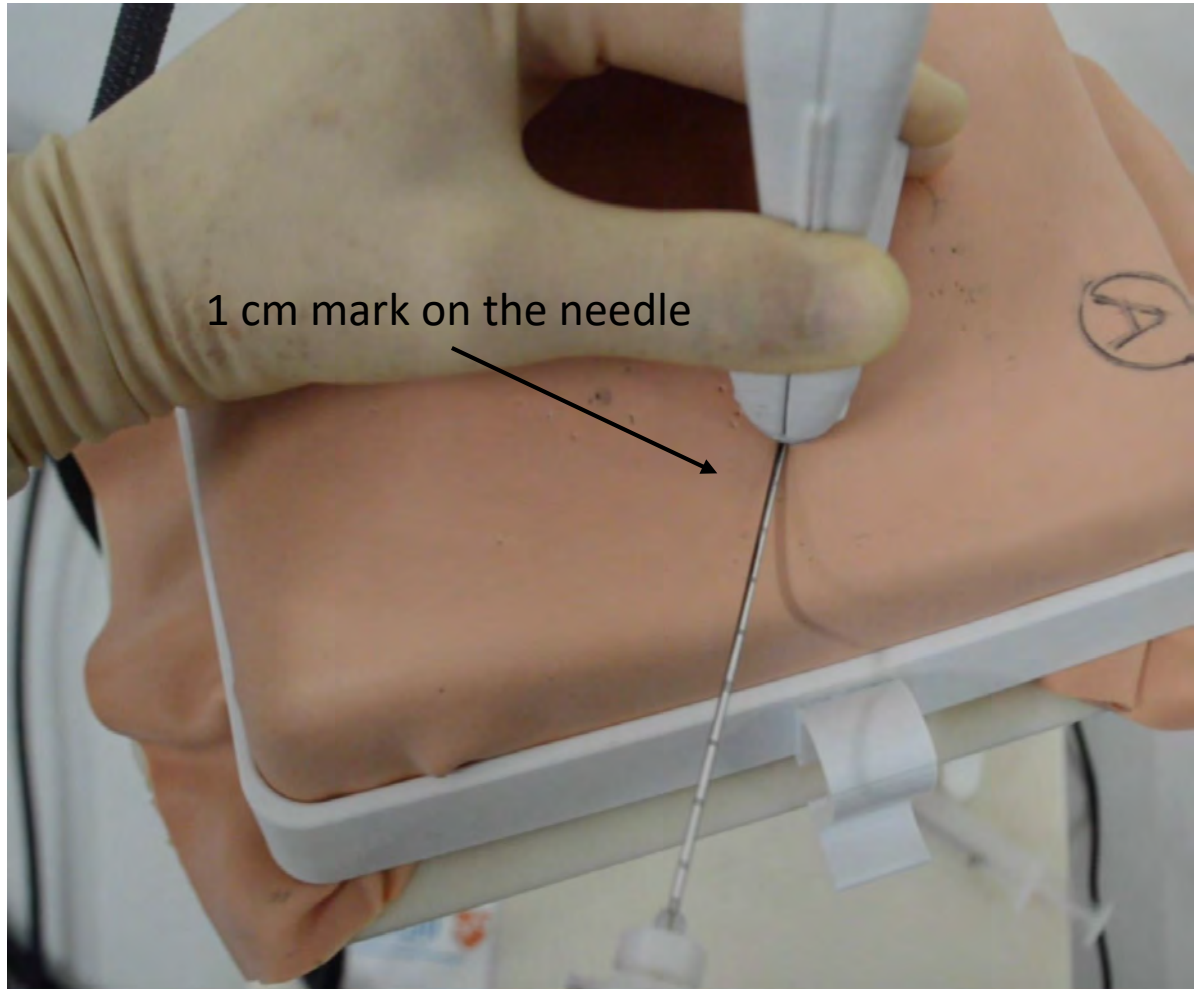
Center image = Correct view

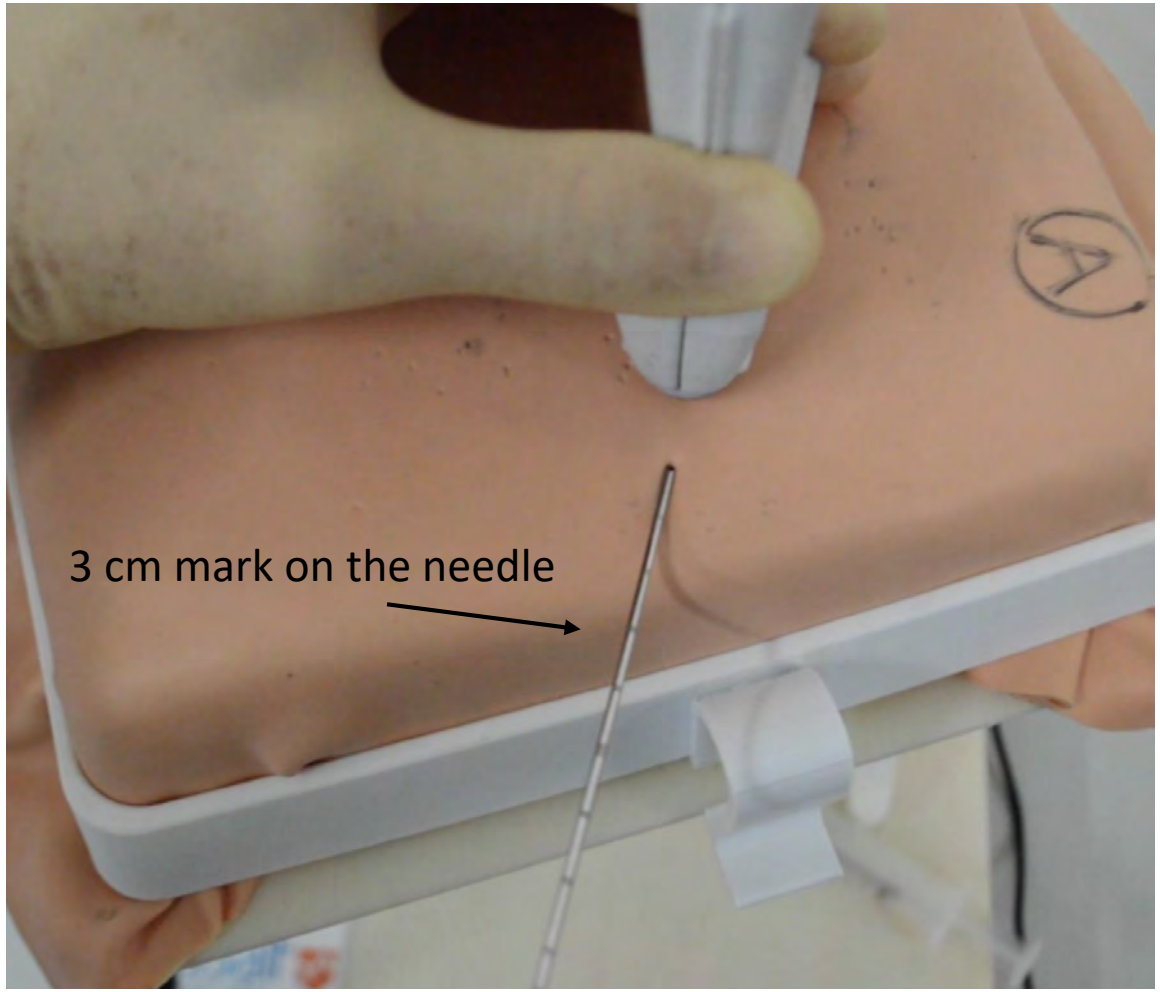
For educational purposes wrong views are **exaggerated**.

After the correct image is acquired and NTA angle is estimated we can move on to the next step: **initial advancement of the needle under the US probe based on external alignment only.** After that, one would shift attention to the US screen and proceed with some probe/needle manipulation for best visualization and further **needle advancement based on feedback from US.**

This first step (initial advancement) is very important and lay the ground for better needling. Wrong point of view, sloppy external alignment will require a lot of work later on to visualize the needle and guide it in. Details are on the next few slides.

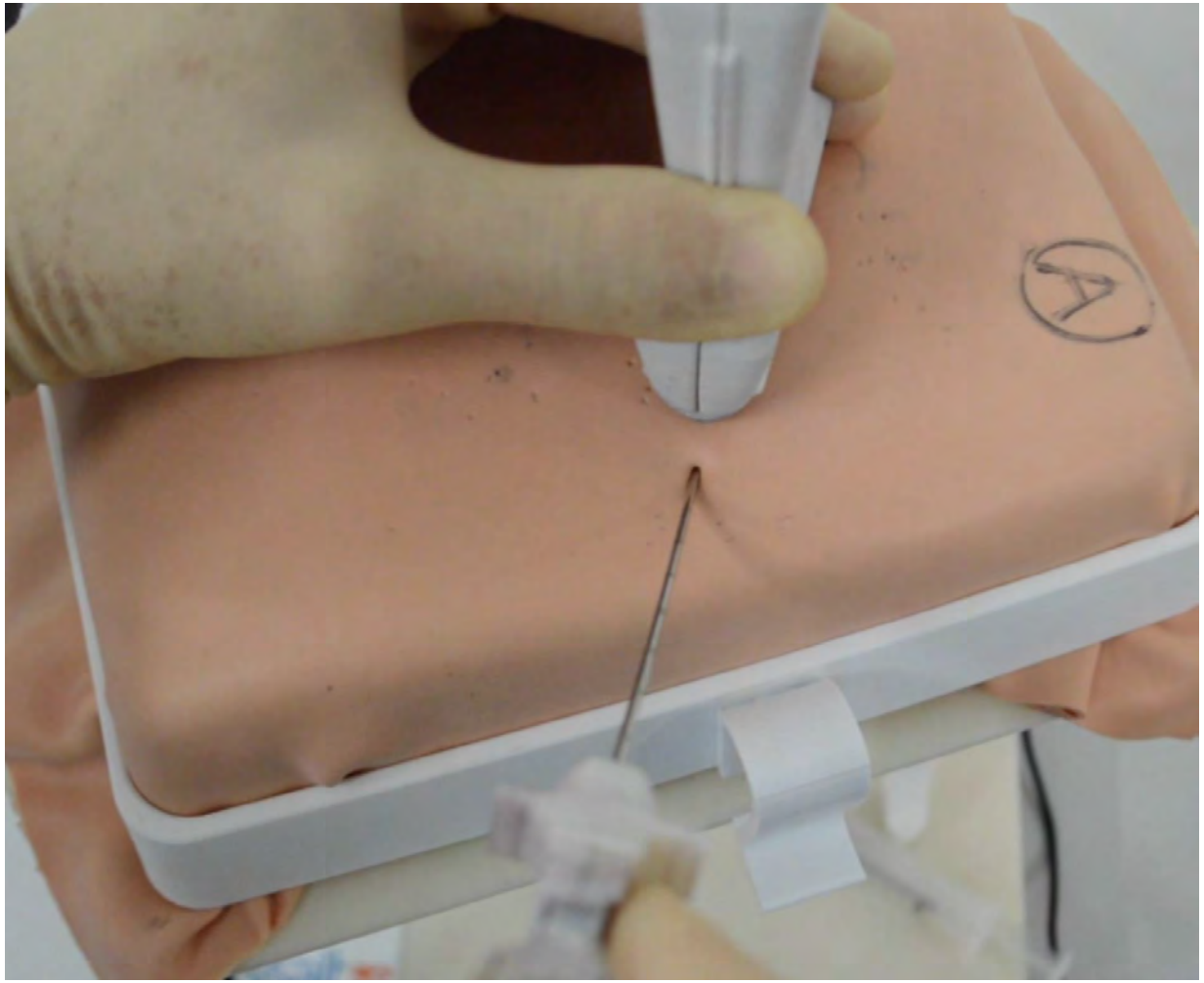
Remember that you can **go back to "external alignments" later on** if you have trouble seeing the needle and keep loosing the needle tip image (to assess the possible reason and predict correcting maneuver).

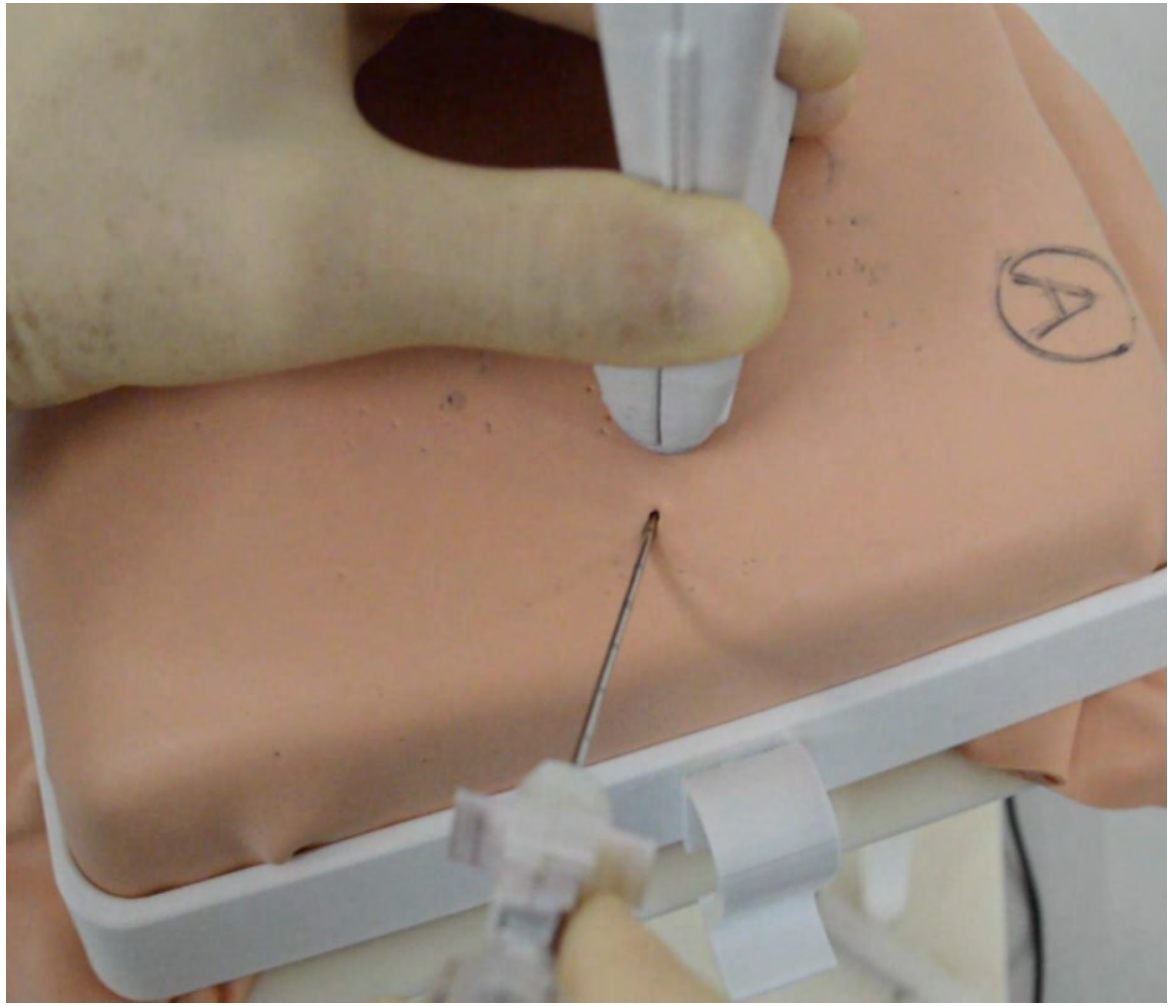




Recommended steps for initial advancement based on external alignment:

1) After confirming correct body and head position to avoid parallax error, **2**) Place the needle bevel up flat on the skin with the tip close to the transducer perfectly aligned with the transducer long axis (look for the seam on the transducer). Make sure that hub, and tip of the needle as well as long axis of the transducer are on the same straight line. Note the needle depth marks: 1 and 3 cm. **3**) Slowly pull needle back so tip is about 1-1.5 cm away from the probe ….(see next slide)



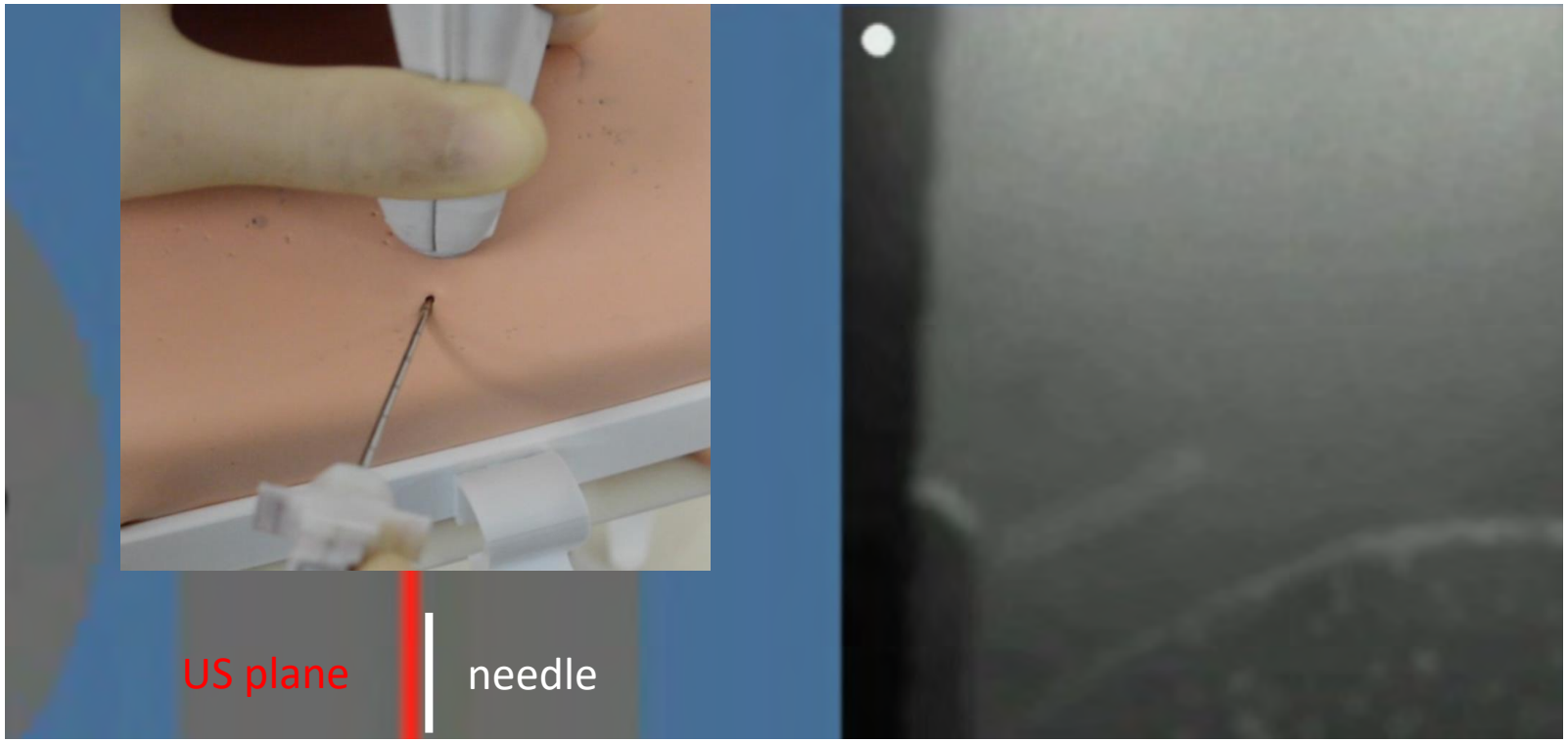


4) **Lift the hub up to established previously estimated NTA angle (use the distance between needle hub and edge of transducer as a surrogate marker)** avoid deviation of the hub to the left or right while you do this, then 5) Initial advancement: advance needle in until 2-3cm mark on the needle shaft is at the skin (this means 1-2 cm of the needle should be under the probe). Confirm one more time that externally everything appear perfectly aligned. Now 6) Shift your attention to the US screen. Here we do see right side of the probe more than left so our line of sight is slightly off so we can be wrong in our perception.

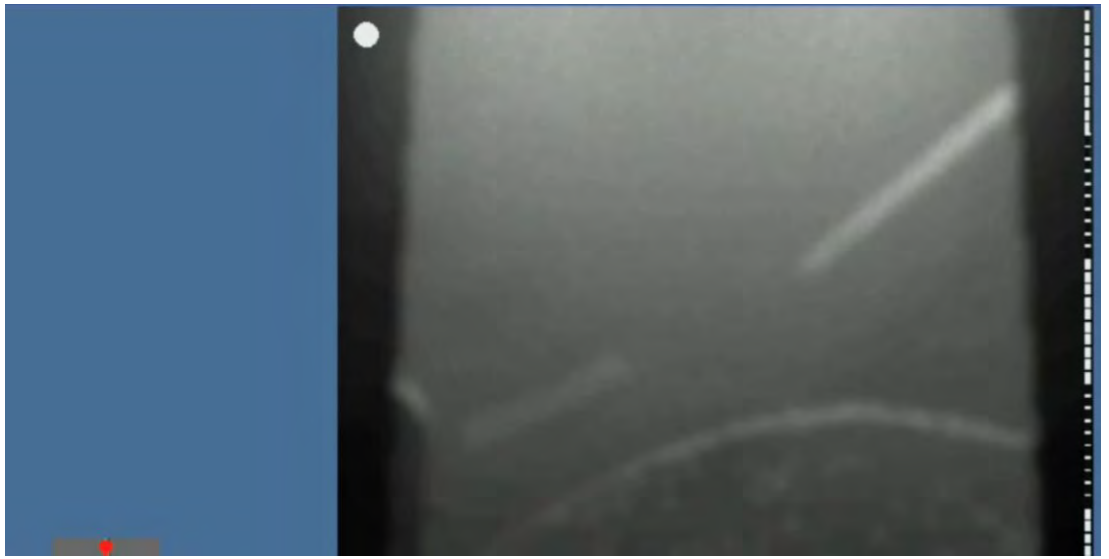
Review questions

- Explain how one can estimate the required angle between needle and the surface based on the image before starting the needling.
- Explain how one can approximately set the required angle between needle and skin surface before puncturing the skin.
- Explain what a parallax error is and how one can avoid it.
- Explain what external alignment is and how it is different from US guided alignment. When is external alignment utilized?
- When do you switch your attention to the US screen?

After advancing the needle under the probe based on external alignment only, one should shift attention to the US screen

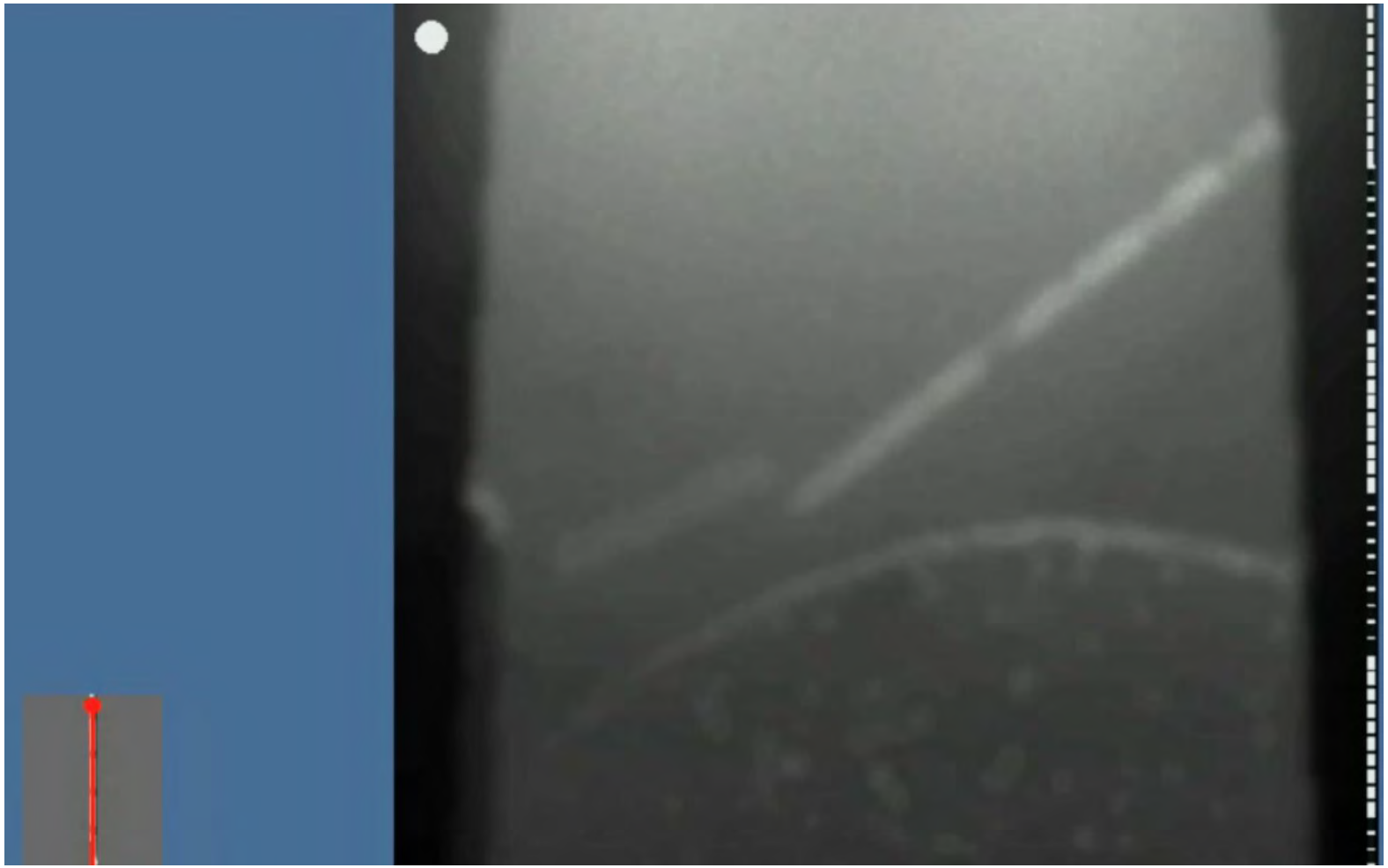


If we look at the US screen we do not see the needle because it is not aligned with the insonating plane. Red line on the picture above represents US plane, white line represents the needle as if we look from above. In this case, the needle is parallel to the US plane but just a hair off lateral to it. If we shift our attention back from the screen to needle and transducer we would confirm that the needle is indeed slightly off to the right and if we slide transducer to the right we should get the needle into the view. If we had some rotational misalignment as well (let's say the needle was not parallel to US plane) then we would need to add some gentle push on the needle hub to fix it in addition to a mini slide (see more on it later).

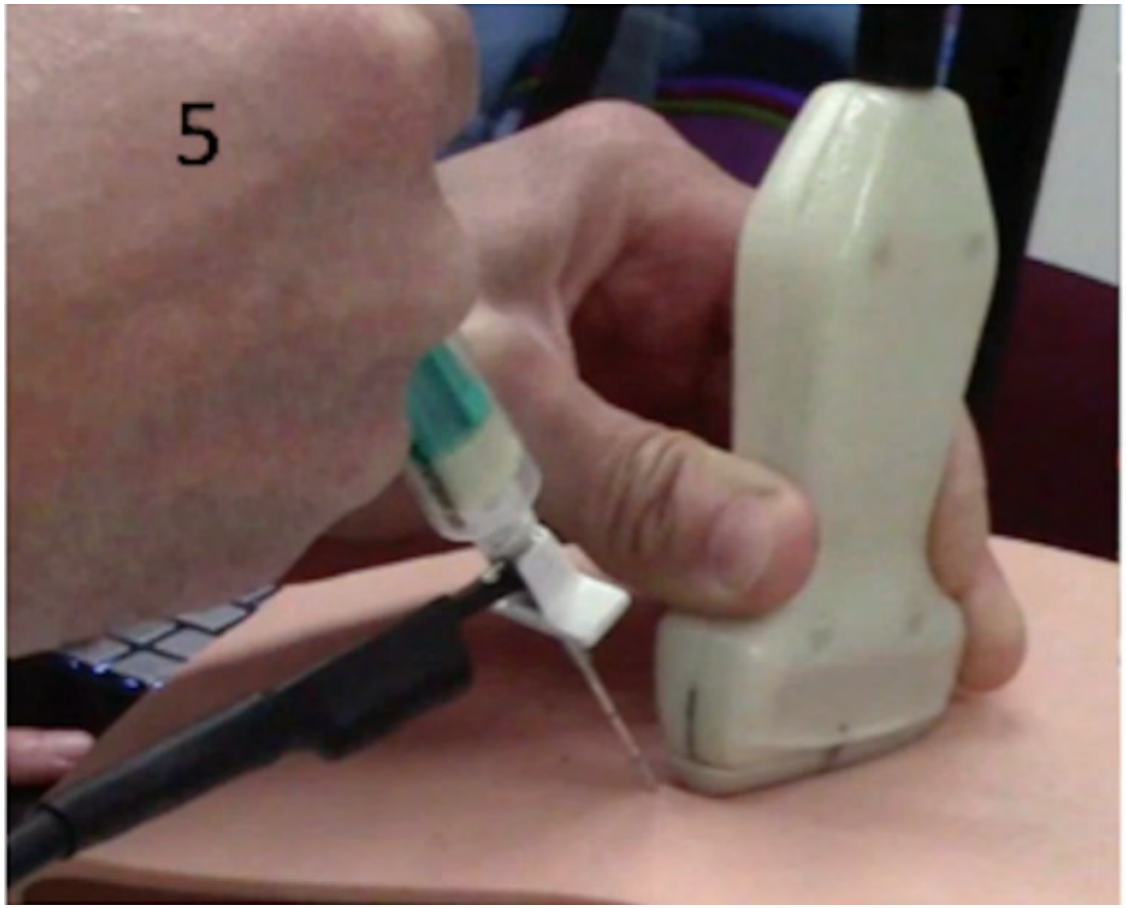


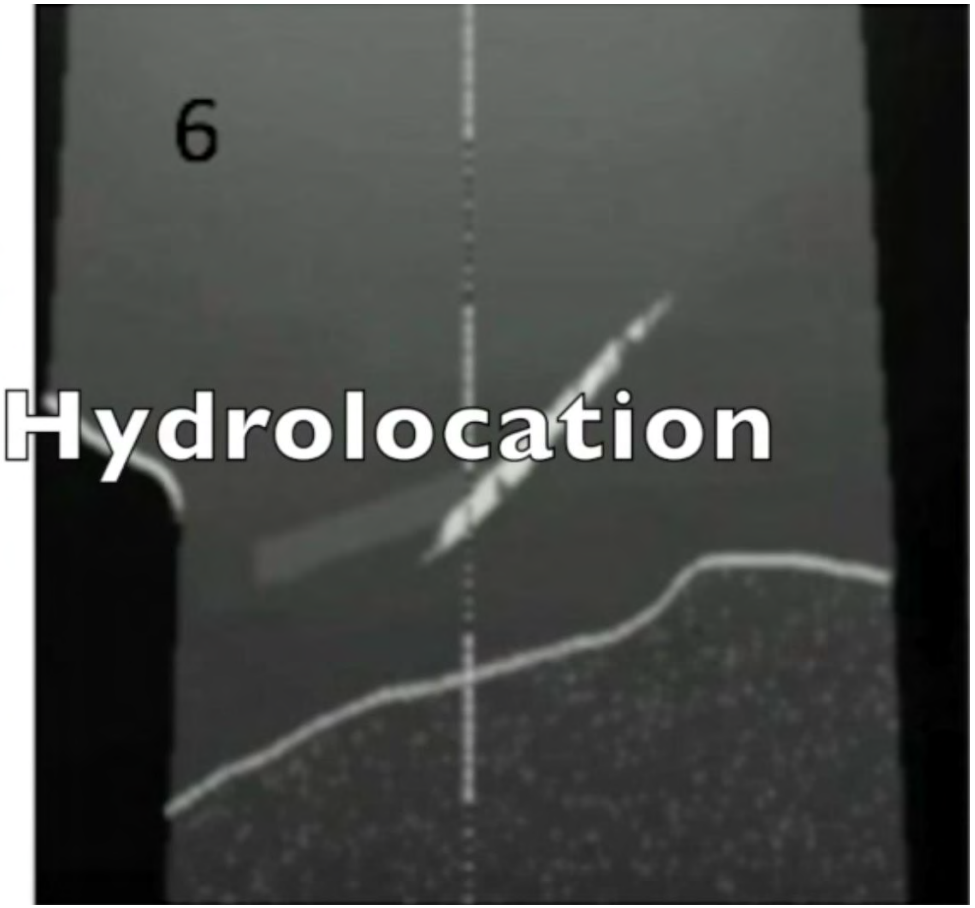
As expected after mini slide of the transducer to the right while watching the screen we got the whole needle image into the view. Now we can adjust the NTA angle based on the image by lifting needle hub up (see a resulting picture on the right).

Now we can advance the needle into TPVS that is less than 2 cm away. We will do it in 2 slow increments 1 cm at a time while watching the US screen. If needle tip start disappearing from the view we will stop and adjust the needle and US plane alignment to bring needle tip into the view. Never advance the needle if you do not see needle tip especially when it is close to a vital structures like lung for example.



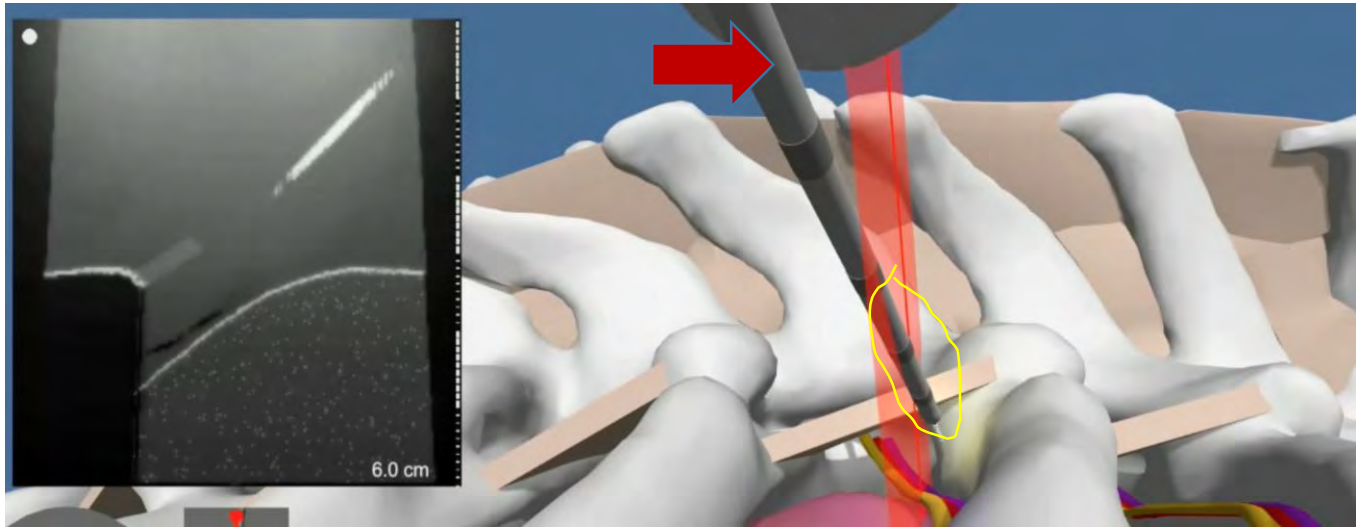
Mission accomplished, we were able to advance needle in without loosing the view of its tip out of our sight.
We did feel a small discerning “pop” when the needle penetrated the internal intercostal membrane. We stop right after the pop and will proceed with hydrolocation.

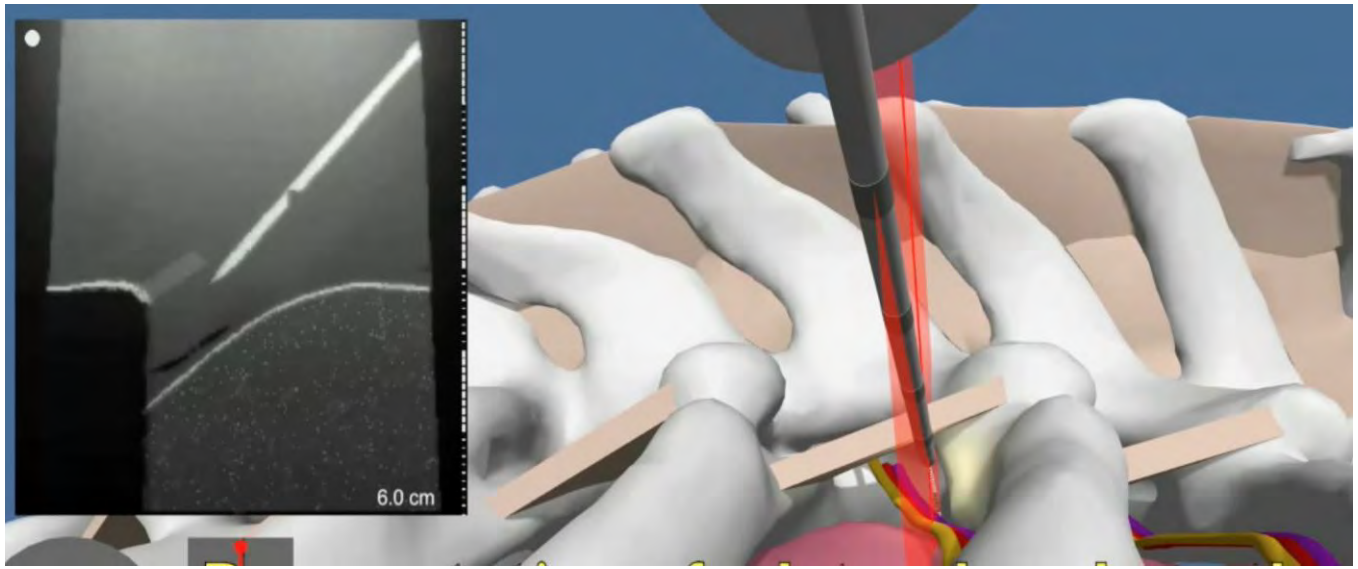


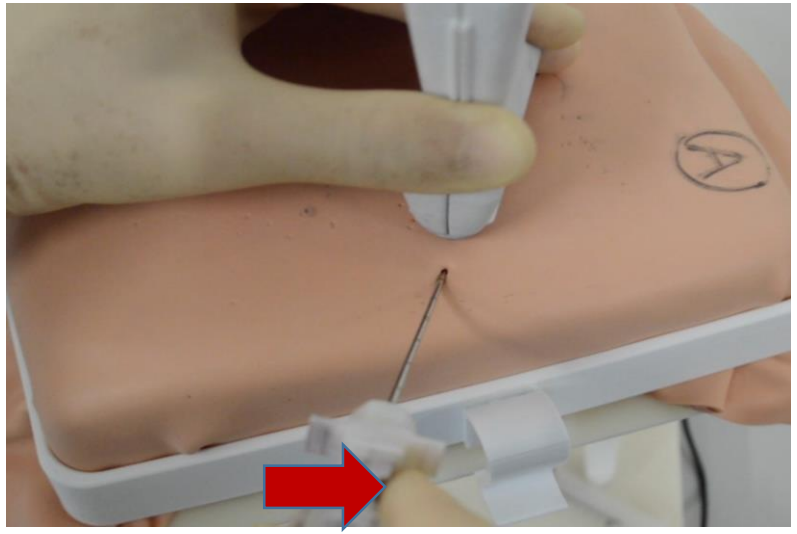


Injecting normal saline into TPVS produces a very unique picture of ventral displacement of parietal pleura on ultrasound screen. This serves as an ultimate confirmation of correct needle placement especially when needle visualization is not perfect. Avoid using LA for hydrolocation, it may increase risk of giving too much.

Example of how one can regain the view of the needle tip if it was lost after some advancement

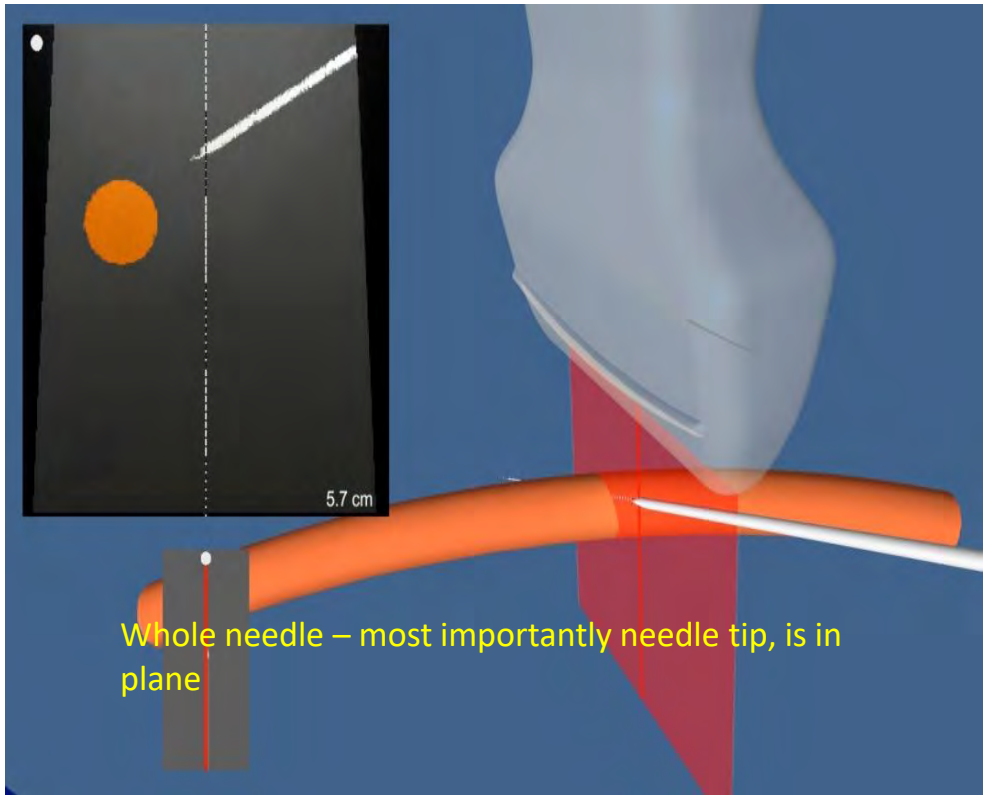


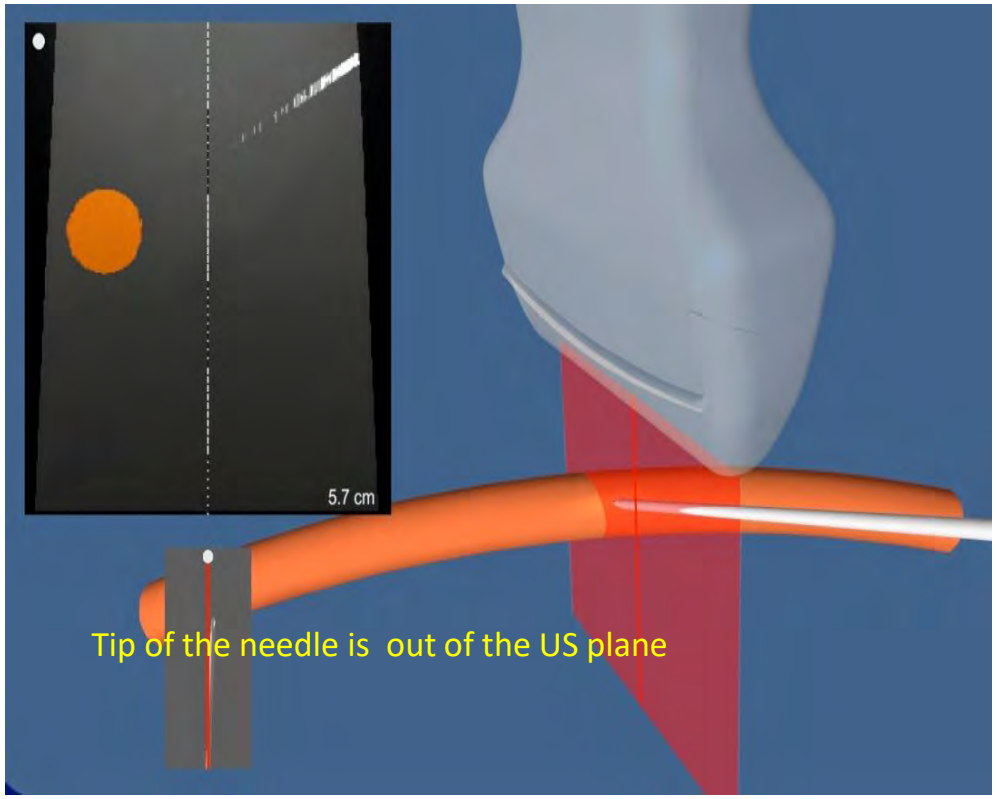


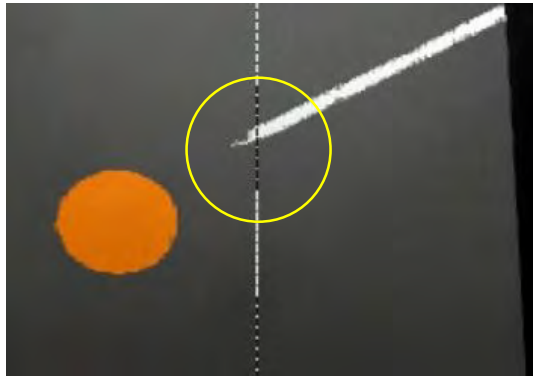


Due to some misalignment of the needle and the US plane, tip of the needle is leaving US plane during further advancement and we are loosing it out of the view on the screen (picture on the top left). We immediately stop further advancement as soon as we notice it and then by pushing the hub of the needle gently to the right we bring needle tip and US plane in complete alignment (picture on the bottom left).
Push of the hub here has corrected rotational misalignment that could be also corrected by slight probe rotation.

Very important to make sure that you can differentiate
the image of the needle shaft that is cut by insonating plane obliquely from the true tip of the needle image







Keep the needle bevel up and look for the characteristic "beak" or "step down" appearance of the needle tip to differentiate it from the shaft that is "cut oblique".
Do not start advancing the needle further if you can not see the needle tip and stop advancement if you loose the image of the needle tip.

Review questions

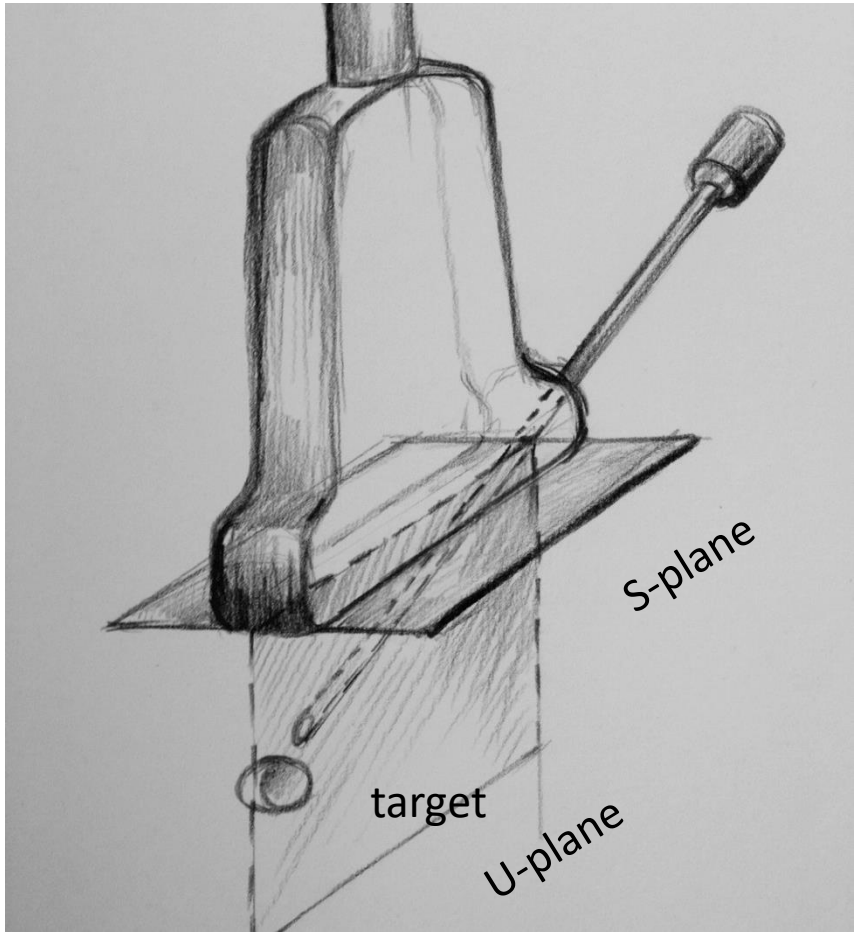
- Explain how mini slides of the probe allowed better needle visualization in the mentioned example.
- Explain how slight lateral push on the needle hub helps to improve needle and US plane alignment in the case covered here.
- Describe the needle tip image on US. What is a possible imposter and what is the clinical significance of it?
- Explain the idea if incremental advancement with alignment corrections after each step.
- What do you do if you realize the needle tip is getting lost from view during advancement.
- Explain the idea of hydrolocation.

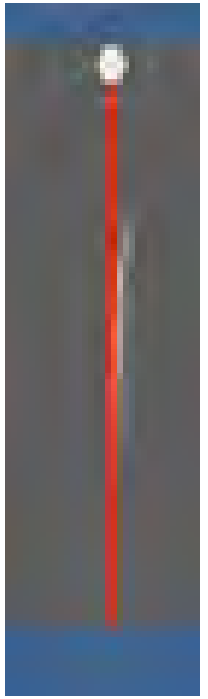
Let’s explore more details of US guided alignment (aligning the needle and US plane)

- We start US guided alignment after we finished advancing the needle under the probe, that we did without looking at the US screen. US guided alignment is done while focusing on the screen.
- To achieve perfect alignment, we can manipulate the probe (**slide, tilt, rotate**) or manipulate the needle (**pull back and advance** again with different trajectory or **push on needle hub**).
- All probe and needle manipulations are done while looking at the screen and not hands, so this requires good hand-eye coordination.
- One should do either probe or needle manipulation at each moment but not both simultaneously.
- Most novices do random moves in random order, but we believe some logic here is useful.
- Frequently when we manipulate the probe and regain the needle view, we may loose the view of the target.
- Frequently the needle tip could be relatively well seen now but disappear out of view again with the next incremental advancement.
- All those challenges could be frustrating and may even compromise patient safety when one decides to advance the needle without seeing it.

2 types of alignment for in plane needling: NTA/NUSPA

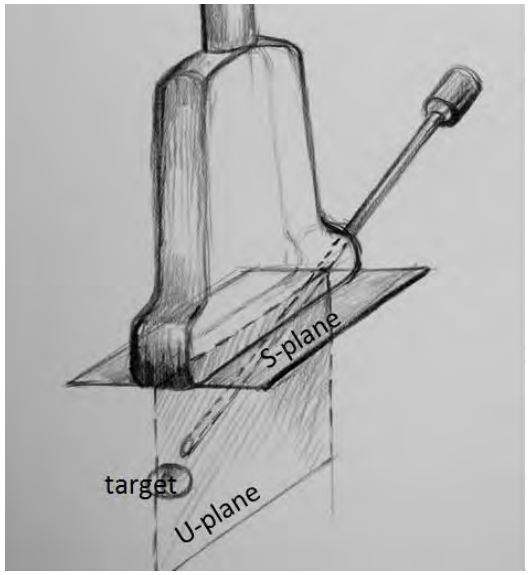
- To simplify teaching we split the process of US guided alignment during in plane needling into 2 types of alignments in 2 planes with a stipulations: no tilt of US probe
- **Planes to focus on**
  - Insonating plane (plane U for ultrasound). When needle is in this plane we only worry about **needle to target alignments (NTA).**
  - Surface plane (plane S) is plane that is perpendicular to insonating plane and projection of insonating plane and needle on it help us to facilitate **needle to ultrasound plane alignment (NUSPA).**



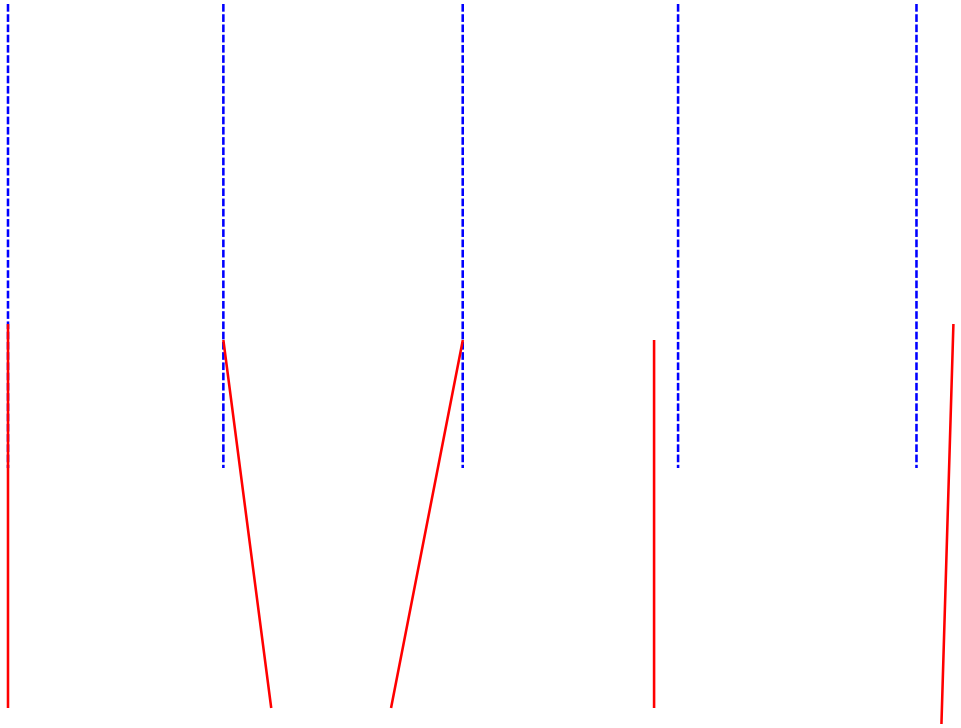


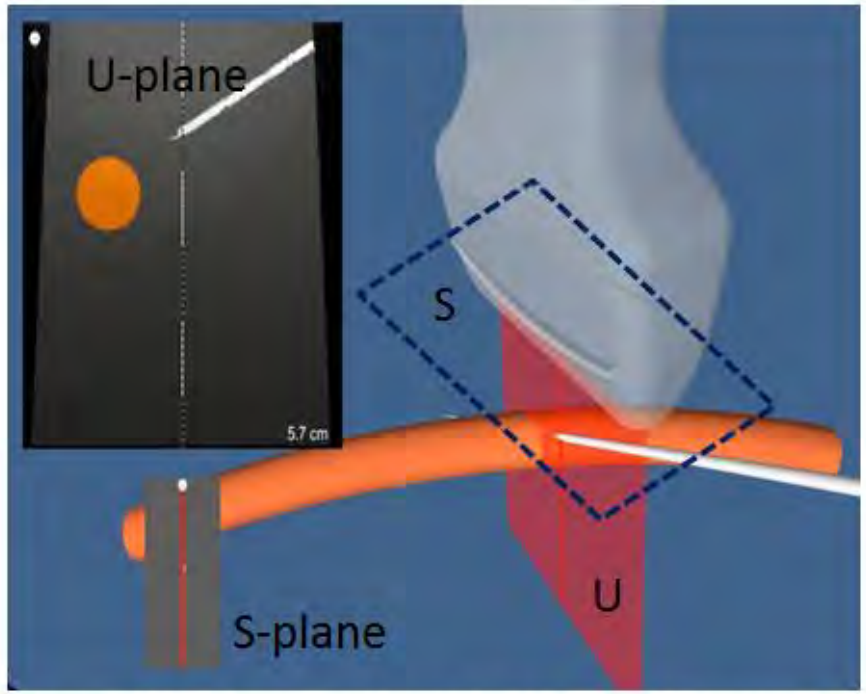
Red is projection of US plane on S-plane
White is the projection of the needle on the S-plane.

NUSPA: Needle to US Plane Alignment

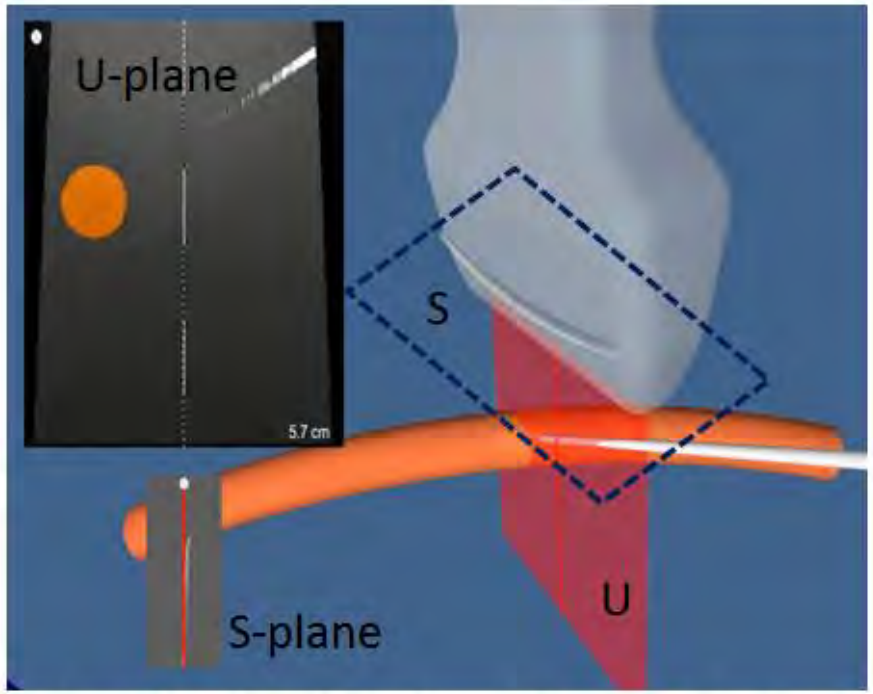


- Imagine that your hand and US probe are invisible, and that the transducer is perpendicular to the skin (no tilt).
- Imagine you look from above the transducer straight down on plane S and you can see the needle through the skin and you can see the insonating plane.
- The image will look like something on the right (we have random options there): blue dash line represent US plane and red line represent needle projections on the plane S.



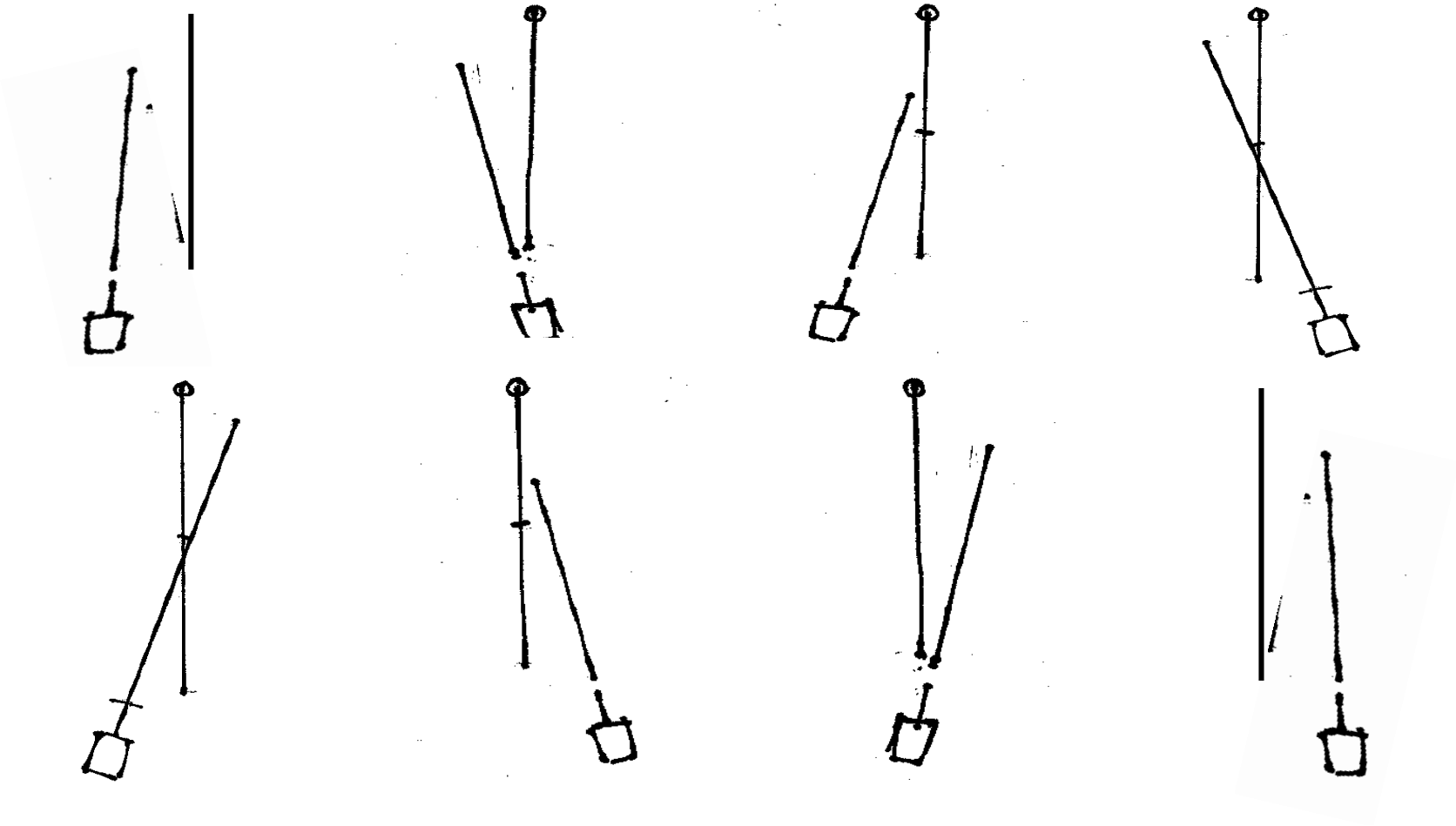


Great NUSA- needle US plane alignment (see S-plane indicator in left low corner: projections of US plane and needle are overlapped) Great NTA –needle target alignment (use virtual US image as an indicator for this : needle is going to hit the target with current trajectory

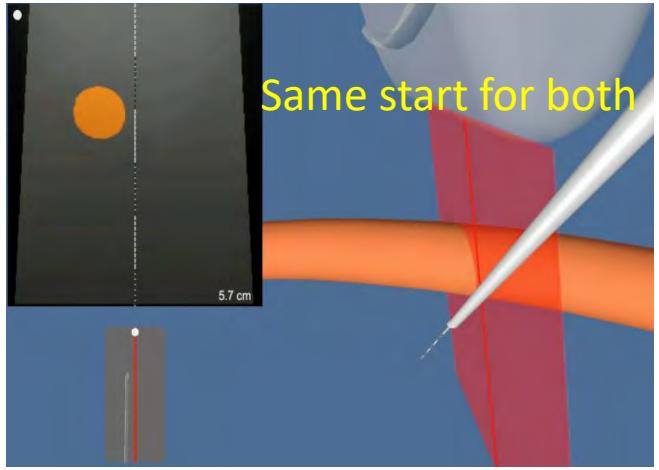


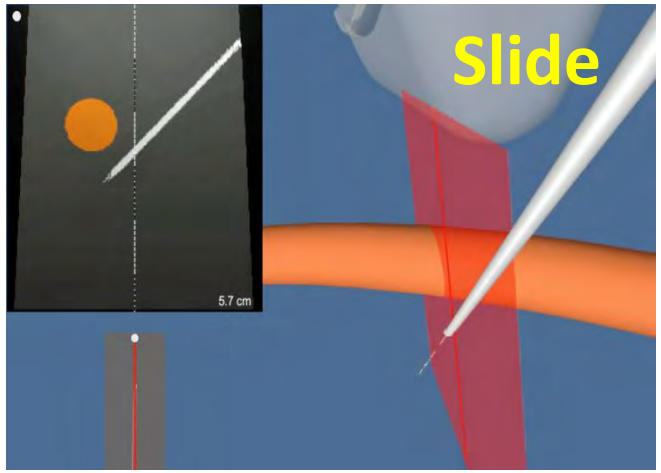
Suboptimal NUSA; tip of the needle is out of US plane (to its right), note the S-plane indicator on lower left. Note the typical US image on upper left ,that is missing classical needle tip image. NUSA here could be fixed by 1) gentle push on the needle hub to the right or 2) mild slide of the probe to the right. Any of this will get the needle tip in the view

There are only a few principle possibilities when the needle and US plane misaligned so we can approach NUSPA logically. All of the presented below misalignments could be fixed with 1 or 2 maneuvers: rotate the probe to make them parallel to each other and then slide probe towards the needle.



Slide or Slide and Rotate or Rotate the probe should fix them all





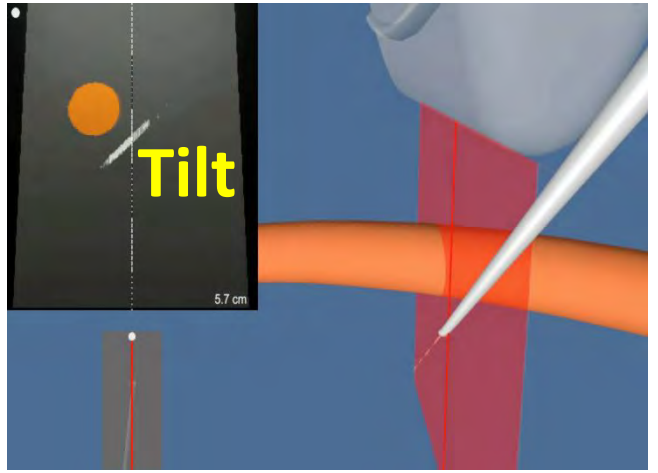
Compare to the tilt we don't necessarily have to expect the needle tip will disappear again after the next increment of advancement. This is very true for the tilt.

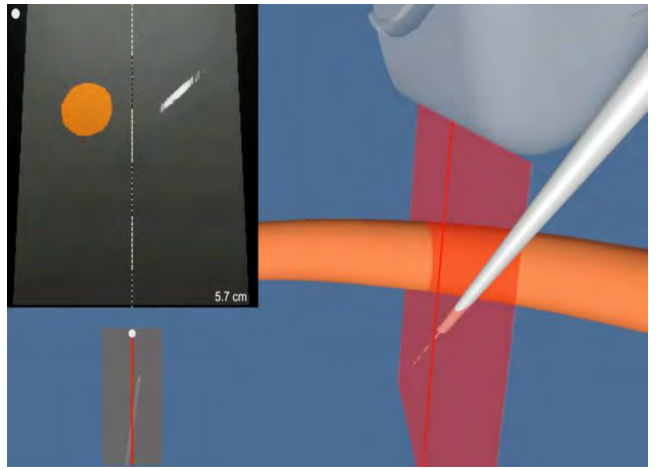
Why we mainly focus on the slide of the probe and not on the tilt of the probe

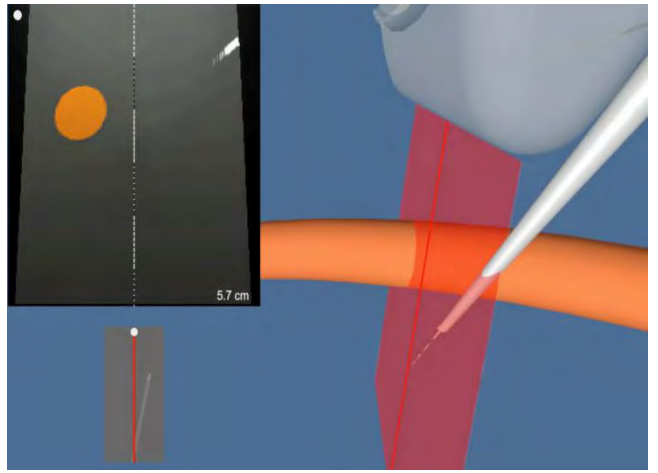
(when we are trying to get the needle into the view (NUSA)

Many people overuse tilt of the probe when they are trying to get the needle back in plane. Mini slide of the probe (left images) is a better option. As shown on the illustration, tilt to the left is inferior to mini slide to the left when it comes to getting the entire needle in view. Mild tilt gets the tip (top right), more tilt gets the mid shaft(mid right) and one need even more of the tilt to get the proximal part of the needle (bottom right). Tilt will work when needle is almost parallel to skin surface or when we only trying to get an idea where the needle is relative to the US plane (left or right of it).

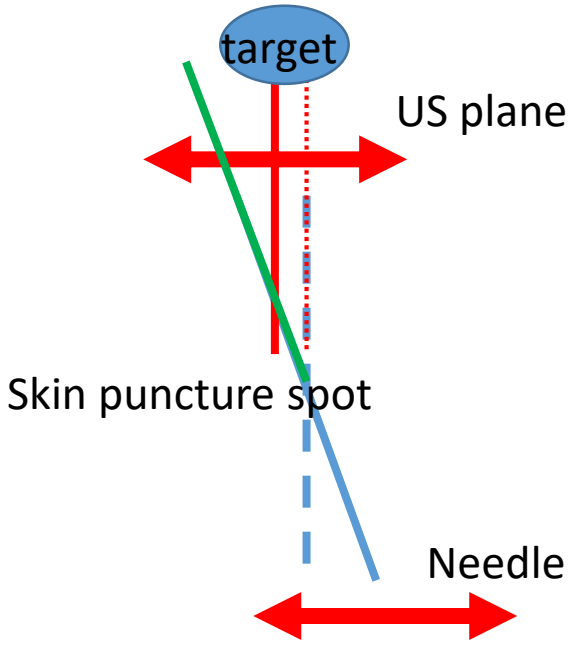
Tilt may be used when slide is not possible due to a small acoustic window while only focusing on the needle tip.

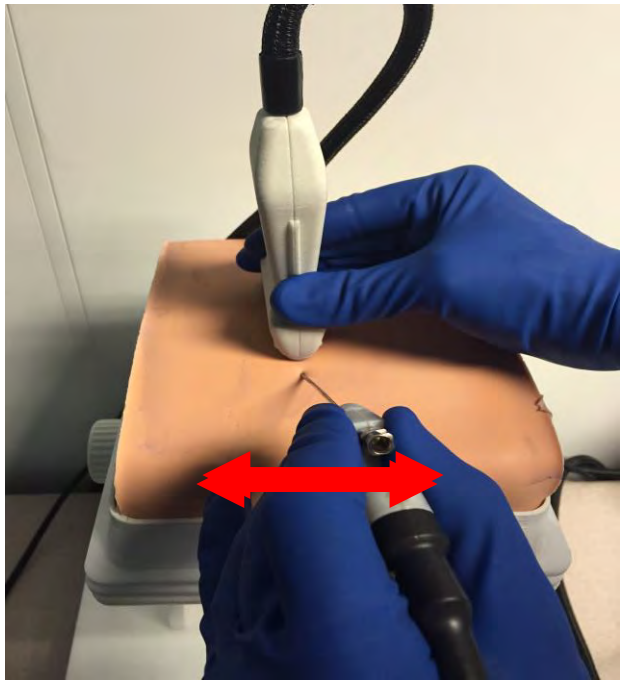






If the needle is sturdy we can replace probe rotation with push on the needle hub (it will rotate the needle) This is technically easier than probe rotation and may decrease the risk of loosing target view that may occur with probe rotation.

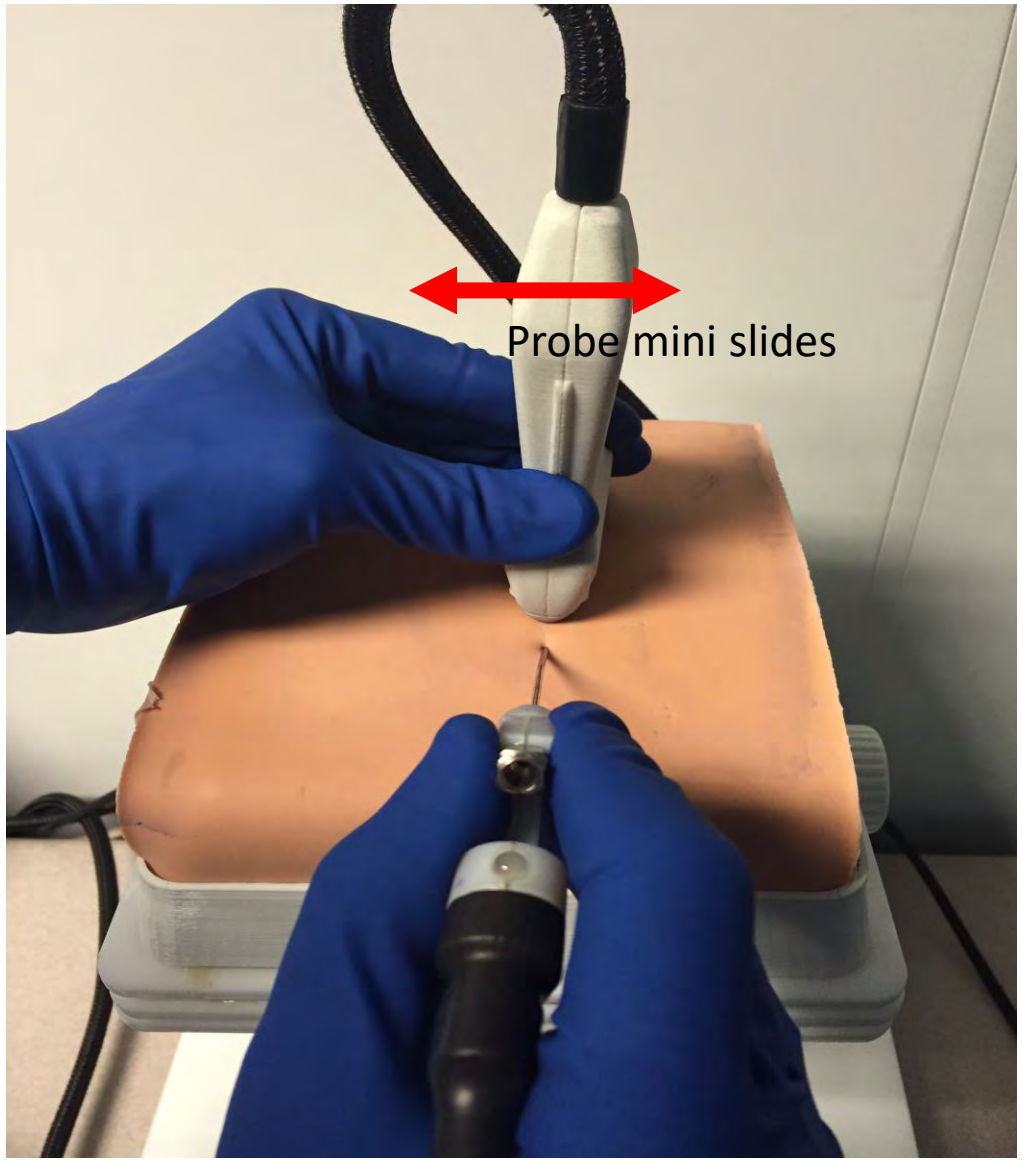


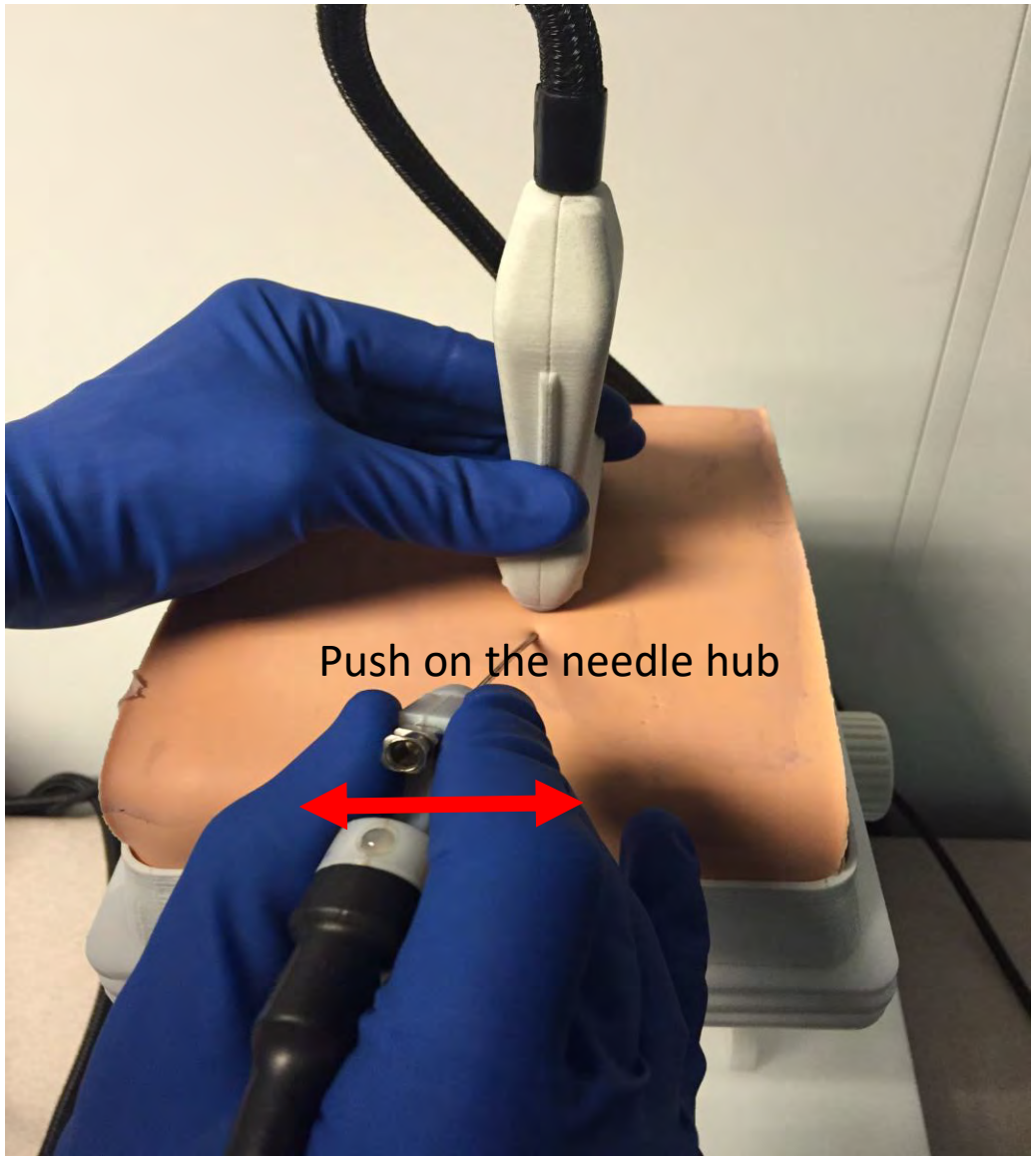


One should always start with great external alignments so only very slight needle rotation is needed, as this maneuver will not cause patient discomfort. If the needle is too flimsy, then one would default to probe rotation.

Here, the blue solid line represents initial needle position and the red solid line is the initial US plane position while dashed lines represent final positions of the needle and the US plane after mini slide and push on the needle hub (view from above). The green line represent US plane after alternative rotation of the probe without moving the needle. By pushing on the needle hub of the needle we can bring needle parallel to the US plane and then by sliding probe laterally we can completely align needle and US plane. Alternatively, we can rotate the probe to achieve alignments (green line) but then we will loose the view of the target. The point here, is that instead of probe rotation we may benefit more from using push on the needle hub (provided that needle is sturdy).

Using sturdy needles and excellent external alignments before US guided alignments allows us to use mini slides of the probe plus push on the needle hub as only 2 maneuvers needed to align the needle and US plane. This greatly simplifies needling. Occasional probe tilt or rotation may be needed but not often at all.





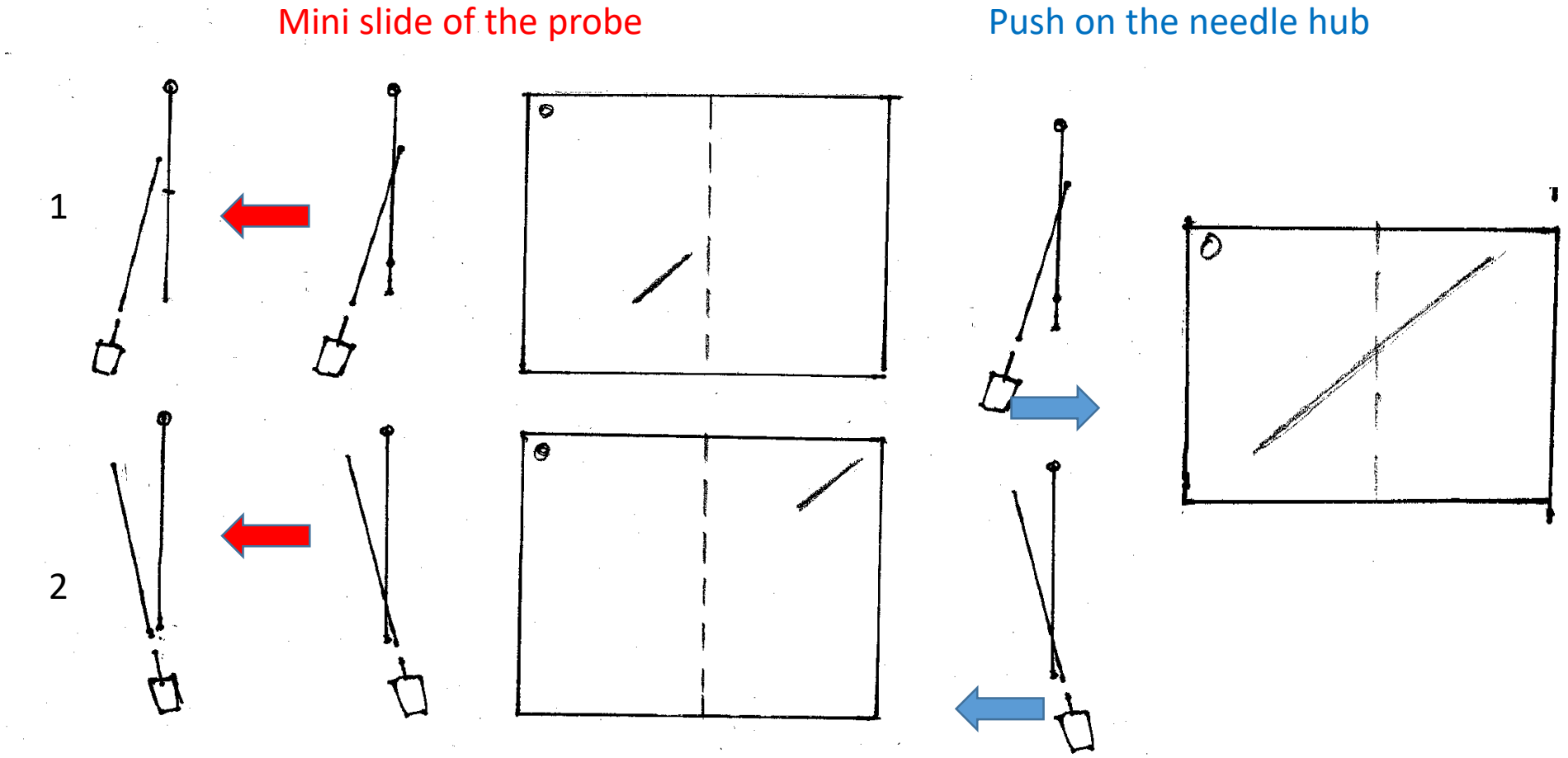
Simplified rules of utilizing probe mini slide and push on the needle hub for US guided alignment

One can develop an algorithm that would guide which maneuver, in what order, and what direction should be used depending on the US image changes after the particular probe/needle manipulation. This would be the most efficient alignments but may be a bit too complex to memorize.

One can just use a simple trial and error approach: slide to the left – if the image get worse, slide to the right, same with the hub push direction. In general most novices find following recommendations helpful.

1. **All movements must be slow and small (as to not overshoot). One can guess the direction of the move (right vs left), or one can always start from the left (for example) if the view does not improve then change the direction to the opposite. Alternatively, one can look at the probe and needle again to make more educated guess**
2. **If there is no needle in view on the first look, start with mini slide.**
3. **If after the slide the needle tip is not crisp, then add a gentle push on the needle hub (direction of the push on the hub will depend on the part of the needle that came to view first: distal vs proximal). (Alternatively you can rotate the probe)**
4. **If starting with a partial needle view, one may try to push on the needle hub first and then consider adding mini slide.**
5. **On the final 5mm advancement it is OK to use any probe/needle move even a probe tilt**

Probe mini Slide-Push on the hub combo. Direction of the push on the hub depend on the view after slide



Imagine a situation when after initial advancement of the needle under the probe we do not see the needle on the US screen. We start with a mini slide and notice that in case 1 we start seeing the distal part of the needle and in case 2 the proximal part. In order to fully visualize the needle one should apply a lateral push on the needle hub in the direction that is opposite to a mini slide in case 1 (distal part of the needle seen) and in the same direction as a mini slide in case 2 (proximal part of the needle seen).

Review questions

- What is NUSPA and NTA?
- What are the 3 options of probe manipulations that may be used to improve needle and US plane alignment? What are the options for needle manipulations?
- Explain the concept of probe mini slide instead of probe tilt as a better way of aligning needle and US plane. What is the stipulation here? (reasonable acoustic window)
- Explain the concept of pushing on the needle hub instead of probe rotation or needle reinsertion. What is the stipulation for that maneuver? (needles that are not easily bent)
- Name 5 rules of using probe mini slide and push on the needle hub as 2 main ways of improving NUSPA.
- When is it OK to use the probe tilt for NUSPA?

Summary

Image acquisitions basic rules

- Good ergonomics always facilitate the procedure (US, patient and you should be ergonomically aligned).
- Start with optimal point of view and adjust it again before needling to avoid parallax error.
- Know your probe/screen orientation, surface landmark (where to put the probe on the skin) and know the targeted image and sonoanatomy of the area . Know required probe adjustment to optimize the targeted view.
- It is ok to use both hands and move the nose and heel of the probe separately.
- Avoid probe tilt to your left or right during image acquisition if possible (use slide instead). Deliberately switch your eyes from US screen to the probe to assess this (if you have a target image but probe is tilted see if you can get one without a probe tilt).
- Some pressure frequently improves the image, and some forward probe rocking helps with angle of incidence.
- Hold the probe low and brace your hand on the patient for stability.
- Make sure you have a decent acoustic window to accommodate future mini slides of the probe.
- Estimate angle of the needling based on the image before starting needling.

Summary

We repeat the basics of in plane needling

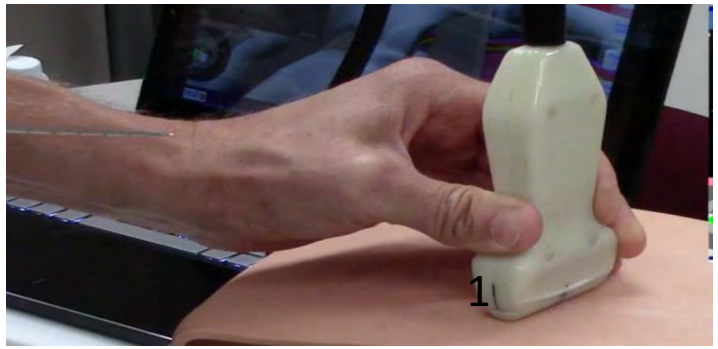
Common rules of procedure with in plane needling (details in previous slides)

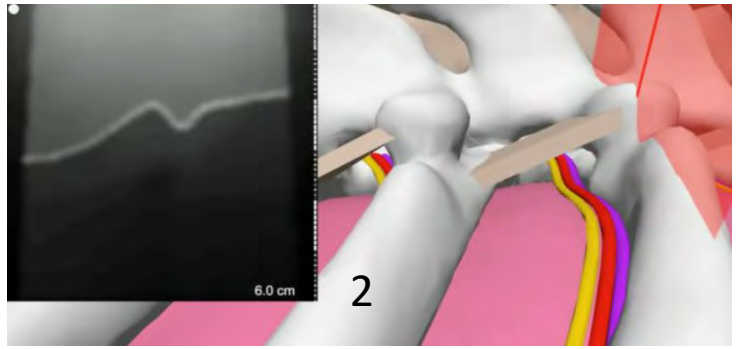
- Start initial needle advancement based on excellent external alignment: looking at the probe/needle/patient interface not on the US screen. Enter skin 1 cm away from heel of the probe and advance 2-3 cm of the needle in with a predetermined NTA angle (use distance between needle hub and probe as a surrogate marker of the angle). Then shift the attention to the US screen (next steps of US guided alignment)
- Remember 2 types of US guided alignment (while looking at the US screen): NUSPA first and then NTA adjustments.
- Use mainly 2 moves: 1-probe (mini slide) and 2-needle manipulations (lateral hub push) to correct misalignments. Minimize/avoid tilting the probe. Use small correcting movements. Occasionally you may need to shift your attention back to needle and probe(external alignment).
- Use Incremental advancement of the needle (1-2 cm at a time) with clear needle tip visualization at each step and adjustment after each step if needed.
- Focus on the tip of the needle (know its unique appearance). If tip is lost from the view during advancement – stop, do not advance the needle further until you get it back in view.
- Use other maneuvers such as hydrolocation when visualization is poor to help with needle guiding.

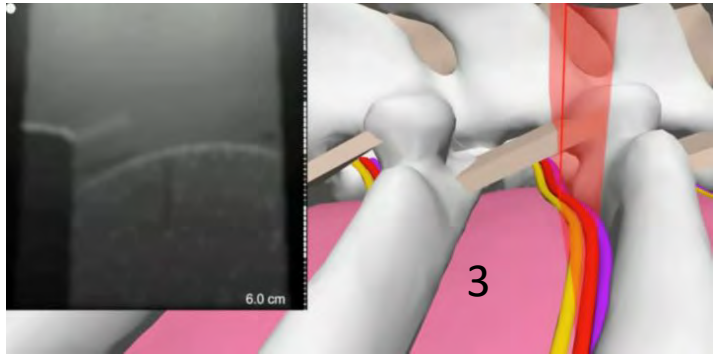
Summary

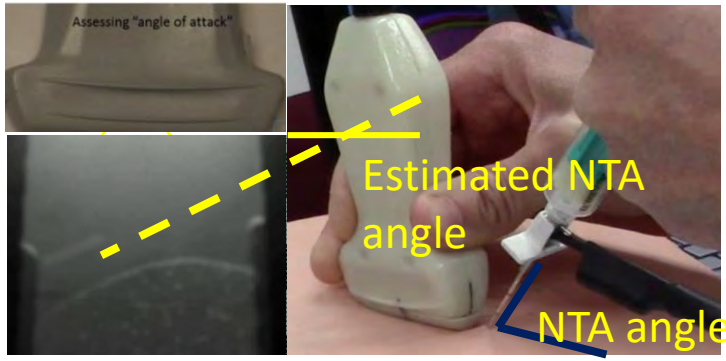
Axial IP TPVB from lateral to medial with patient prone. Step by step.

1.Image acquisition and assessment steps







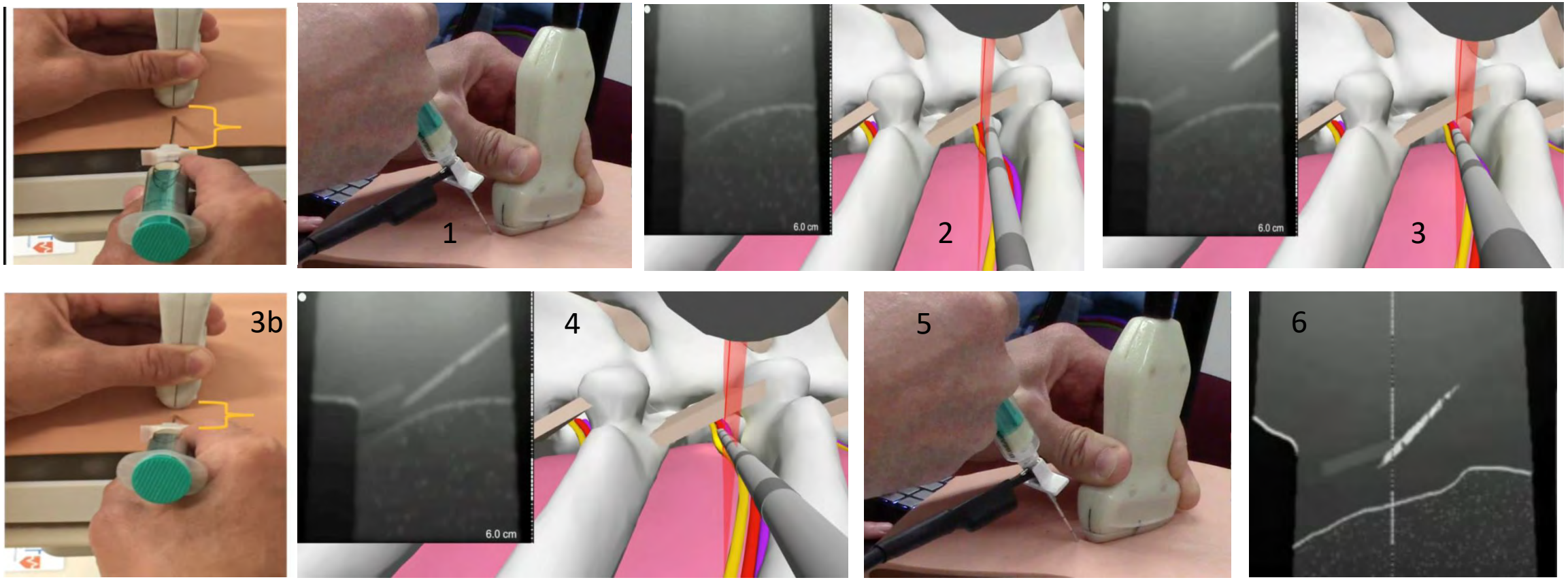


1) Mark the side, count ribs and 2) Place US probe over costotransverse junction of the interest with TP in the middle of the image 3) Slide probe lateral and caudad and then 4) Push on the nose of the probe (rock it) so our target is in outer third of the image). Confirm that there is no probe tilt and mini slides do not affect image critically (we still see TPVS). Assume position with minimal risk of parallax error

5) Estimate the “angle of needling” provided that needle entry is 1 cm away from the heel of the probe. Here the required angle is close to 30 degrees.

Summary

Axial IP TPVB from lateral to medial with patient prone. Step by step continues. 2 Needling and confirmation steps



1) Focus on external alignment of the needle and the probe (imagine seeing US plane line from nose to heel of the transducer) – place needle 1 cm back to the transducer aligned with the imaginary US plane, “pop” through the skin and then establish earlier estimated angle of attack (use the distance between hub and the probe as a surrogate marker of the angle Advance needle up to 2-3 cm mark at the skin; 2) switch your attention to US screen. If you do not see the needle do a mini slide of the probe left or right if needed to find the needle-3) then do a mini push on the needle hub (same direction as a slide) if needed to improve needle tip visualization; Now adjust the angle of attack if needed by elevating(here) or lowering needle hub-3b; 4) Advance the needle 1-2 cm towards the target and 5) repeat “probe slide and needle hub push” if needed (usually same direction), repeat another advancement until needle tip is in TPVS; 6) inject saline to see ventral pleura displacement as a confirmation