Curriculum 1
lecture 2

Thoracic Paravertebral Block (TPVB):

Ultrasound (US) Assisted Technique of TPVB

3 types of techniques for TPVB

- **Pure Landmark-based TPVB** (bonus curriculum)
- **Ultrasound (US)-assisted TPVB** (covered in this curriculum)
- **US-guided TPVB** (some will be covered in curriculum one lecture 3)

- **In pure landmark-based techniques:** the operator uses external palpable landmarks to estimate the position of the TPVS and uses end points other than US (predetermined distance, LOR, nerve stimulation, paresthesia) to identify when the needle tip has been advanced into the TPVS
- **In US-assisted techniques:** US is used to mark the skin projection of deeper landmarks and to measure important depths and distances. Needle manipulation is done without US, using other end points such as LOR, stimulation, or predetermined depth. US is used for confirmation of needle tip location after needle manipulation is done
- **In US-guided techniques:** one utilizes US in real time during needle manipulation. We acquire US image of the TPVS and advance the needle into TPVS in real time. Seeing the needle tip in the TPVS or the spread of LA in the TPVS is the ultimate end point for correct needle position for this technique.

Now watch the video that is available to see the entire procedure from start to finish

US assisted TPVB

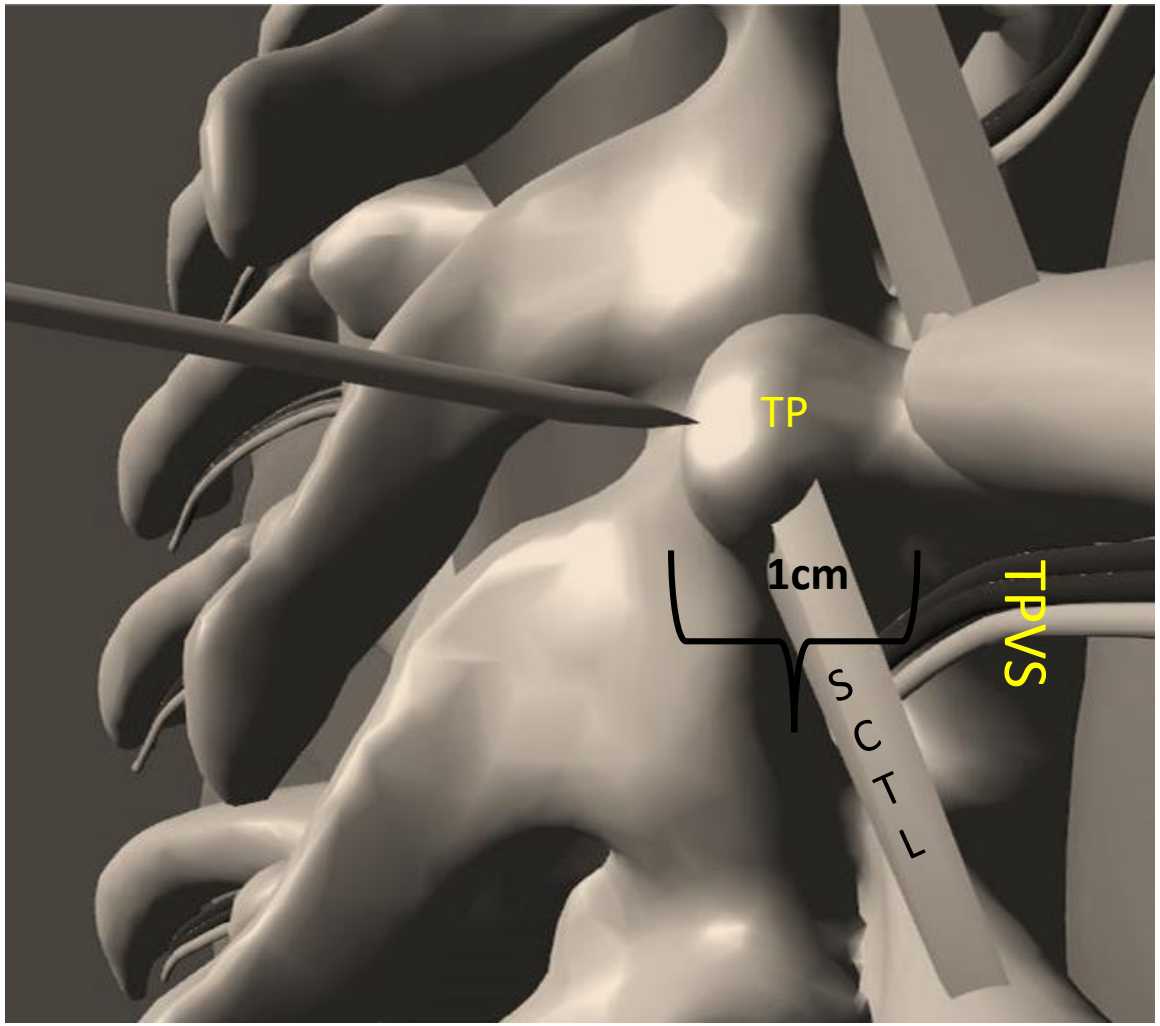
Outline of the lecture

The essence of the UF version of US assisted TPVB technique

- Technique specifics
  - Safe landing on TP
  - Direction of advancing the needle past TP – why below TP
  - Correct trajectory of needling
  - Primary and complimentary end points for the final needle position
  - Minimal and maximal predetermined distances
- Block specific terminology with some details on each steps
- Brining it all together

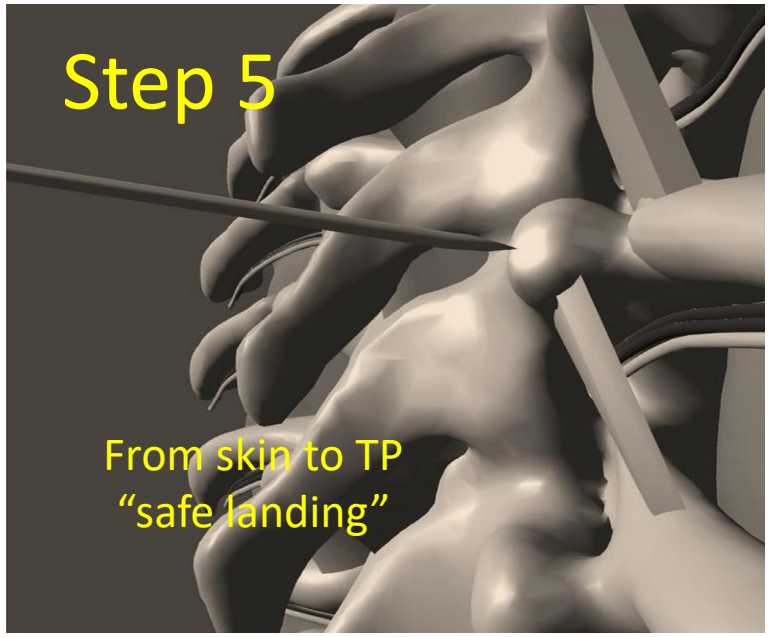
Essence of UF US-assisted technique

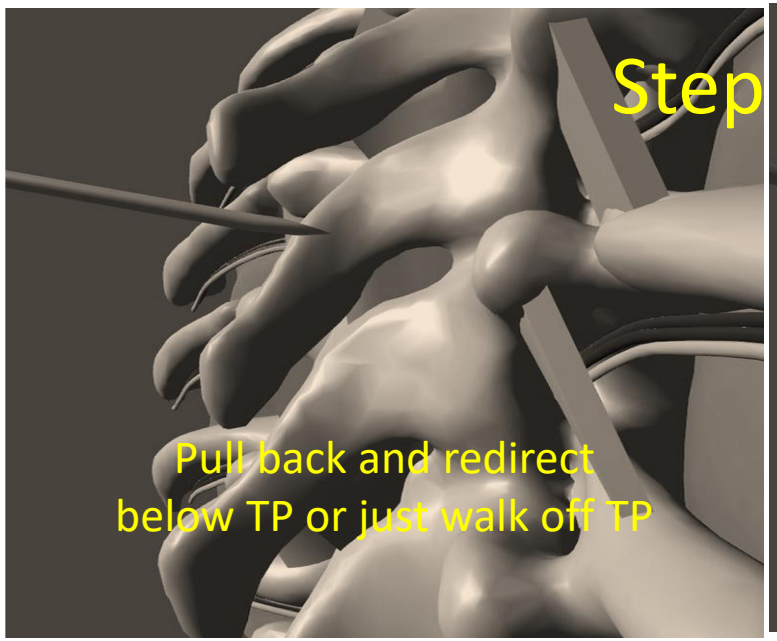
- There is a **consistent relationship** between the tip of transverse process (TP), SCTL, and pleura (see illustration on the right).
- This allows us to use the tip of **TP** as a "spring board" for the performance of the TPVB.
- Using US, we **can determine the TP location** and **measure depth** from the skin to the TP and from the TP to the lung.
- Then, without US, we **advance the block needle to the TP** (**safe landing**) and walk the needle **below it** to the minimum **effective predetermined distance past TP (initial advancement)**.
- SCTL is quite robust at the tip of TP. After the initial advancement, if the needle tip is shy of the TPVS and embedded in the SCTL, it would be difficult to inject. We can use **resistance to injection as an additional and complimentary end point** to decide whether we need to advance the needle further (**secondary advancement**).
- Use of US for confirmation of the correct needle placement (expansion of the TPVS during saline injection) may be even better.

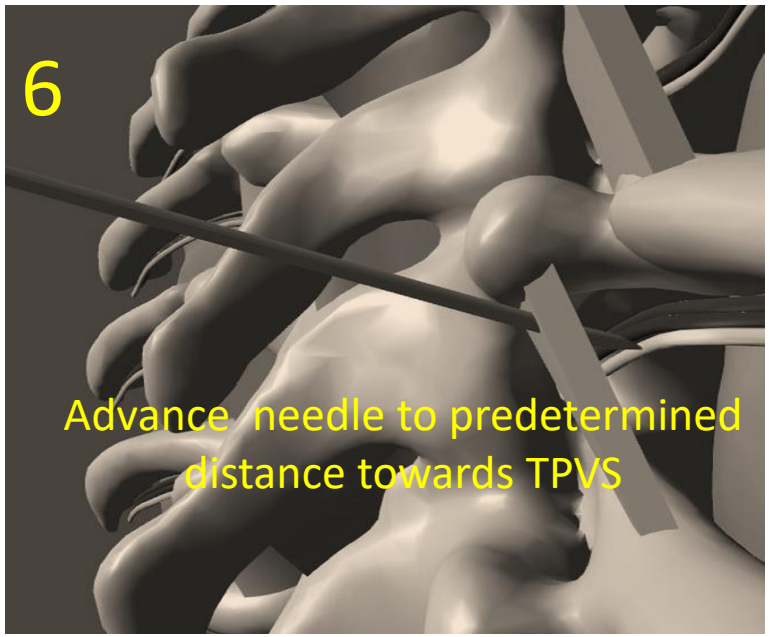


7-8 principal steps of US-assisted technique of the TPVB

1. Marking side and level of required block
2. Marking the skin projection of the tip of TP with US, based on this you can mark the entry point
3. Measure the depth from the future skin entry to the TP and to the lung. Deciding on the safe landing distance (SLD), initial advancement (IA), and secondary advancement (SA)
4. Numbing tissues with LA via small gauge “search needle” while confirming tip of TP location and depth
5. Safe landing on TP with a block needle
6. Initial advancement: walking caudad to the TP to minimal effective predetermined distance
7. Check for “badness” (e.g. blood, CSF, air), LOR and/or TPVS expansion on the US
8. If no LOR after initial advancement, do secondary advancement and repeat step #7



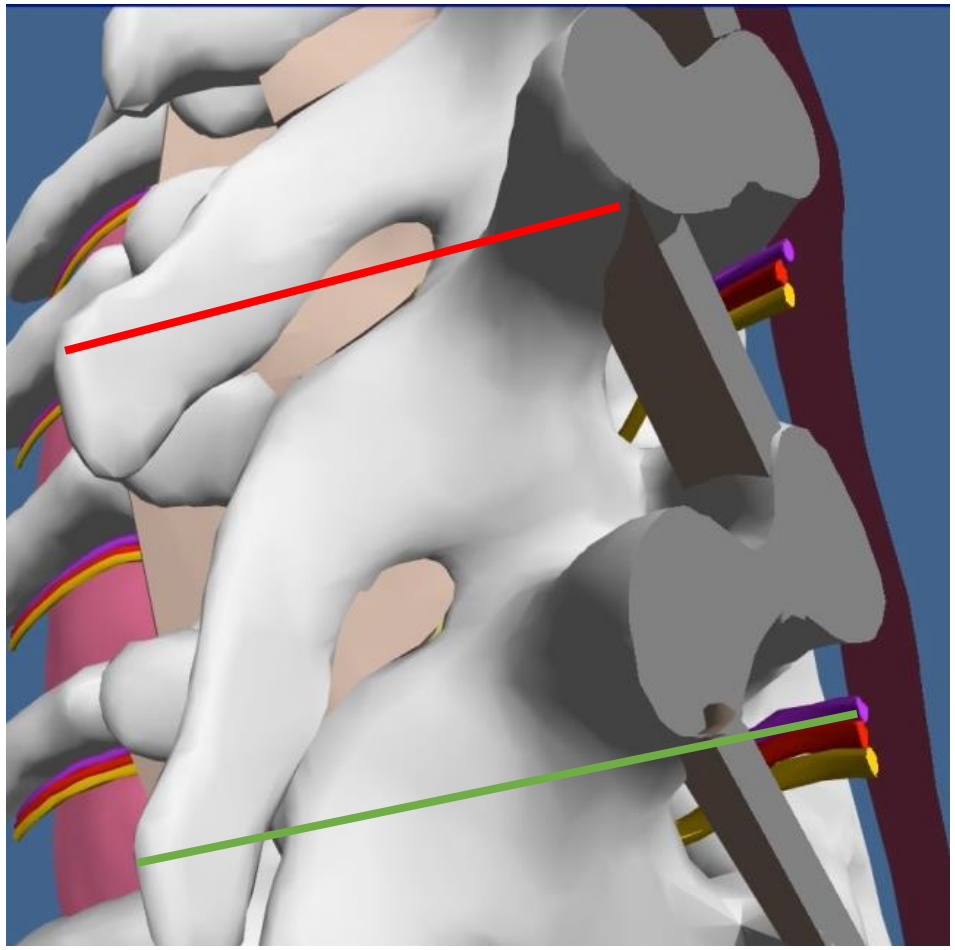




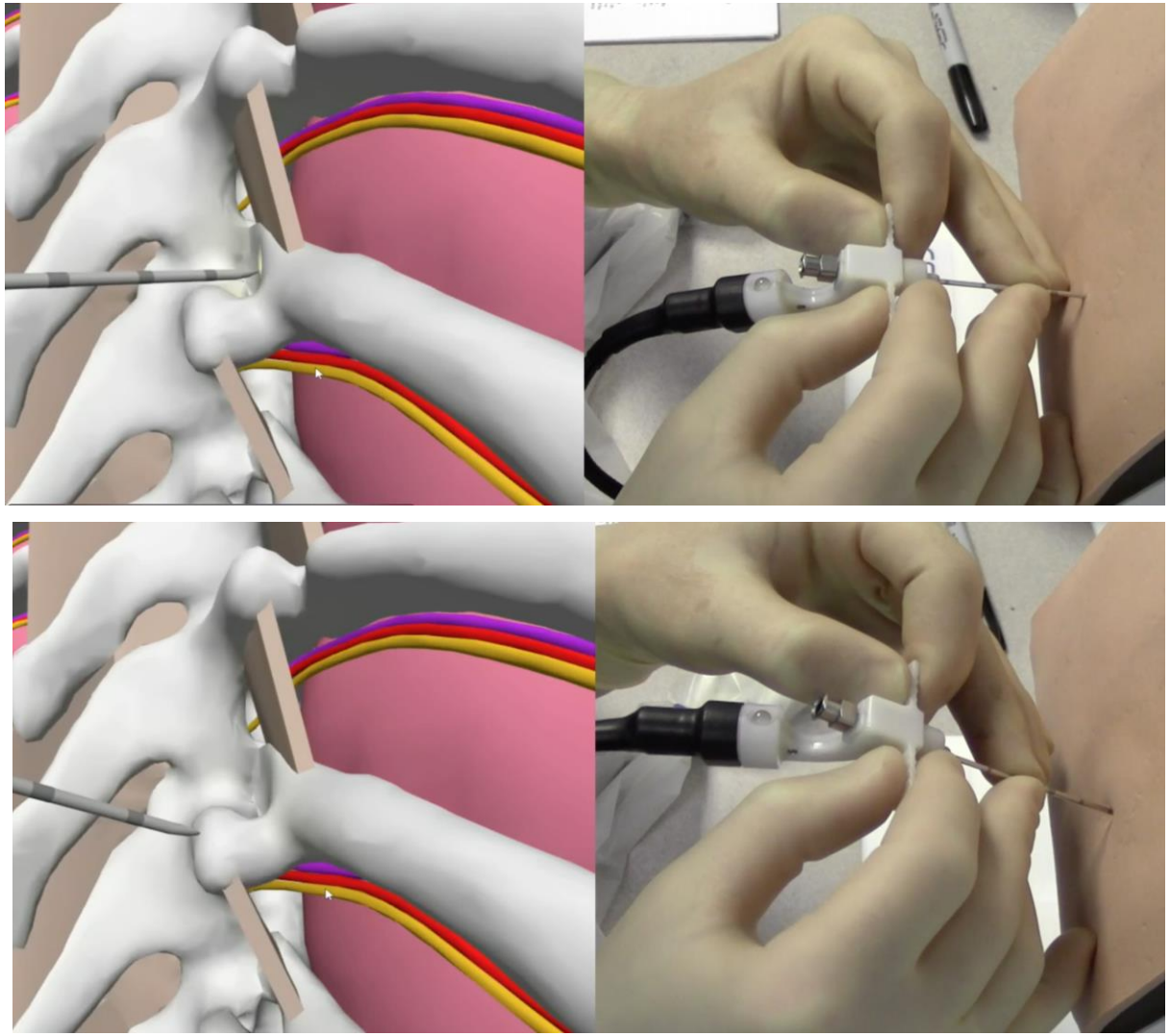
How to land a needle on TP safely and efficiently

(Frustrations from past oversimplified recommendations)

- **“TP tip is 2.5-3cm from midline at the level of spinous process (SP) above”-** this turn out to be not very consistent (in the image on the right red and green lines are on adjacent levels and the green line misses TP), so we need to know the depth to TP to realize when our mark was off.
- **“Depth from skin to TP is from 1-5 cm”-** so 1cm or 5cm? If I do not feel bone with my needle while trying to land on TP, am I not deep enough(red) or off the correct path (green)?
- One will injure pleura if wrongfully assuming to not be deep enough while on the wrong path.
- **There are several solutions here - Ultrasound is probably the best**
  - Use US to mark TP projection on the skin and measure depth to TP
  - Use US for live needle guidance on TP



Why after landing needle on TP we advance it below TP and not above?



If one does not use live imaging, it is difficult to be 100% confident (especially in lower thorax) that the needle is indeed landed on TP and not on the rib (top left image).

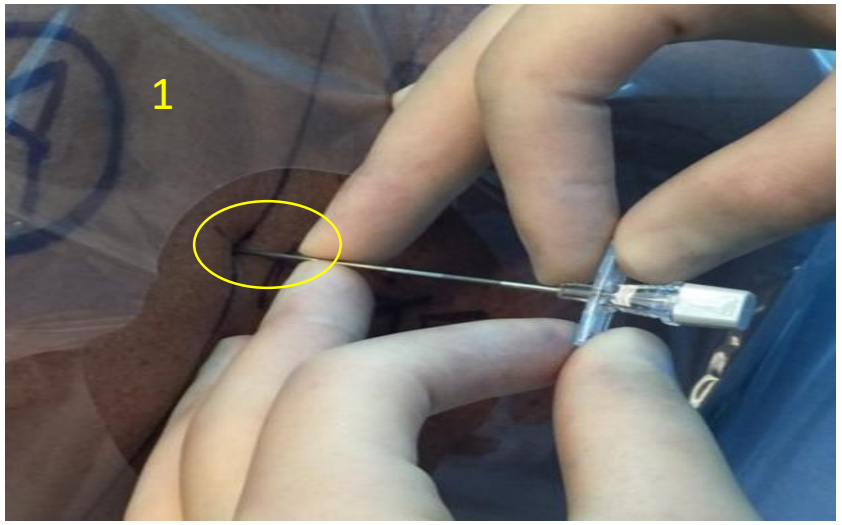
If we consistently walk below our first “bony landing” spot we will be able to pick up those cases when we erroneously landed on the rib instead of TP: during attempt of advancing needle below our initial landing spot we would feel the bone more superficially. This will prompt us to change our needle entry about 5-10 mm down.

In case of advancing the needle above TP, one would be at higher risk of lung injury when initial landing is on the rib instead of TP and not recognized and the predetermined distance is used as a primary end point for the block. Using LOR as an end point for TPVB may alleviate this problem. However, as we discuss further LOR is not a perfect primary end point but rather a complimentary secondary end point. TPVS is also largest below TP.

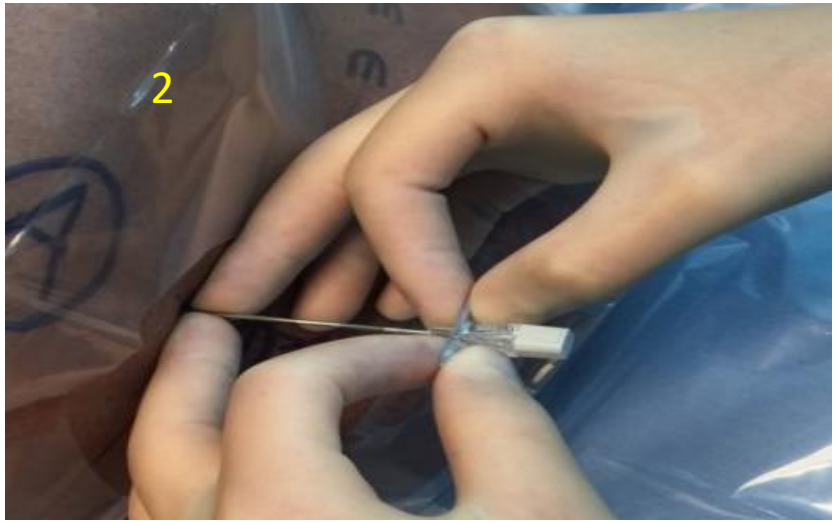
Why use the predetermined distance as a main endpoint? Why not use other end points?

Advancing the needle to a **predetermined distance past TP** is probably the **easiest and safest end point** for TPVB compared to all other endpoints. (**Your only focus is on the needle trajectory and depth of needle advancement past TP.**)
Other end points such as nerve stimulation or LOR may not be as sensitive or specific, require experience, complicate the procedure (if done simultaneously), and may increase the risk of advancing the needle too deep. Most people cannot accurately keep track of the depth of advancement and feel for LOR simultaneously.

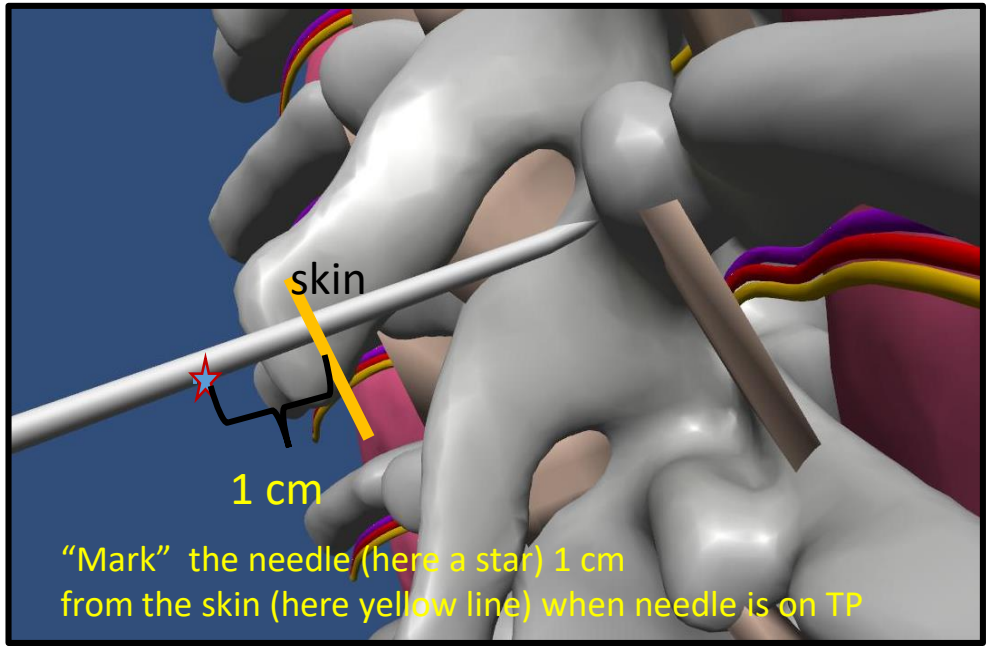
(Right) Once the block needle lands on the tip of TP, the middle finger tips are positioned 1 cm away from the skin and will serve as a hard stop for needle advancement when walking off the TP.

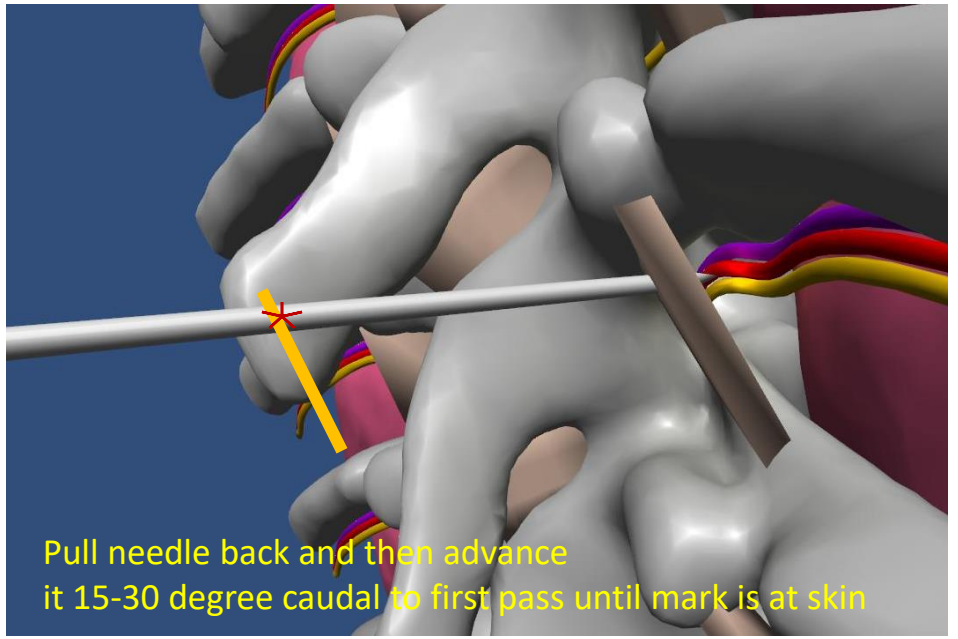


After walking below TP, the needle is advanced until the middle fingers touch the skin (needle is advanced to a predetermined depth of 1cm past TP).



What is the <u>minimal effective distance past TP,</u> and does it always work?



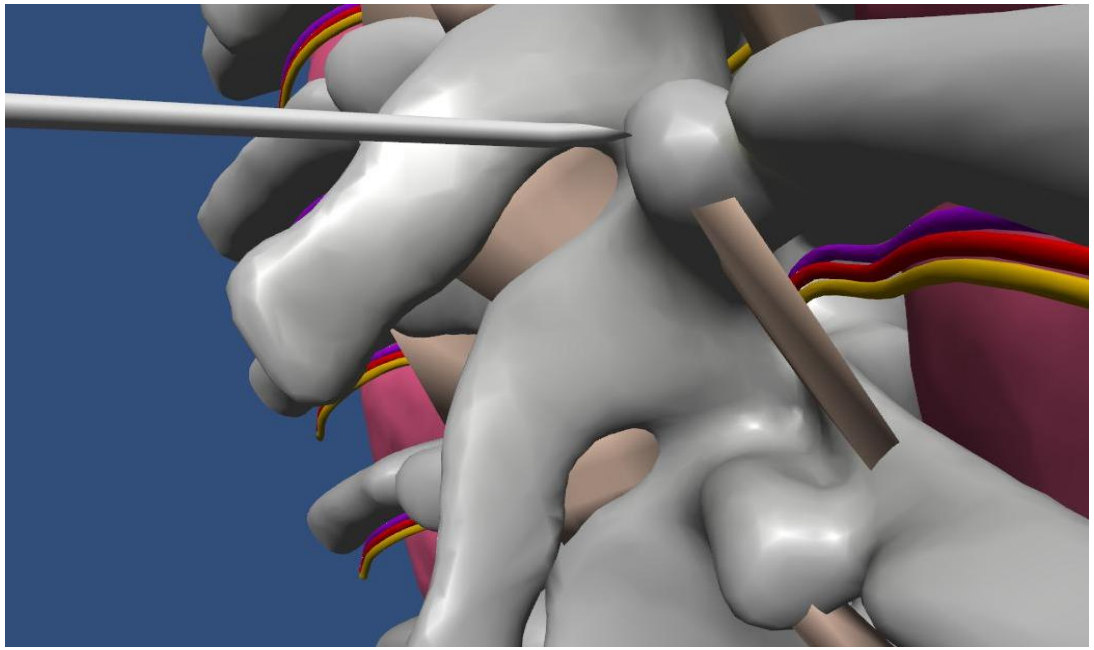


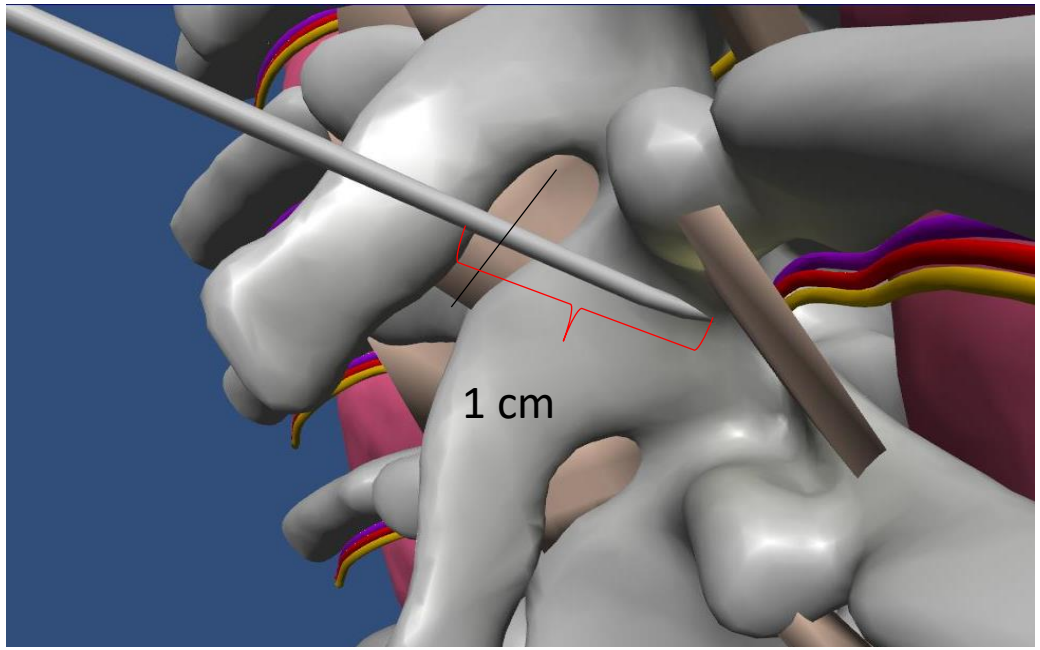
For the majority of our patients, if the needle trajectory when walking below TP is close to perpendicular with the skin, a distance of 1 cm past TP is just enough to penetrate SCTL. This is because the AP dimension of TP is about 1 cm.

(We confirmed this with our study of 50 chest CTs)

The problem with the predetermined distance concept is that distance to TPVS after walking off TP will depend on the needle trajectory (a simple matter of geometry)

(Illustrated below) Despite the same anatomy as in the illustration prior and use of the same predetermined distance of 1 cm, the needle tip in this case did not reach the TPVS due to a different trajectory of the needle (more cephalad contact with TP requiring more caudad angulation of the needle). Note that advancing the needle 5mm more will get it in the correct spot. Should we increase the minimum effective distance from 1 cm to 1.5 for all? (1.5 cm and even 2 cm are mentioned in many books and papers and not unreasonable based on our CT study)

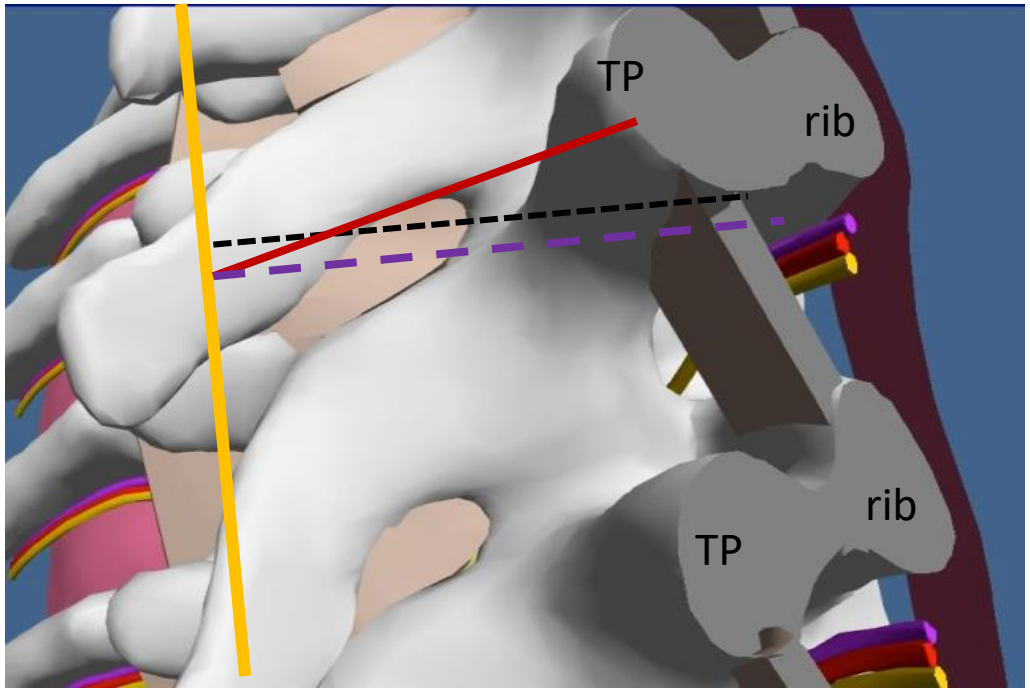




We still think that 1.5 cm and 2 cm past TP are not good routine distances. It is better to keep this distance minimal (1cm or even less for some patients) and strive for a consistent thoughtful trajectory, keeping the **initial advancement a safe distance**, and use **complimentary end points such as resistance to injection to assist with TPVS identification. If it is difficult to inject after initial advancement one can proceed with a secondary advancement** (while still checking for LOR after small 1-2 mm incremental needle advancements), but not deeper than 1.5 cm past TP.

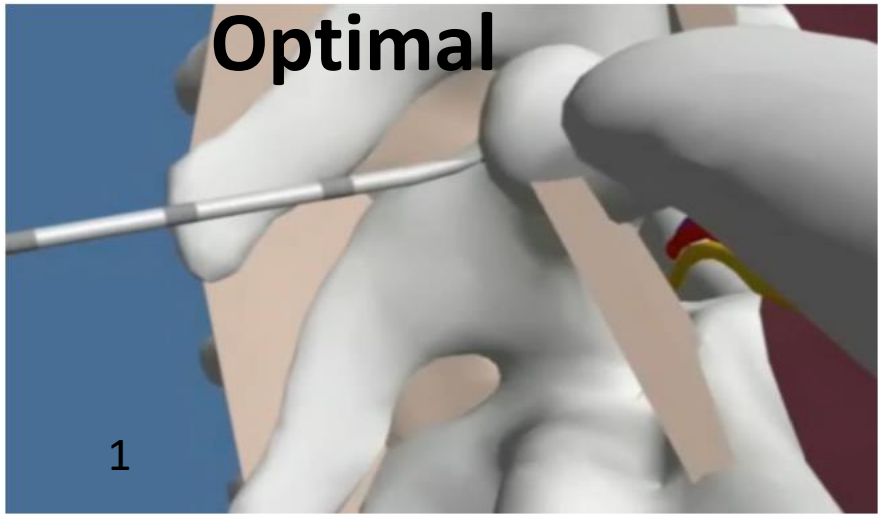
What is the optimal needle trajectory?

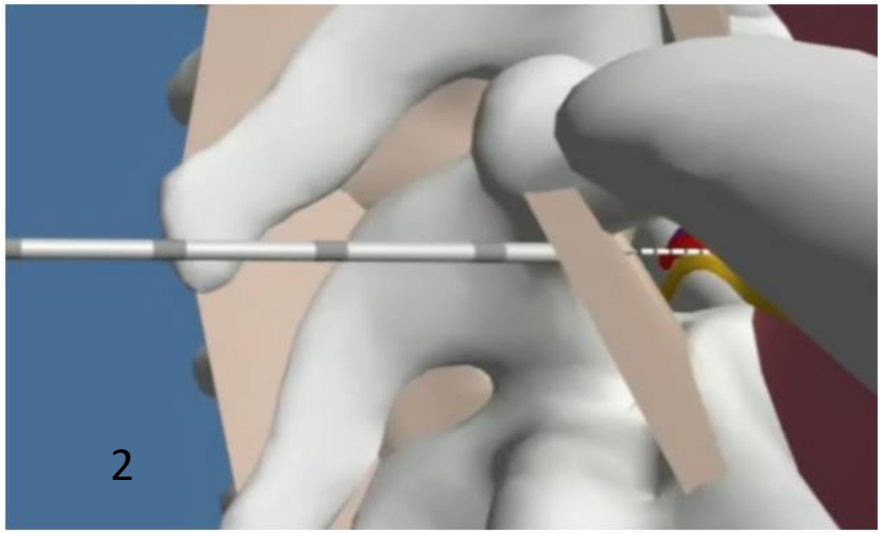
- The trajectory of a needle pass is determined by
  1. Skin entry point and
  2. Needle angulation
- **The optimal needle trajectory occurs** when the needle enters skin at or slightly lower than the projected caudal edge of TP
- After skin entry, the needle is angled slightly cephalad to safely land on TP (red line). Make sure the needle stays in the sagittal plane (avoid medial or lateral angulations)
- After contacting TP, the needle is walked caudad off TP with **the final needle angle close to a right angle to the skin** (purple dash line) or only slightly downward
- Using this trajectory, we can reliably use predetermined distances of 1 cm past TP for initial advancement, and about 5 mm more for secondary needle advancements (if required). These distances should work for the majority of average sized patients.
- US allows us to measure and confirm distances for minimum and maximum needle advancements for individual cases (see next slide).



We recommend that the final needle angle when entering TPVS be close to a right angle to the skin surface or only slightly downward (purple dash line)

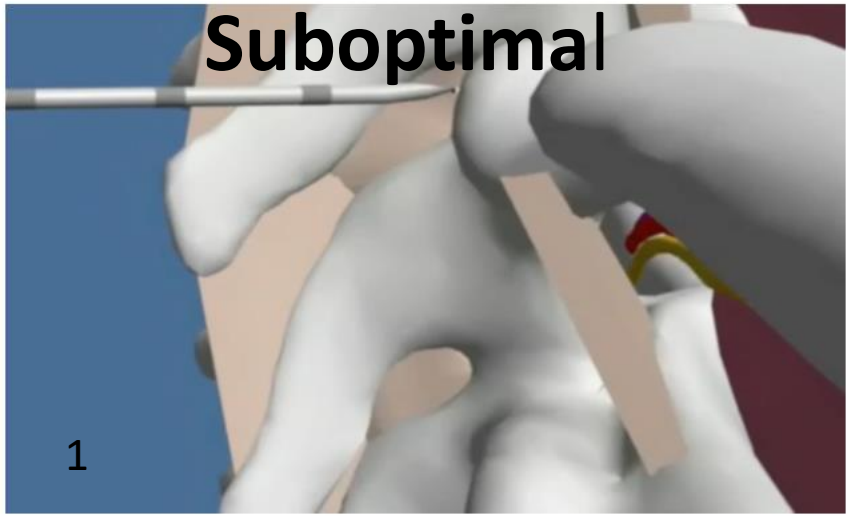
Optimal

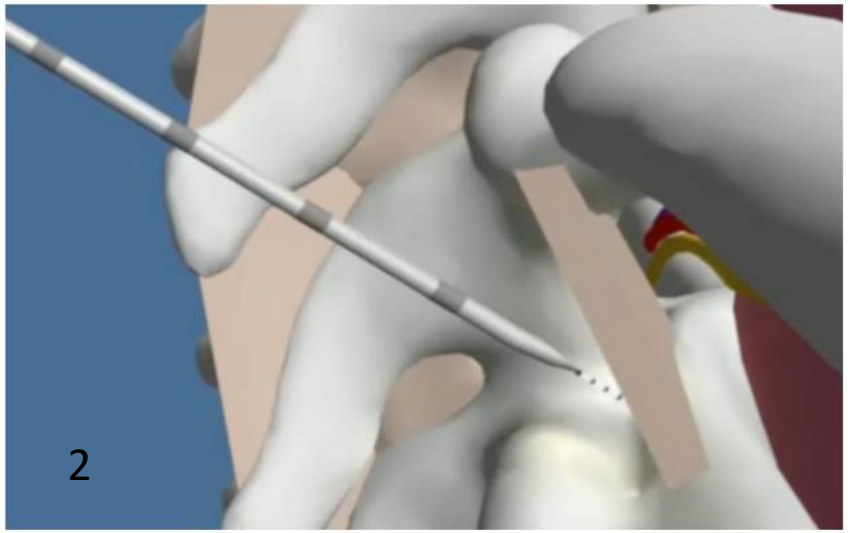




Example of the correct technique: needle enters at the lower edge of TP and is angulated up to land on TP and then is advanced 1 cm deeper below TP. At the final position needle is perpendicular to skin

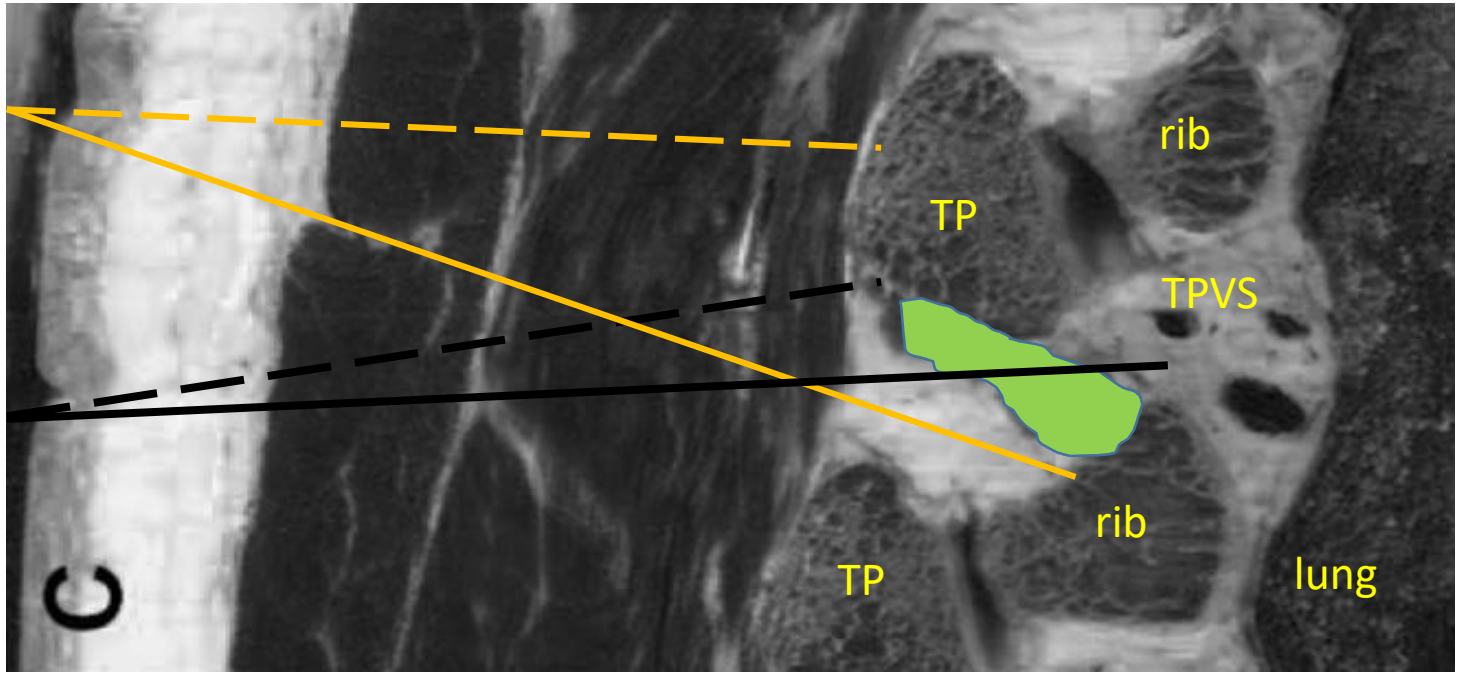
Suboptimal





Example of the suboptimal technique: needle enters too cranial and is angulated downward too much so even advancing it 1.5 cm deeper than TP results in incorrect needle position

Benefits of the correct trajectory and using LOR only after initial advancement



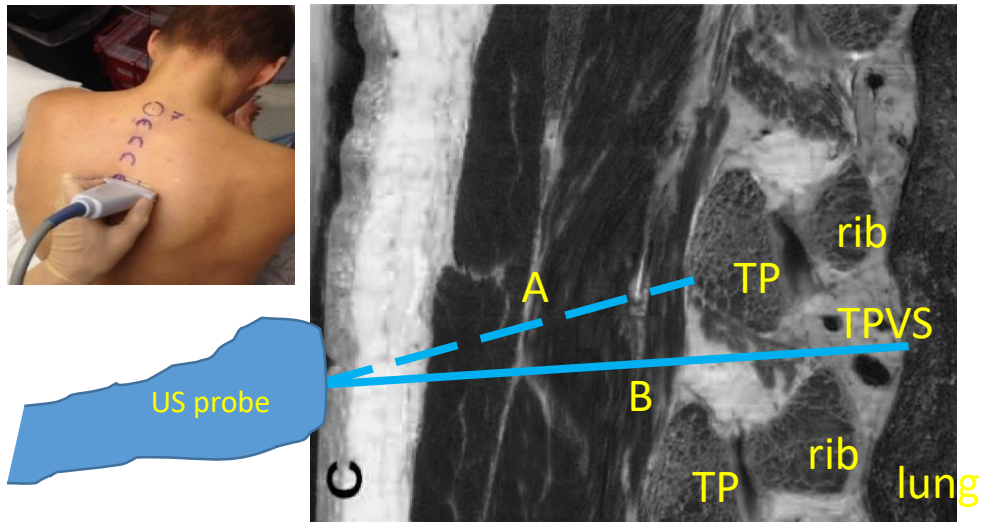
1. **Consistency in using minimally effective and maximally allowable distances**
2. **Finding bone free window** when spaces are tight (compare black to yellow trajectories)
3. **Avoiding false LOR** before penetrating SCTL-(green here) Compare black to yellow - if LOR is used as a primary end end point, one would experience false LOR in the fat pocket between muscle and SCTL. That is why we recommend to use LOR only as a secondary end point after initial advancement to predetermined distance with correct trajectory

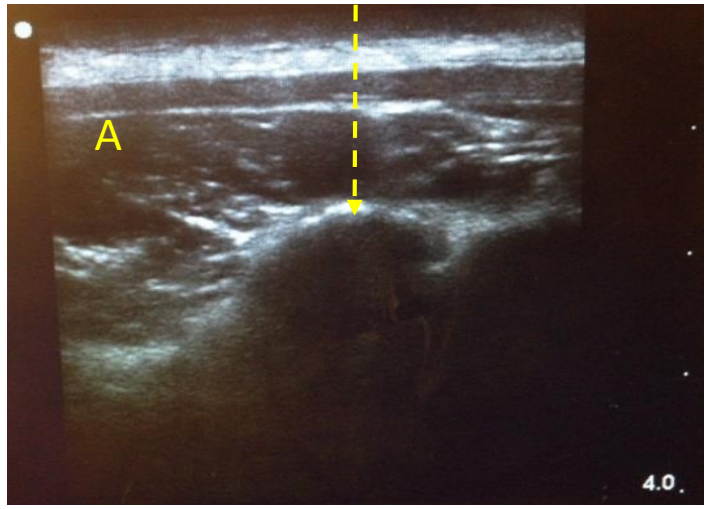
Review questions

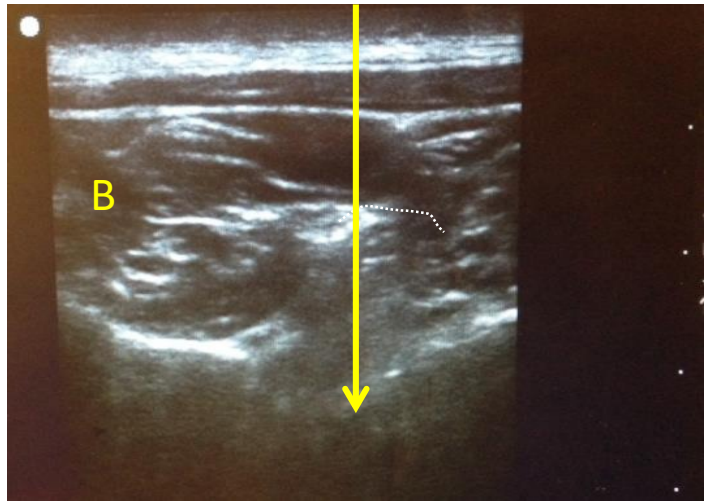
- What are 3 types of techniques for TPVB? How is US assisted technique is different from US guided?
- Name 7-8 principle steps of the UF US assisted technique
- What is “safe landing”
- Why is marking skin projection of TP is not enough, and we also need to know the depth to TP (SLD)?
- Where is the needle entry in regard to projection of TP tip?
- What 2 depths are measured from the entry point using US? How do we calculate SLD?
- What is initial advancement (IA), do we check for LOR during IA?
- Why do we walk below TP and not above it?
- What is the optimal trajectory of safe landing and initial advancement?
- What is the primary end point? What is minimal effective distance?
- Why is the minimal effective distance of initial advancement with optimal trajectory about 1 cm?
- Why will we have no resistance to injection after initial advancement and sometimes we will?
- What is secondary advancement?
- Why are we not using nerve stimulation or LOR as a primary end points?

How can US help to customize the depth for initial and secondary needle advancement for different size patients and different levels?

Position the US probe axially over the intended needle entry point on the skin. This should be at or slightly caudad to the skin projection of the lower edge of the TP. Then obtain an US image similar to the top right box (A) by tilting the US probe up so that the insonating plane simulates the needle angle for a "safe landing" on TP (blue dashed line). Make sure there is no excess pressure applied to the probe. This will give you the depth of **skin to TP**.







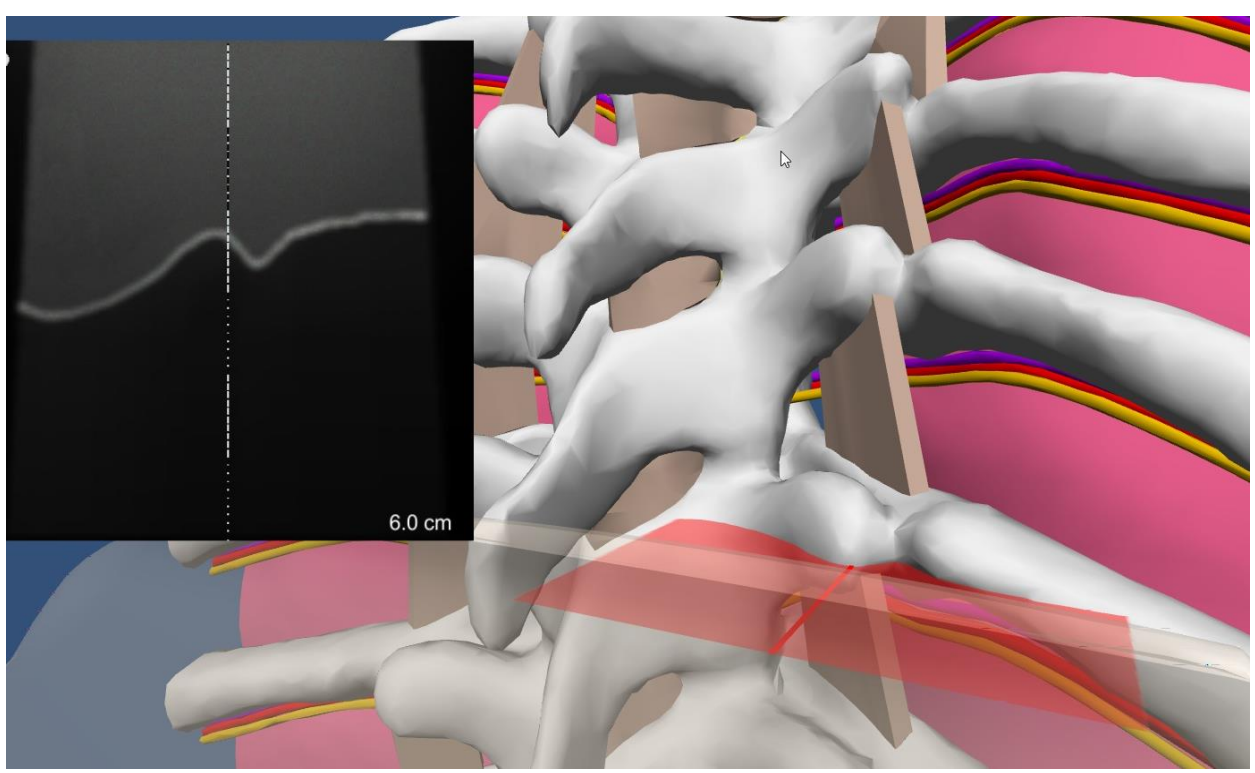
Delta=B-A

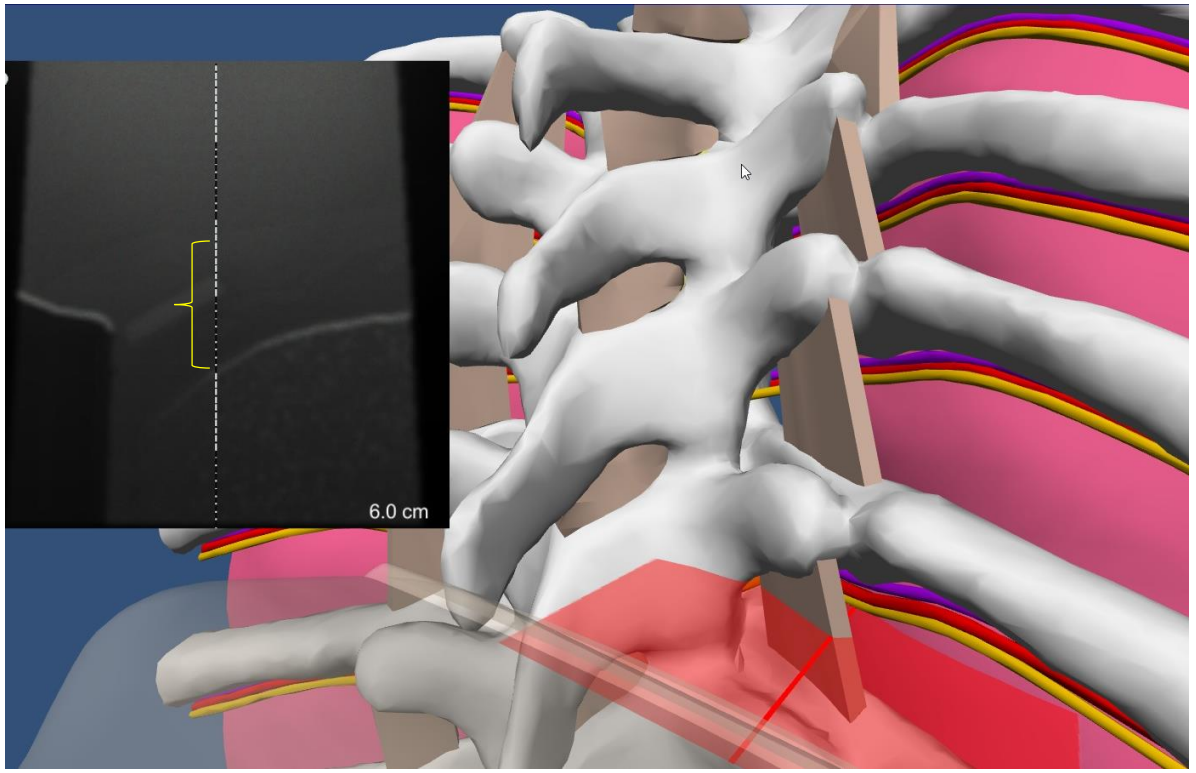
Then tilt the US probe downward so the insonating plane simulates the "initial advancement" pass (blue solid line) and the pleura is visualized. This will give you the depth of pleura.

From these 2 images, we can estimate the "delta" (or difference in depth) between TP and lung. If the delta is more than 15 mm (average delta is 15-20), we can use our default 1 cm for initial needle advancement and 5mm for secondary advancement.

If the delta is less than 15mm (e.g. patient is small), then use less then 2/3 of delta for initial needle advancement and 1/3 for a secondary. Theoretically, SA could be more than 5 mm if delta is more than 15 but this is hardly ever needed if trajectory is correct.

Delta of TP-lung on the mixed virtual reality simulator

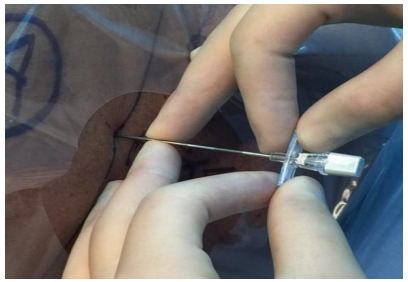


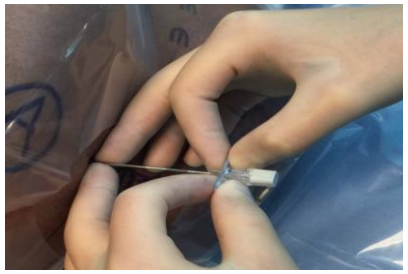


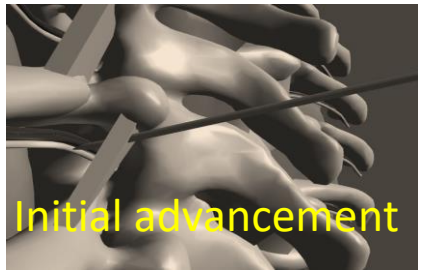
The US insonating plane is shown on the virtual images in color and correlate to the virtual US images in black and white in the left upper corners. Note the depth difference between TP (image on left) and pleura (image on right). In this case, the delta (yellow bracket) is close to 2 cm, so we can use 1 cm for IA and 5 mm for SA if needed without risk of lung injury.

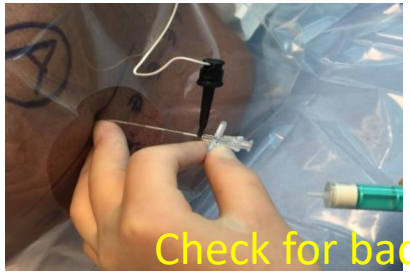
Block specific terminology (jargon)

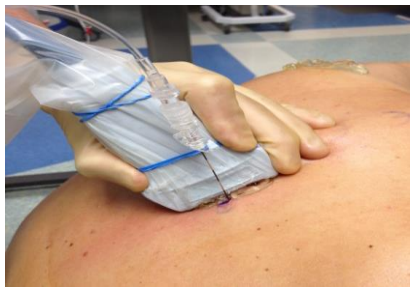
- **Let us review and clarify the specific terminology for our block technique. We will review the following terms in the next few slides:**
  - “Safe landing” on TP
  - “Initial advancement”
  - “Check for Badness at the needle hub and LOR ”
  - “US check”
  - “Secondary advancement”





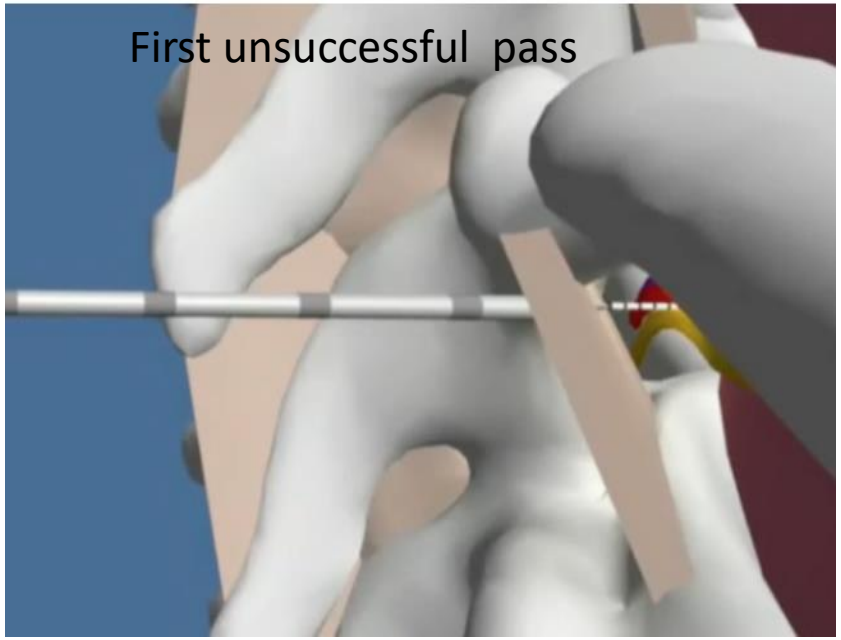


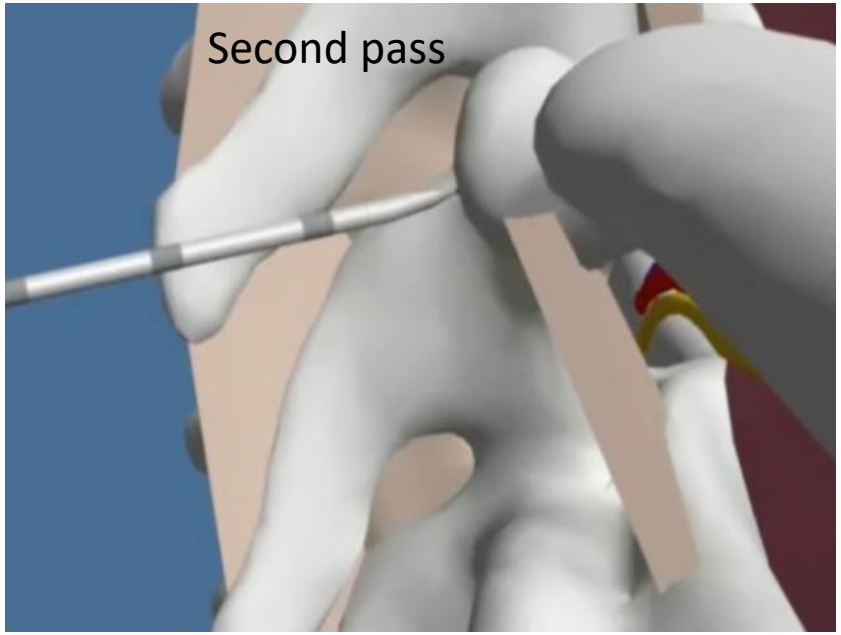




Safe landing on TP

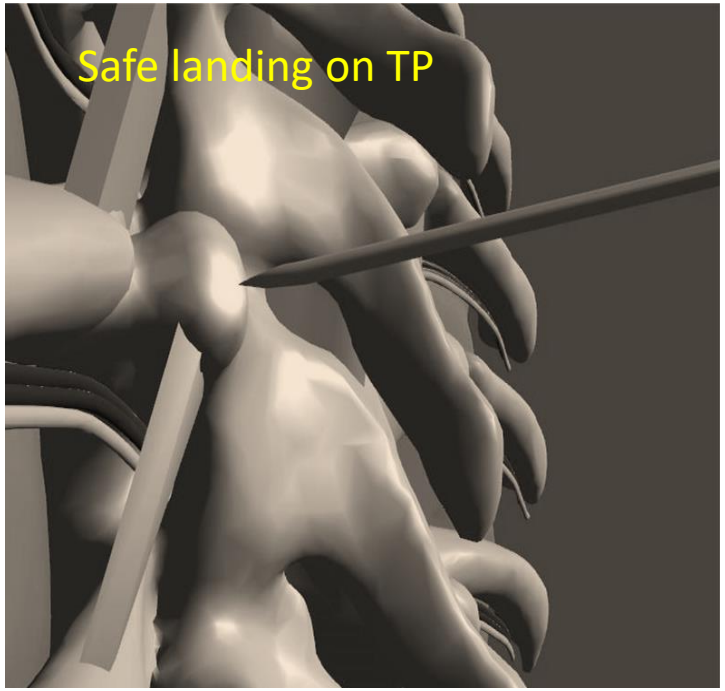
Opposite to an “unsafe landing on lung”. US can help to mark the projection of TP, but one may still miss TP due to error in needle angulation. One must also know when to stop advancement and to pull back and redirect. US helps here as well by allowing us to determine the depth to TP and Safe landing distance (SLD). SLD is about 5 mm more than depth to TP.

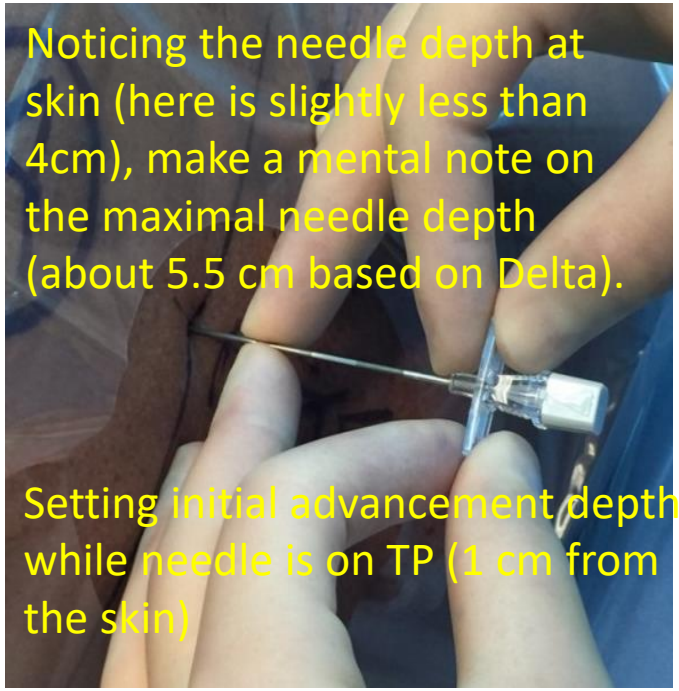




Knowing depth to TP and its skin projection helps to land on TP safely and quickly: if the needle is advanced to safe landing distance (SLD) and we do not feel bone it means that our trajectory is off and adjustment is needed.
Because SLD is less than pleura depth no lung injury can happen, and because we mark the TP projection on the skin we should locate it within 1-3 passes. The goal is to land on the inferior (or middle) part of the tip of TP (this will make the next step of advancing the needle below TP easier).

“Safe landing on TP” continues





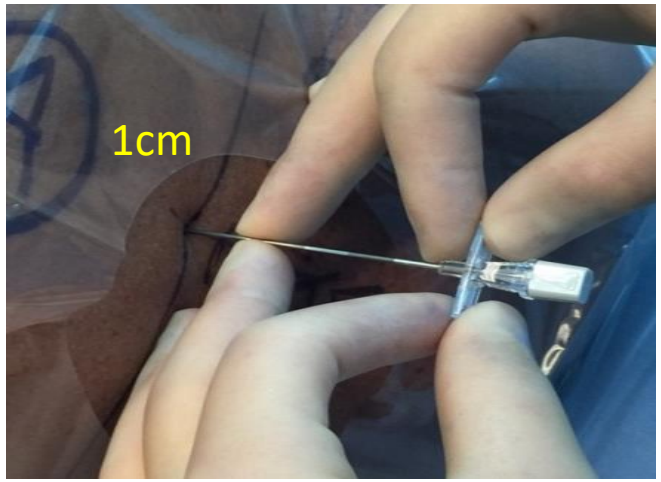
- **Needle must be stable** (no sliding in any direction) when it is landed on TP. Adjust if needed.
- **Note the depth of the needle at skin after landing on TP and make a mental note of the maximal allowable depth** (depends on Delta but usually 15 mm deeper than its depth while it is on TP).
- Note that needle depth to TP may be slightly different than measured by US, however this does not affect other US determined distances as Delta or IA.
- When the needle is stable on TP, hold the needle wings with the thumbs and index fingers of both hands, and use both middle fingers to grasp the needle usually **1 cm away from the skin (typical depth of initial advancement)** .
- You will maintain this grasp on the needle during the next step, initial advancement (see next slide).

“Initial advancement” (IA)

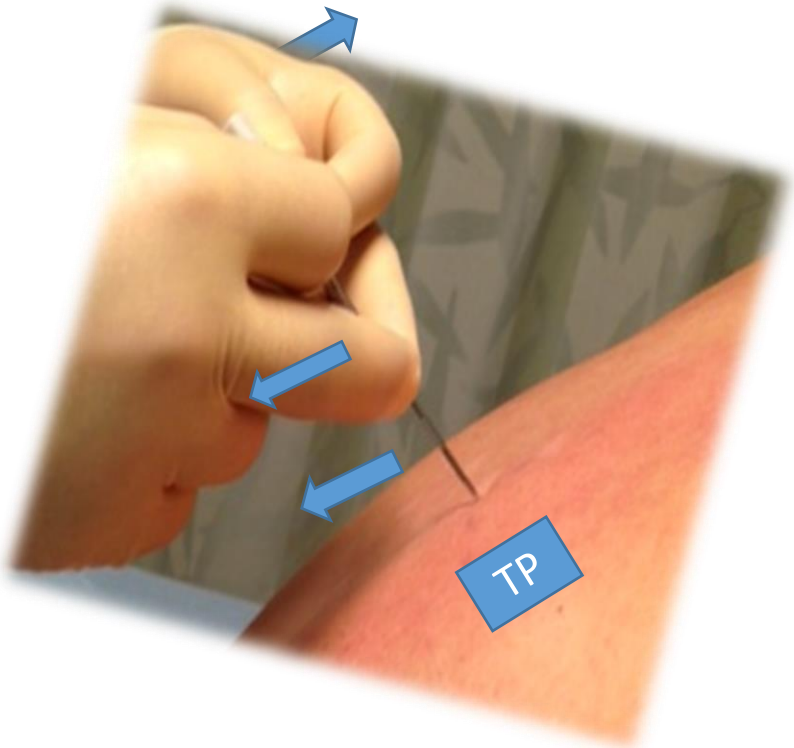
- Initial advancement- follows “safe landing” on TP
- During IA, the needle is walked down (caudad) off TP and advanced to a predetermined distance. The advancement is usually done as one smooth movement using both hands without checking for LOR during advancement but with attention to tactile feedback (does needle feel engaged in SCTL, is there a pop sensation?)
- Trajectory of IA is strongly recommended to be **close to perpendicular** to the skin surface. Consider shifting the soft tissue down with the needle instead of changing the needle angle to maintain perpendicularity if needed.
- Recommended distance of **initial advancement for most patients is about 1 cm past TP** (unless patient is very small). 1 cm is the minimum effective depth past TP that should usually get us into TPVS, can be short of TPVS, but rarely deep enough to cause lung injury (provided we safely landed on TP not rib or CV junction and patient is not too small).
- If the patient is small, IA should be scaled down accordingly to 2/3 of delta.
- If the patient is big and TP is quite deep instead of walking down (it is impossible to do when TP is deep without bending the needle or causing too much of discomfort) pull the needle back and angulate it 15-30 degree compare to Safe landing pass.

Few caveats on IA (common errors)

1. Do not be sloppy on setting 1 cm distance from the skin. Be accurate (e.g. make sure it is 1.0 and not 1.3 cm)
2. Be mindful that the needle trajectory is as perpendicular to the skin as possible. Consider dragging the skin and soft tissue down ("soft tissue down shift") if it seems that angle is getting more unfavorable.
3. Pay attention to tactile feedback when advancing the needle (SCTL engagement and "pop" as the needle passes through SCTL).
4. Stop needle advancement when the middle fingers touch the skin. Take care not to allow the needle slide along the middle fingers. Also resist the temptation to compress the soft tissues after your middle finger "stoppers" have touched the skin. Otherwise, the needle tip may be advanced excessively.
5. Consider adjusting your point of view and using "eye grip"- when your eyes are focused on the set depth to reinforce the safety.



Needle manipulation: "Soft tissue down shift and prying maneuver " vs pull back to skin and "seesaw" during initial advancement



If the needle lands too cephalad on TP, you can not easily walk caudad off TP without using a steep needle angulation and the final trajectory will not be optimal for using predetermined depth as an accurate endpoint to enter the TPVS (angle not perpendicular to skin). If this is the case, instead of lifting the hub to angle the needle caudad (we term this the "seesaw maneuver"), we recommend exerting downward pressure on both needle hub and shaft in order to shift the soft tissue and the needle tip down below TP (no needle angulation). The moment the needle tip is under the lower edge of TP, you can use a prying maneuver by pushing only the hub of the needle down and advancing the needle tip under TP to maintain the needle perpendicular to the TP surface. Do not overuse this maneuver because it can be uncomfortable for the patient. It is always better to choose a good entry point (at the interior aspect of TP tip) then to work around a less optimal entry point.

“Finger stoppers” and “finger dance” versus “eye grip” for control of the needle depth advancement

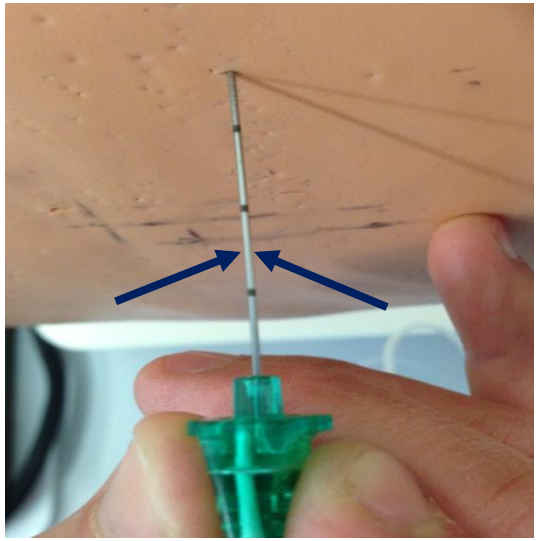
We highly recommend the following Tuohy needle hold (left). The long fingers are placed along the needle shaft at the planned depth of advancement and serve as “stoppers”- the moment finger tips touch the skin we halt the advancement of the needle.

Alternatively, one can use a marking bid on a needle (requiring a special needle) or a so called “eye grip” for good control of the depth advancement.

“Eye grip” is a technique when one focuses on a particular spot on the needle (grip it with his/her eyes) and advance the needle slowly until that spot is flushes with the skin.

We prefer using “eye grip” for a search needle (see picture on the right) and for SA. We use “finger stoppers” for the large Tuohy needle during IA. One can combine both techniques.

Note that fingers may obstruct the view of needle marking. When the needle lands on TP we usually take long fingers off the shaft to reassess and then place them back (“finger dance” see later). Good light and point of view is important as well as discerning marking on the needle shaft.



“Eye grip” on the required depth. Here we are probing for the TP and expect to land on it at the depth that is slightly less than we marked with our “eye grip”. We stop advancement when that spot on the needle is flushes with the skin and redirect the needle if we do not feel TP.

“Badness at the needle hub and LOR”

- We do not expect this, but check for the following at the needle hub after we remove the stylet or syringe :
  - Blood
  - Pleural fluid
  - Air movement
  - CSF
- If we see any of the above – the needle is removed and we start over.
- Remember, we may miss those “red flags” on observation (nothing is 100%), and that is why we double check for some of the inadvertent needle placements (intravascular or inside the dural sleeve) with test dose injection later.
- After this step, we **check for resistance to saline injection** (for simplicity we call it LOR even though technically to have LOR one needs to start with resistance and then appreciate the change, and here we do a “snap shot” check).
- If resistance is high we proceed to SA. If it is low or equivocal, we do “US check”.

Review questions

- What is the Delta and how does it affects standard IA and SA?
- Where do we note on the needle shaft the maximal allowable depth and where do we note/mark with the fingers the depth of IA?
- What is safe landing distance, and what do you do if you do not feel bone with the needle tip after advancing needle to that distance?
- When do you walk off the TP mm by mm and when do you pull the needle back and redirect it below TP?
- Name a few important things you are focused on during IA.
- What is the “soft tissue down shift and prying” maneuver? When do you need it?
- What is “badness at the needle hub” and when do we check for it?

“Secondary advancement”(SA)

- Secondary advancement is only needed if we believe that the initial advancement did not get the needle tip into TPVS - no LOR noted (**Use saline for LOR check**, air will affect US use later on).
- **Before starting SA, one more time, note the depth of the needle at the skin and recall the maximum depth left for SA (make a mental note what needle mark should be at the skin at that point).**
- **SA is done until LOR or until you have advanced the needle to the maximum preset depth (whatever comes first).** Most of the time, LOR occurs within a few mm after starting SA before reaching max SA. Occasionally there is no LOR
- **The maximum preset depth is based on the Delta** and most of the time is 5 mm past the depth of IA (provided IA was 1 cm).
- **Stop even If there is no LOR but you used up all allowed distance! if you feel no LOR but used up all preset depth, introduce the US and check for location of turbulence during injection of the saline.**
- We recommend to do SA using both hands for better needle control, with full attention to the depth and tactile feedback. SA should be performed in 3 small increments: 2mm, 2mm, 1 mm.
- After each incremental advancement of the needle, check for resistance to injection. Halt SA when you feel LOR at any moment. Always double check for badness after achieving LOR (aspirate for air or blood).

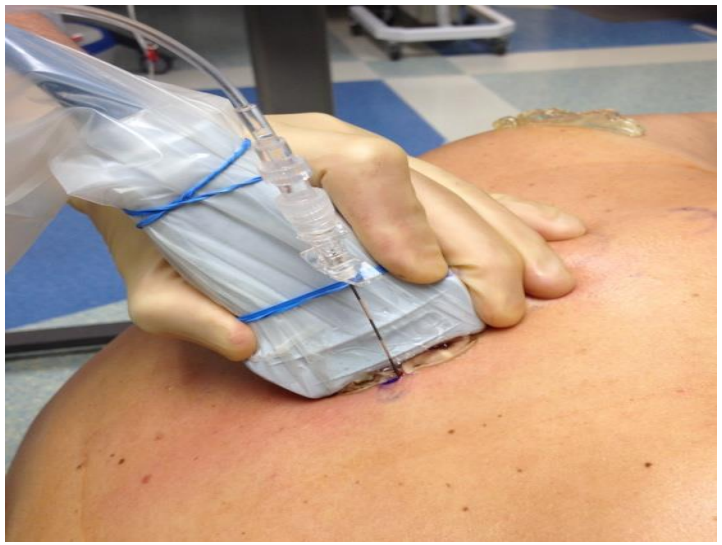
Troubleshooting during suboptimal Secondary Advancement

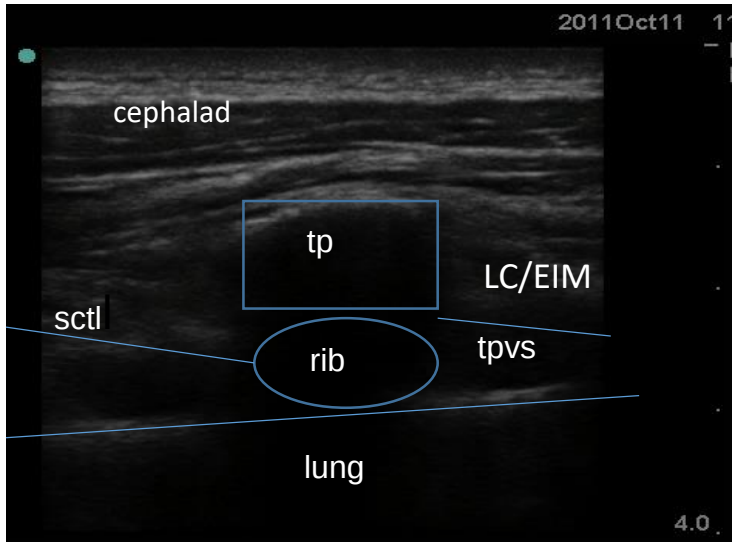
- **What if there is no LOR after initial advancement, and during secondary advancement at the depth where you would expect to feel LOR you feel bone instead (when you look at the needle, it is not close to being perpendicular to the skin surface)? What bone did you just hit?**

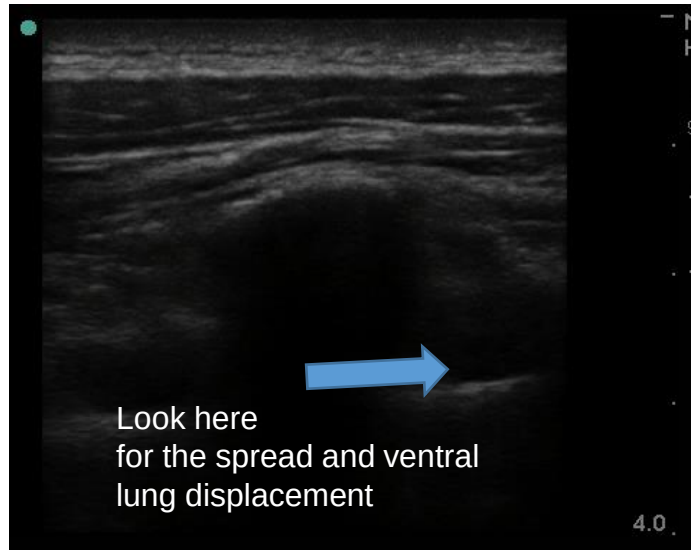
  - You are likely touching the rib below or TP below if angle is even steeper than on the top right picture. Pull the needle back and redirect slightly cephalad from your previous trajectory striving for almost a right angle to the surface
  - Occasionally in order to find the bone free window you will need
    - 1. Start with a new entry caudad to the previous one and
    - 2. Instead of excessively angling the needle caudad after the safe landing, shift the tissue down while maintaining the same needle to surface angle (close to perpendicular)
  - Another reason for hitting the bone could be too medial entry point. Bottom image on the right (so verify the entry point again)

Note that bone free window is much smaller medially so there is higher chance to hit the rib below

“US check” is verification of correct needle placement in TPVS with hydrolocation- watching the area of interest on US while injecting saline



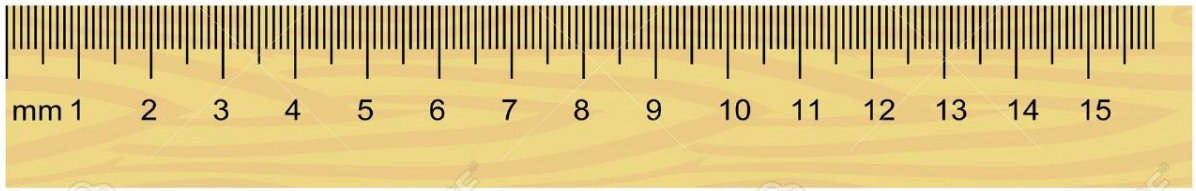




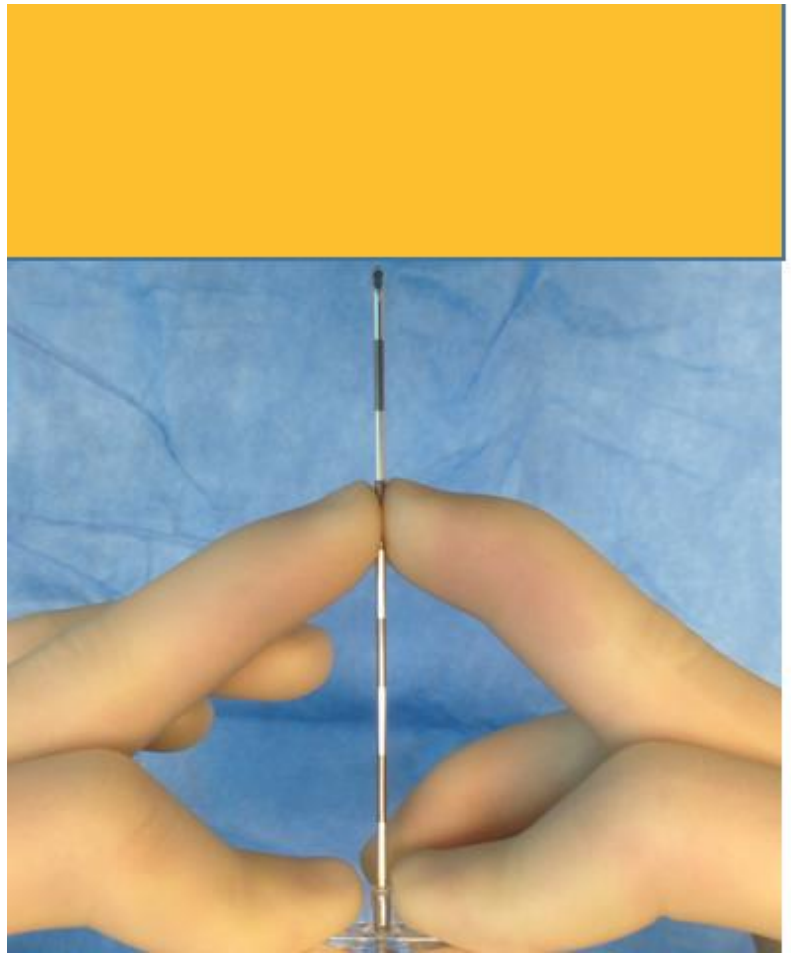
Place transducer medially to the needle and try to visualize TPVS in the area where needle tip would be while injecting few ml of saline.
If you see ventral displacement of the parietal pleura with injection of fluid, this is a very clear and reassuring sign of correct needle placement in TPVS.
If during injection you clearly see tissue expansion above SCTL and not below, this confirms that needle could be advanced a bit more.
The US check could be done routinely (recommended) after achieving LOR (after initial or secondary advancement) or when one used up the maximal allowable distance during secondary advancement and never appreciated LOR. US scan for pneumothorax should be done before and after procedure as well.

The important safety point for this procedure

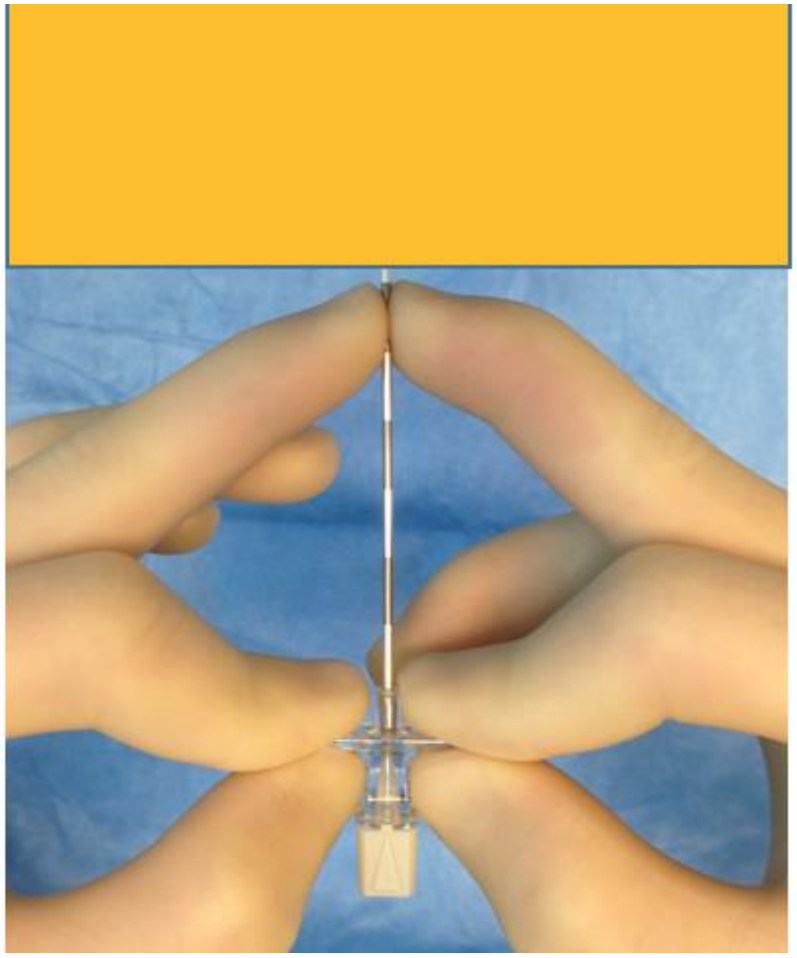
- **Set the depth limits** after you finish your US measurements and obsessively **keep track of the needle depth** during the entire procedure (while trying to land on TP and while advancing the needle past it).
- This is true for both the **search and block needle** (one can injure the lung with either needle).
- US distance to TP could be about 5 mm less than needle depth to TP, but US derived Delta is clinically consistent - so stick to it!
- One more time your depth limits are: **SLD, IA and SA dimensions.**
- If after starting the procedure you are not sure how deep the needle already is and how much further you can advance before reaching your limits, pull the needle out or place it back to TP, note the depth and restart.



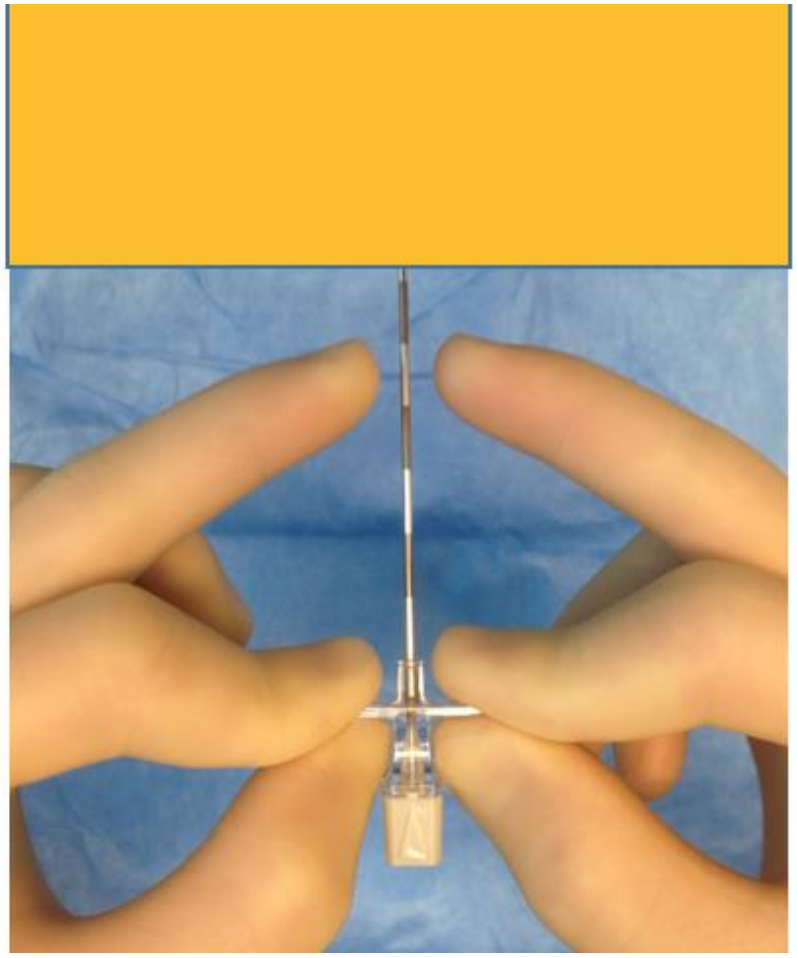
Depth limits, ”eye grip” and a “dance of long fingers as a stoppers”. Step by step (example)



Set needle tip on the marked entry point with correct angulation. Position fingers stoppers at 3 cm (SLD) based on US measured TP depth about 2.5 cm

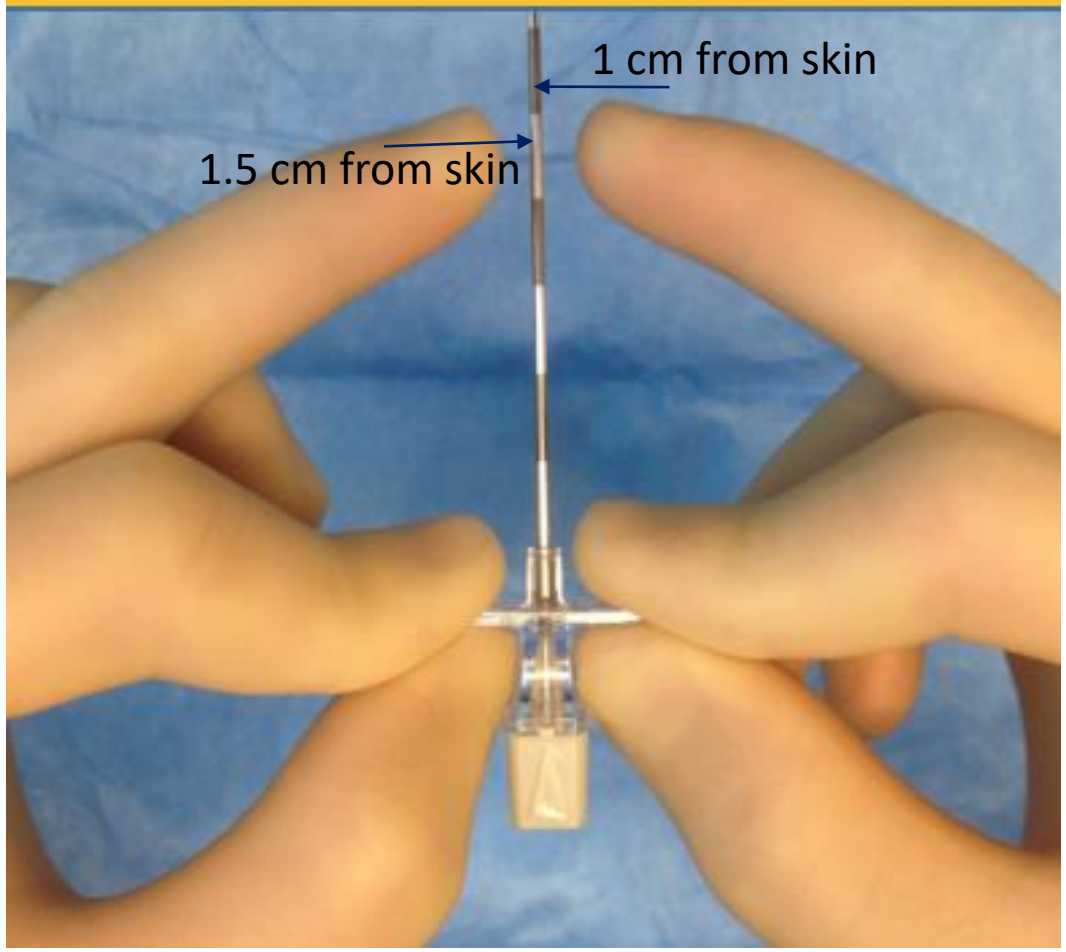


Advance needle and land on TP. It turned out that the depth to TP is slightly less than 3 cm. (our fingers did not touch the skin)

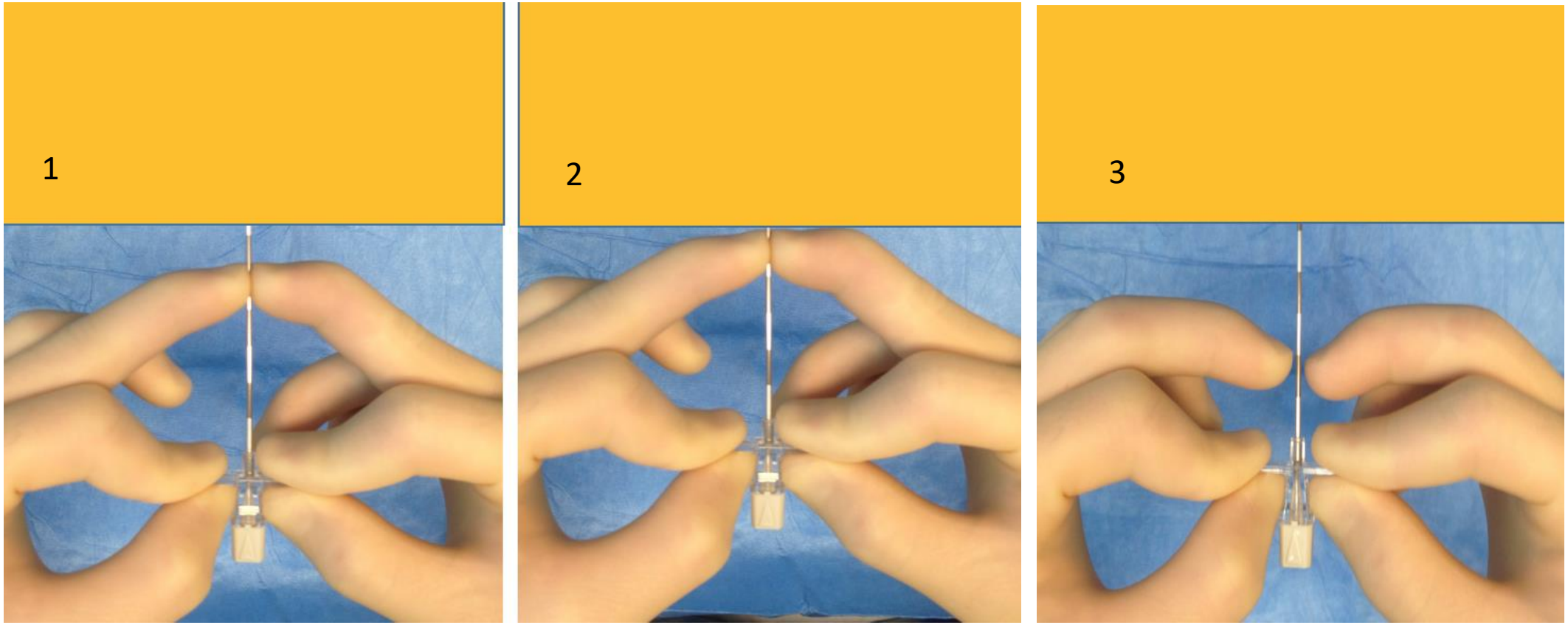


While needle tip is resting on TP, remove the finger stoppers from the needle shaft for better assessment of depth limits (see next image for close up) you are about to set

Remove fingers from the shaft for a better view and then put them back- “finger dance”



While the needle is stable on TP and fingers stoppers are off the needle shaft we change our point of view to have a close look at the depth marks of the needle.
Now make a note of the depth limits for initial advancement and secondary advancement on the needle shaft **from the skin.**
Note 4 dark and 5 white cm stripes on the Tuohy needle.
Proximal border of the dark stripes correspond to even numbers: 2-4-6-8 cm from the needle tip (first dark stripe that correspond to 2 cm mark here is inside the body so we only see 3 stripes).
Now memorize where the maximal allowable depth is: here it is just slightly less than 4.5 cm (1.5 cm from skin). You are not allowed to advance the needle deeper than that without US confirmation.
Note where 1 cm from the skin is on the needle, you will put your finger stoppers on that point before starting initial advancement (next)



1 -Place long fingers one cm from skin (long fingers will work as stoppers to prevent you from advancing needle beyond 1 cm)
2 -Do initial advancement (Note the feel of engagement in SCTL and possible “give”. Stop when long fingers touch the skin)
3 -Take fingers stoppers off the needle to confirm with your eyes where the maximal allowable depth mark is in relation to the skin (should be about 5 mm away). Take the stylet out and check for badness and resistance to injected saline with LOR syringe.

If no LOR after IA, start SA with “eye grip” on maximal allowable distance while checking for LOR every increment of advancement: 2, 2, 1 mm, stop. Usually LOR occurs after first 2 mm.
Stop advancement and introduce US for hydrolocation if there is no LOR after maximum allowable distance mark is flush with the skin

Review questions

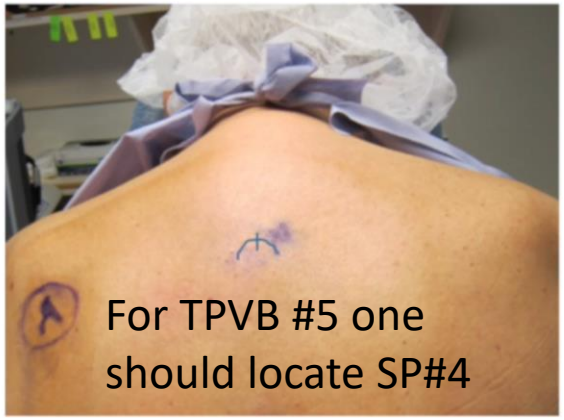
- Why is normal saline better than air for LOR check after IA?
- What does resistance to saline injection after IA mean?
- What do you note on the needle again before starting SA?
- When do you stop SA?
- How can you hit bone during SA? What bones could it be?
- What if you reach maximal allowable depth and there is no LOR?
- How may US help to confirm correct or incorrect needle placement?
- Name 3 depth limits that you commit to during the procedure?

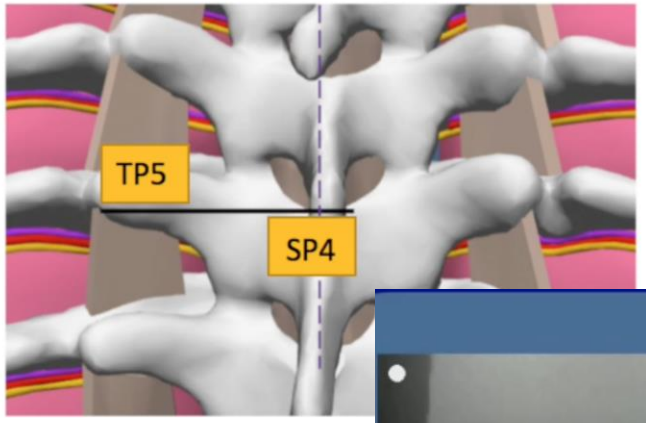
After covering some fundamentals of the technique, let’s focus on a few more details

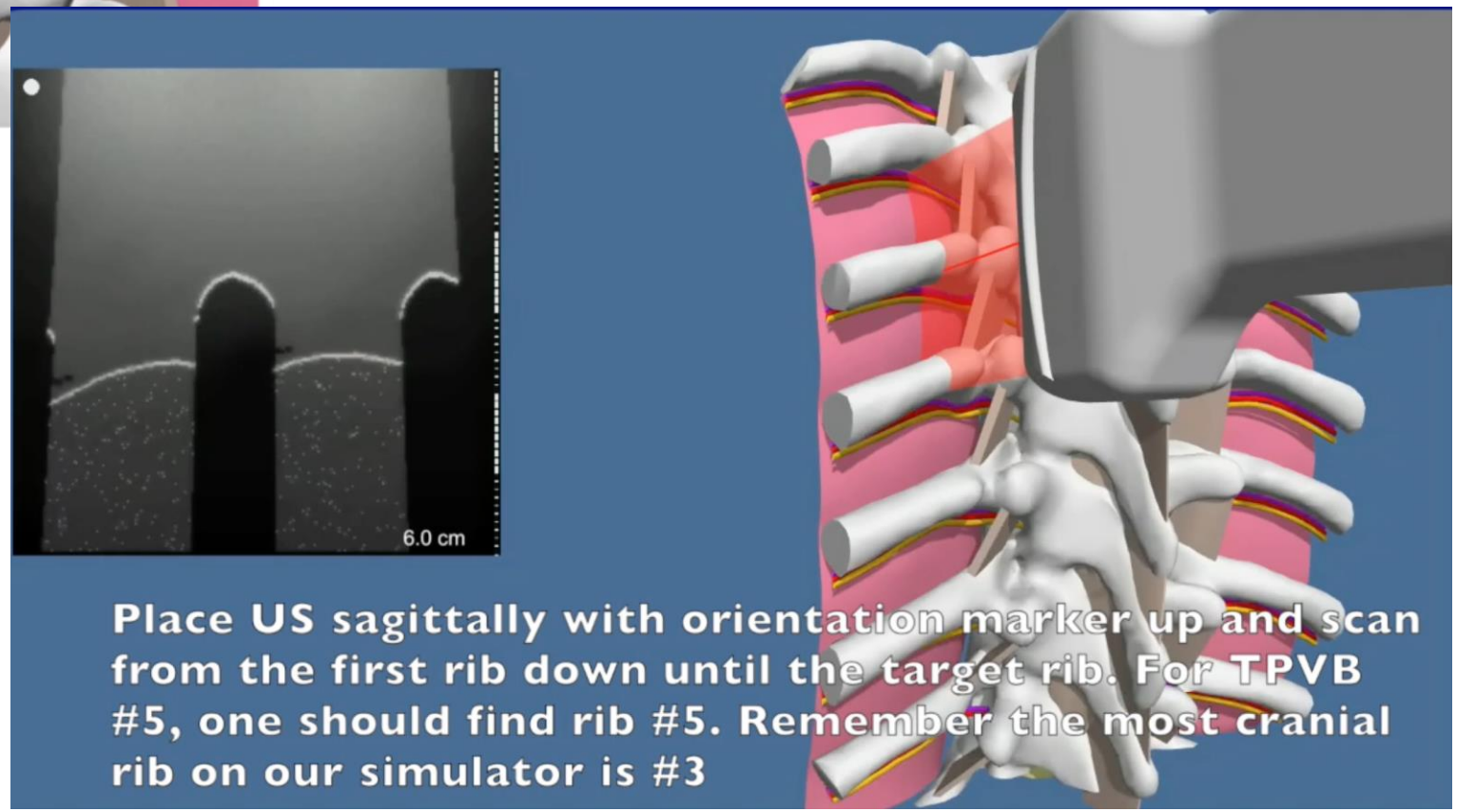
- How to determine the correct level of the block
- Tips on numbing tissue and use of a search needle
- How to mark the TP projection on the skin
- How to practically determine important distances
- How to land on TP safely and efficiently with a needle
- Possible problems during locating TP

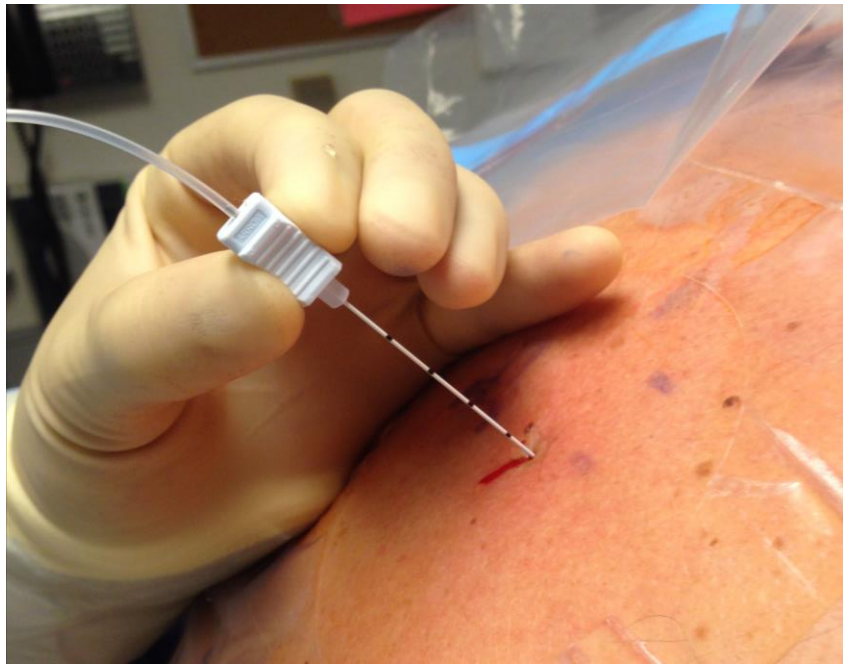
Few words on correct side and level of the block marking.

To avoid wrong side surgery and/or wrong side block, **always mark the side of the surgery or trauma.** To mark the correct level one can palpate and count SP (one above the required block level) or use US to count ribs (mark same rib level as a block level)







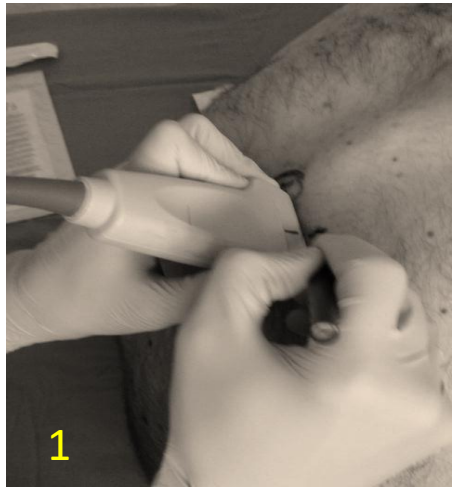


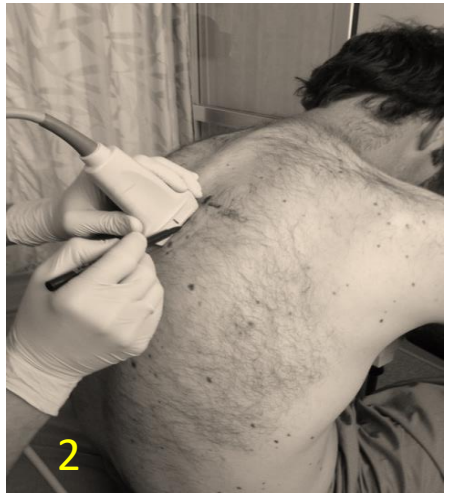
Tips on numbing tissues and probing with a search needle before using a 17 G Tuohy for a block

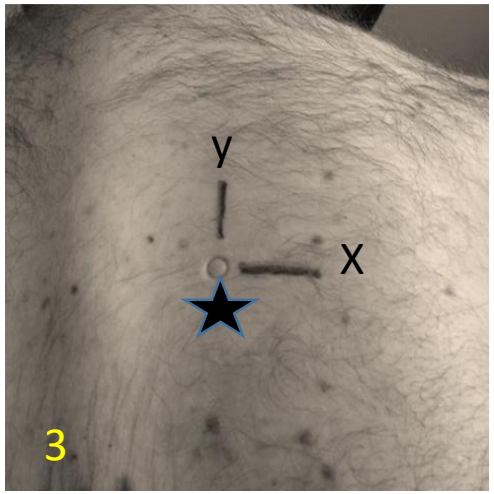
After numbing the skin entry point with small 25-27 G needle we recommend to switch to a 5 cm 22 G block needle with clear depth marks . We use this needle as a search needle to confirm/adjust all information on location and depth of TP that we obtained with ultrasound. While doing all that we also numb soft tissues below the skin, TP, and 1 cm below TP as well.
When we trying to land the needle on TP we make sure we do not advance the needle past SLD (depth marks are very handy here). After landing on TP we also make sure we can easily advance the needle below TP to a depth 1 cm deeper than TP depth and inject a few ml of LA after negative aspiration.

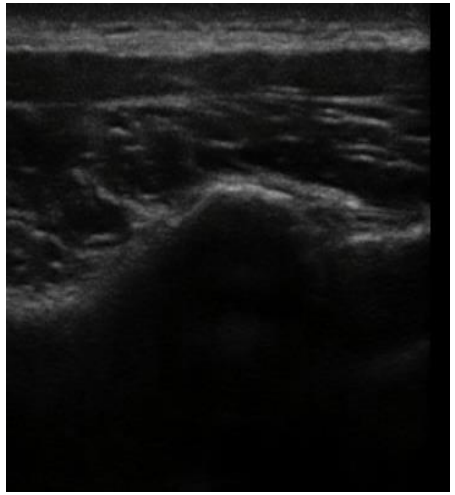
Some may use 22-25 G needle that are included in the block kits, but unfortunately those needles have no depth marks, relatively short (the longest is only 38 mm), too bendable for navigation between bones, and also too sharp to provide additional feedback on penetration of ligaments and fascial planes.

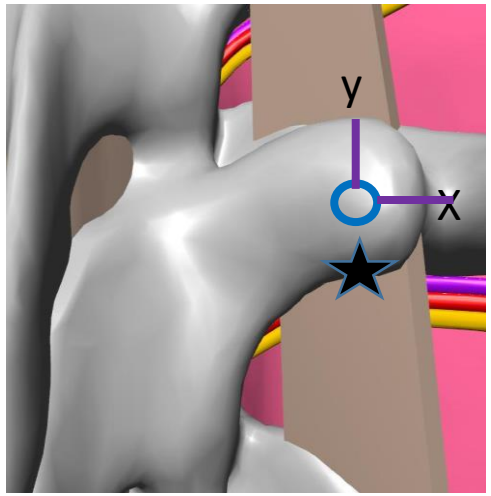
US marking of the tip of TP in 3 steps.
Needle entry 5 mm below it (star)









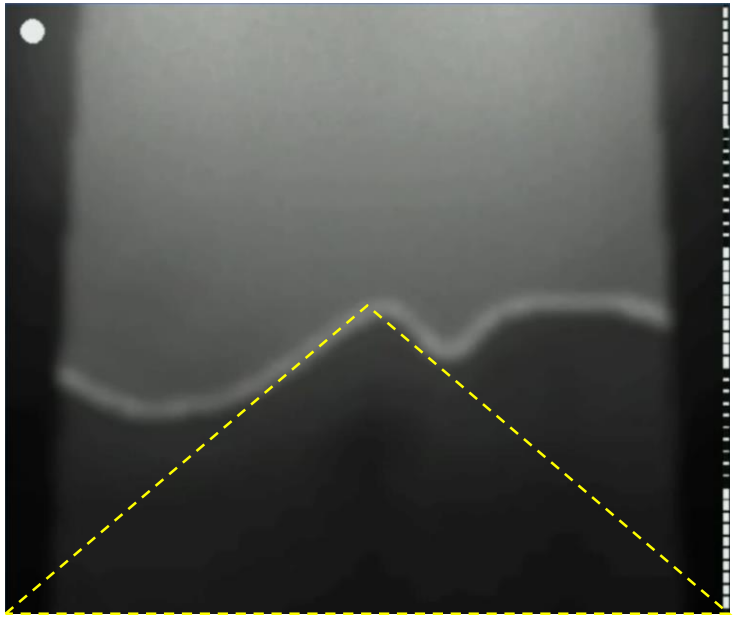


1. Probe in **axial plane**, **Tip of TP image** in the middle of the US screen. Mark Y line at the middle of the probe.

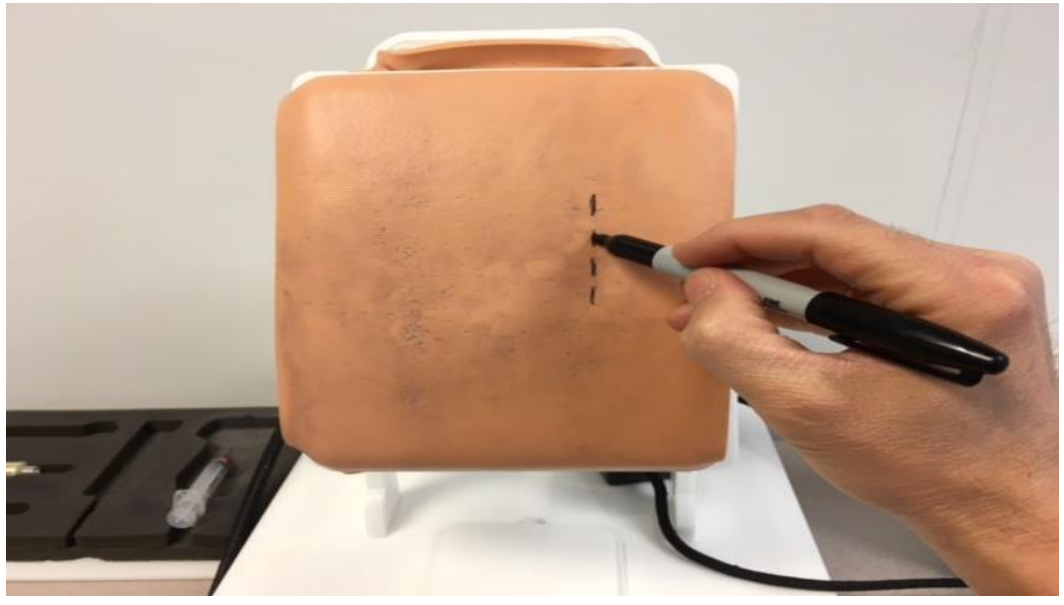
2. Probe in **sagittal plane**, on the Y line**, tip of TP** is in the middle of the screen. Mark X line at the middle of the probe.

3. Connect the X and Y lines (TP tip projection). Mark the needle entry 5 mm below the cross mark.

US marking of the tip of TP in 3 steps: marking on the simulator (step1)



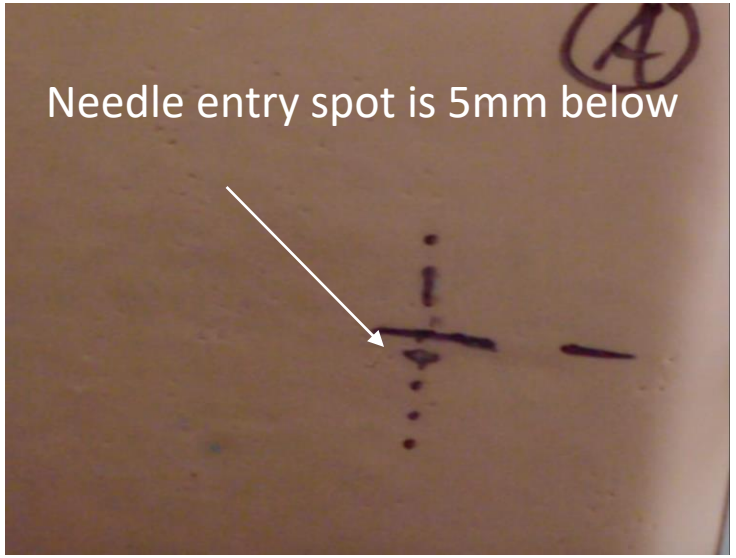
Step 1: Mark the projection of TP tip in axial plane. Draw a vertical line through the mark (line should be longer than length of the US probe, this will help position correctly for a sagittal scan).
If there is no midline marking on the US screen (We use M mode). If there is no M mode capability, imagine a triangle with corners at the sides of the image and tip at the TP (dashed yellow line). Move the probe left and right until the imaginary triangle has sides of equal length.



US marking of the tip of TP in 3 steps: marking on the simulator (Step 2 and 3)

Step 2: Place transducer with sagittal orientation over the line that you drew during the previous step. Slide it up or down until the middle of TP is centered on the screen. Use equal sided triangle trick (from the previous slide). Mark skin at the center of the probe. Make sure you move your head further to the side so that you have a better point of view of the middle of the transducer to avoid a parallax error during marking.

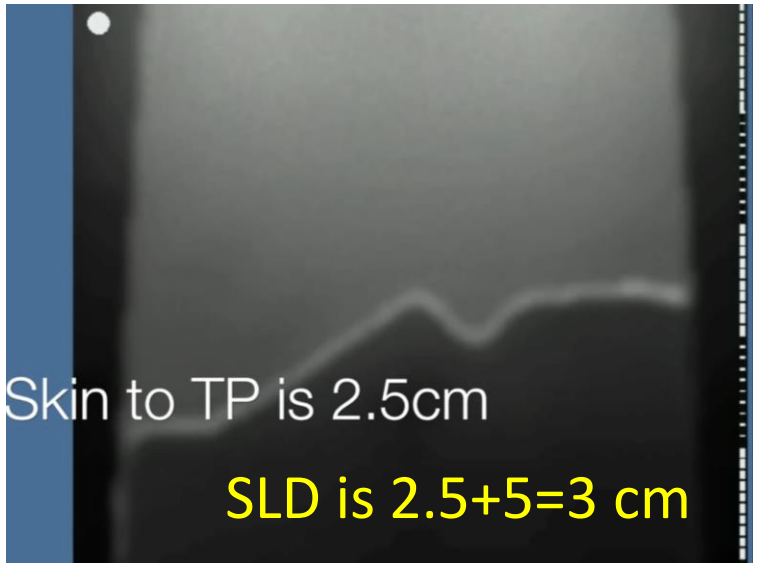
Step3: extend the lines from Steps 1 & 2 and note the point where they intercept. Needle entry is 5 mm lower than the cross mark. (TP is about 1cm tall so 5 mm below its tip will be about at the caudad edge of TP).

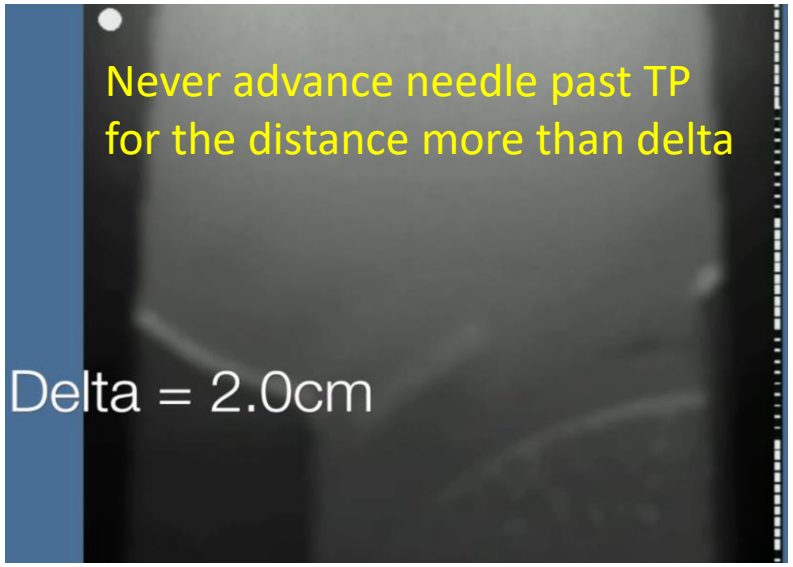


Measurements of distances (skin to TP, skin to lung, and calculating delta)

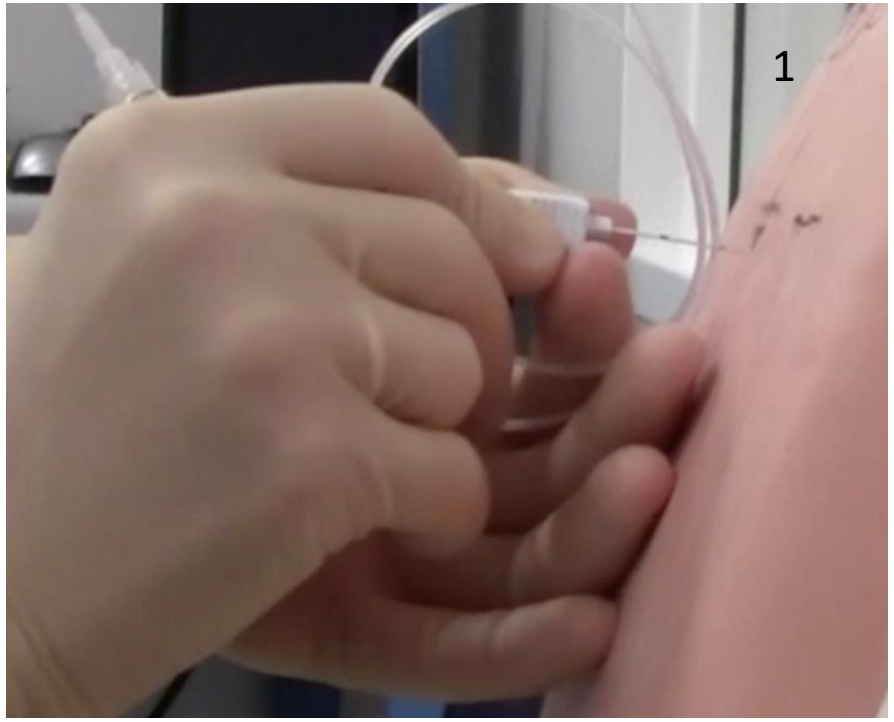
Place the US probe so the middle is against the vertical mark and its upper edge is at the level of horizontal mark and look at the screen after tilting probe slightly up. You should see Modified standard axial view of TP with TP in the middle (if it is not in the middle-adjust and remark). Make sure you do not rock the probe medially and do not apply too much pressure. Note the depth from skin to TP. Add 5 mm to get SLD.

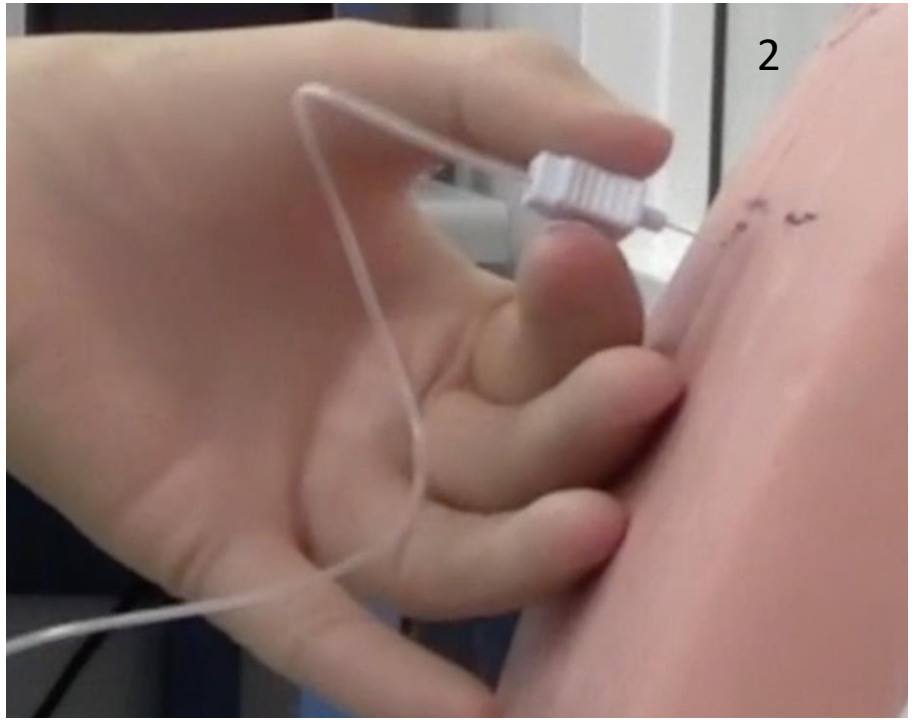
Now “untilt” the probe so it is perpendicular to the skin. You should see standard axial TPVS view. Note the depth to the lung at the middle of the image. Now you can calculate delta. If Delta is more than 15 mm than IA is 10 mm and SA is 5 mm.





Numbing tissues and probing for TP with a search needle (confirming SLD) before using a 17 G Tuohy for a block on the simulator

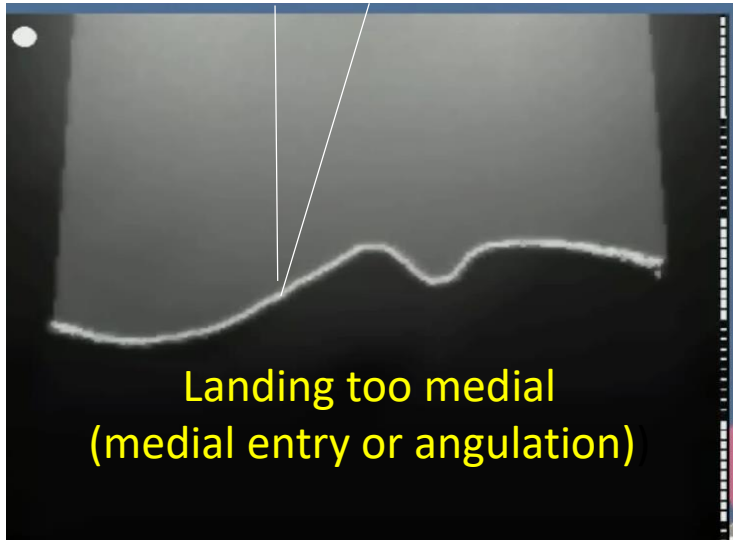


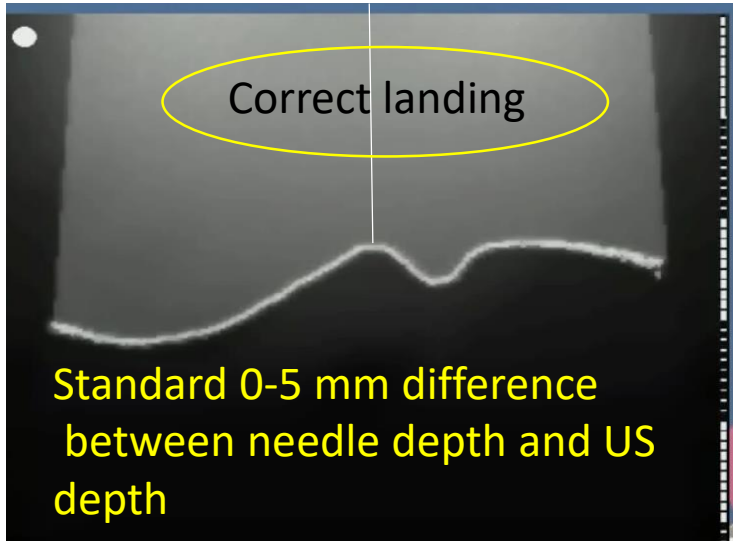


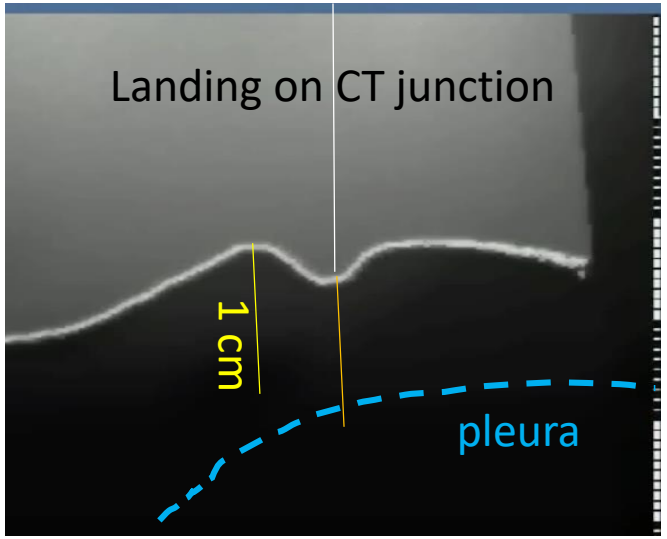
1. Safe landing on TP at the expected depth and location
2. Advancing needle below TP to a depth that is 1 cm deeper than TP and injecting few ml of LA

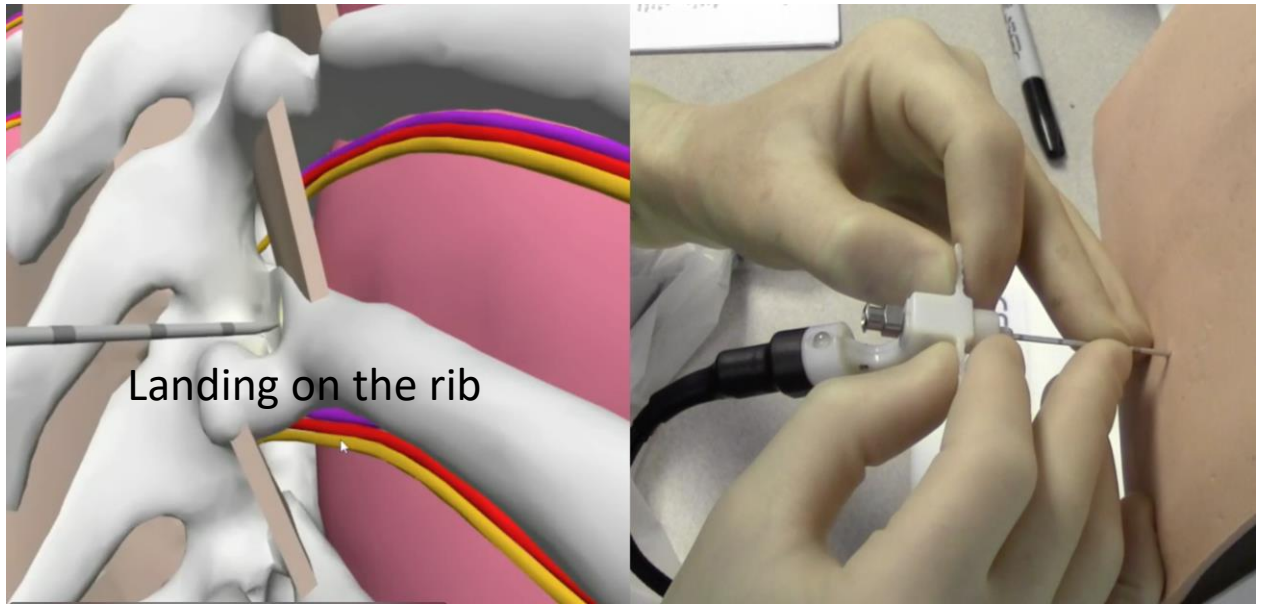
If needle depth to touch the bone and US depth to TP are too different, then investigate (may be you erroneously landed on the rib instead of TP or on the medial part of TP or on CT junction)
see next slide…

Few examples when search needle depth is more than expected based on USLD due to incorrect landing



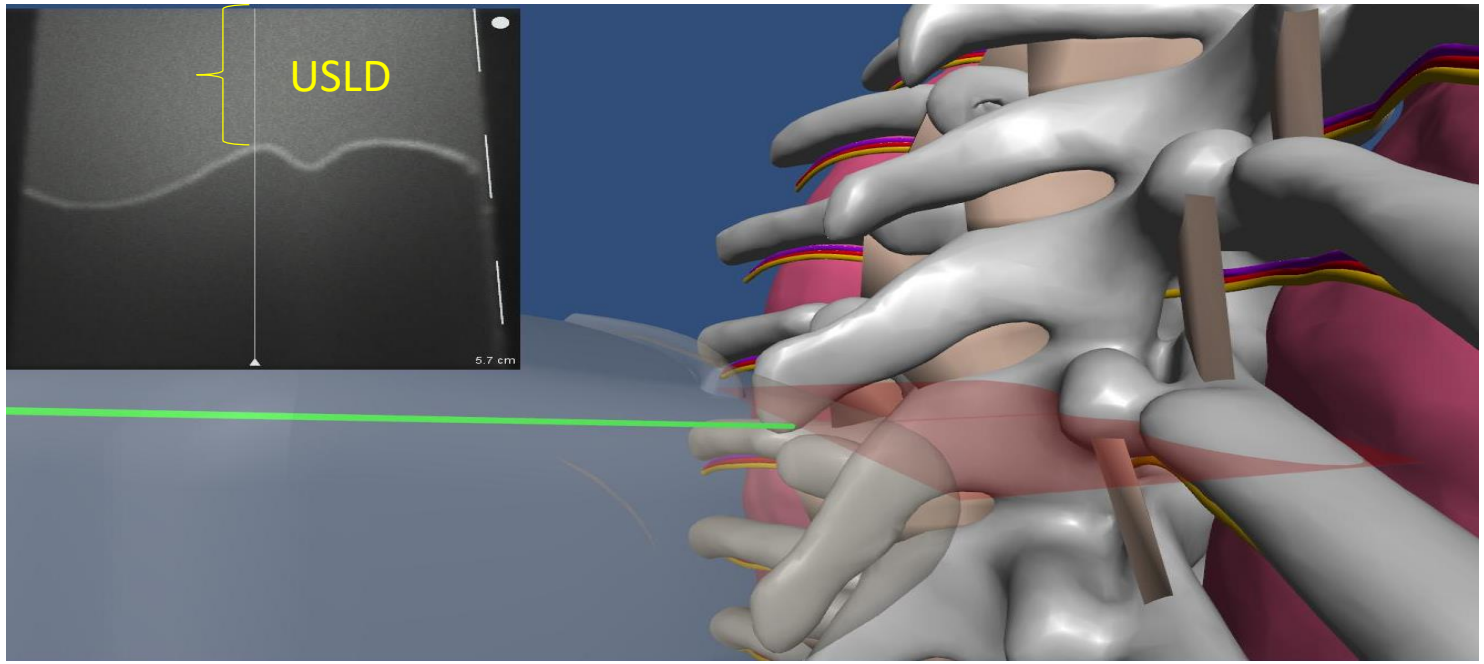






This one is most dangerous if not recognized. Routine advancement 1 cm deeper may result in the lung injury

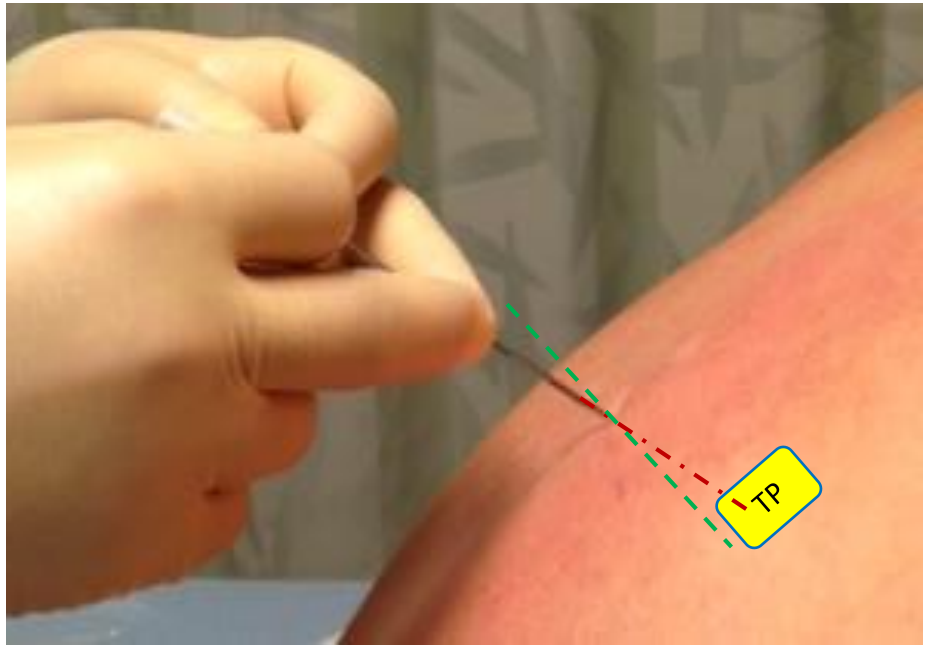
Safe landing on TP (details one more time)



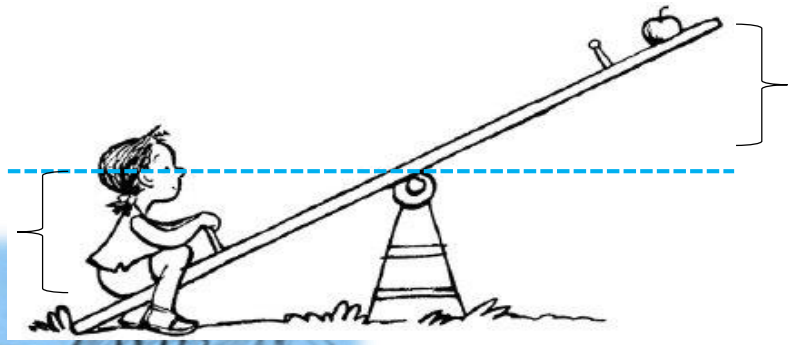
Here, the ultrasound depth from skin to TP is about 2.5 cm (depth markers are on the right of the virtual US screen). We add 5 mm to this depth for a SLD. Place both middle fingers at 3cm (SLD) and use them as stoppers during your attempts at a safe landing on TP. Enter the skin a few mm below the caudad edge of TP and slightly angulate up, then advance. If entry point and angulation are correct, one should land on TP few mm before fingers would touch the skin. Occasionally one may not land on TP on the first pass due to small errors in the trajectory (see next)

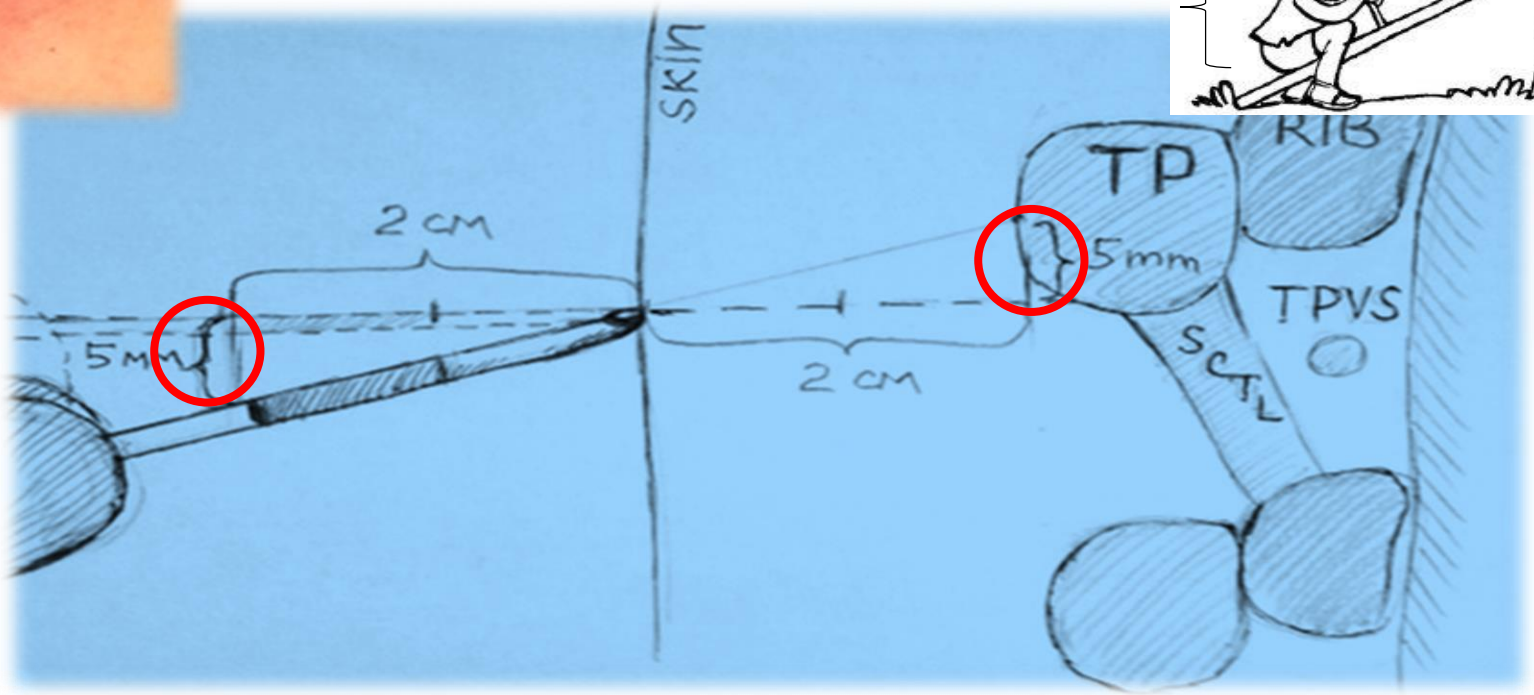
SLD illustration (continues)

- If after the first pass, your middle fingers are touching the skin and you did not feel bony contact, STOP!
- Remember if you do not advance needle beyond SLD you will not injure the lung.
- Consider that the needle went caudad to TP (note the green dashed line on the right).
- Pull the needle half way back and correct the trajectory (try hub up slightly more cephalad) until you land the needle on TP.
- Use our “seesaw principle” to help to set a correct angle upon skin entry (see next slide), and try to undershoot rather than overshoot the angle on the first pass so you have a consistent plan for correction (go more cranial on the following pass).



“Seesaw principle ” facilitate setting correct needle angle

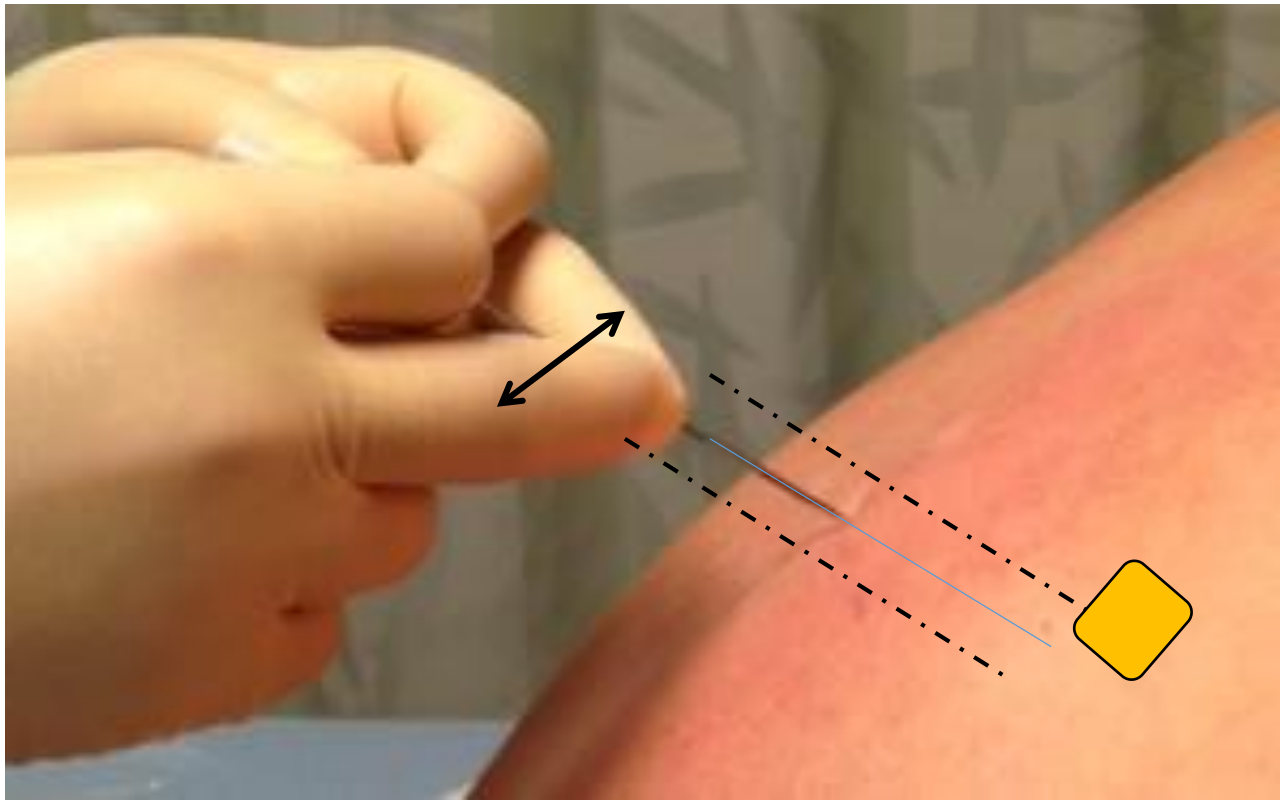




Start with the needle just touching the skin at an angle **close to perpendicular to all planes** at the level of the caudad edge of the TP with both middle fingers as stoppers at the expected TP depth.

In the illustration above, the TP is about 2 cm deep from the skin. Our finger stoppers hold the needle almost at the same distance from the skin as the distance from the skin to the TP. If you lower the needle 5mm down with your finger stoppers, the needle tip will go 5mm up, just like a seesaw.

Alternatives to the “seesaw trick” and “fanning” when trying to locate TP



Shift the tissue up or down in small increments (~ 5mm) by dragging the soft tissue/skin and repeat advancement using the same needle angle.

Instead of using the seesaw trick, you can shift the soft tissue up or down without changing the angulation of the needle to skin.

This works better with a sturdy needle and in a patient with loose soft tissues, especially in a patient with lax skin.

Alternatively, one can also change the needle entry point without changing the angle of advancement.

Review questions

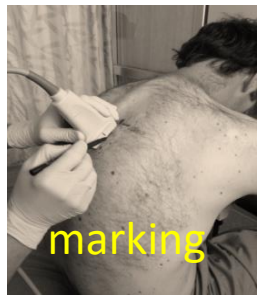
- What are the options to determine the correct level and how do they differ?
- What needles do we recommend for numbing and confirmation of depth we get from US exam?
- Why do we use both axial and sagittal scans to mark TP tip, which one is used first?
- What is the rule of equal sided triangle?
- What should be in the middle of the US screen during TP marking?
- What is important for accurate depth measurements?
- How do you put the transducer on the skin for measurements and how do you adjust its angulation?
- How do you calculate SLD? Delta?
- Why it is dangerous to erroneously mark the tip of TP more lateral than it is?
- Why is there a difference between US depth and needle depth?
- Name the situations when one would touch bone at a depth higher than expected based on US measurements despite the usual adjustment?
- Explain the seesaw principle?

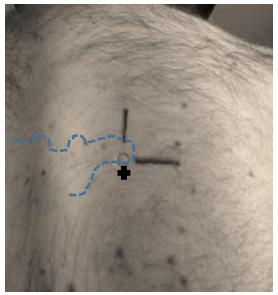
US-assisted TPVB: Putting it all together

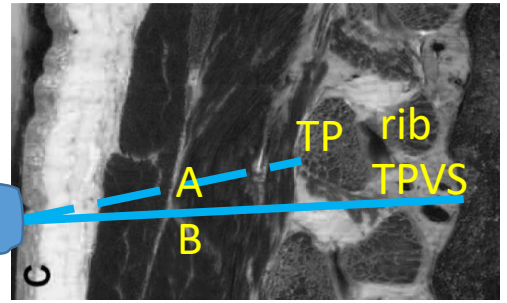
- Now that we have covered the basic sonoanatomy (first lecture) and fundamentals of the US-assisted approach (marking the optimal skin entry point, measuring important depths and distances, and setting the correct needle trajectory and basic needling tricks), we will move on to the actual procedure.
- We will reinforce the ideas presented in this curriculum a few more times to help you remember the steps and important points of the technique.

US-assisted TPVB steps with pictures,

1. Marking side (L vs R), **determining and marking the level** of the block/blocks.
2.Use **US for marking** skin projection of the TP tip (first axial than sagittal scan).
3.**Measure and calculate** important distances: "SLD"(depth to TP on US + 5 mm), "delta"(difference between US pleura depth and US TP depth)
4. Use **search needle** to numb skin, confirm TP position and its depth.

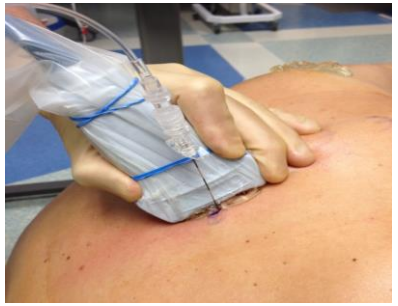






5. **"Safe landing" on TP with a block needle**. After **safe landing on TP**, note the needle depth and set the maximum allowable depth based on Delta. If delta is standard, **we pre-set a 1 cm distance** from the skin for IA.
6. Advance needle **1 cm past TP underneath it with needle being almost perpendicular to the skin surface in all planes . This is "Initial advancement ".**

7.Check for blood, CSF, air movements at the needle hub after removing the stylet . **Check for resistance** to injection of saline with LOR syringe. Positive LOR means that needle is in TPVS!!! **Confirm with US.**
8. **If LOR is negative, advance the needle 2 mm at a time while checking for LOR in between until LOR but no more than 5 mm past IA.** This is **Secondary advancement**. **Confirm with US** .



Now watch the video that is available to see the entire procedure from start to finish again

Reinforcing steps one more time (memorization and visualization are recommended)

- Mark the side and level of the block
- Mark skin projection of TP tip, mark needle entry point 5 mm below it
- Measure skin to TP and skin to lung distance from skin entry point. Calculate SLD and Delta, set IA and SA in your mind
- Numb the skin entry point and start probing with a search needle while also numbing tissues
- Landing on TP with the block needle
- Initial advancement past TP with the block needle
- Stylet out, check for badness and LOR with saline, If LOR positive, skip the next step
- If no LOR start secondary advancement
- Confirm with US during saline injection (push hydrolocation on the simulator)
- When happy with US confirmation continue with test dose, catheter placement etc (push the button “needle in place” on the simulator)

Reinforcing steps with details (memorization and visualization are recommended)

- **Mark the side and the level of the block**
- To determine the level of the block use US rib count (mark the same rib as required level of TPVB) or palpate and count spinous processes starting from C7–mark SP of vertebra above of the required TPVB level(for TPVB5 , mark SP4)
- **Mark skin projection of TP tip and needle entry point 5 mm below it**
- Make sure your point of view is correct
- Start from viewing TP in axial plane (do not tilt or rock the probe) Make sure that TP tip in the middle of the image, adjust and then mark the skin at the middle of the probe. (especially avoid accidently marking the skin more lateral then true point)Take the probe off the skin and extend the mark 4 cm up and 4 cm down.
- Mark TP tip again while US probe is sagittal on the line you just made. Avoid, tilting and rocking the probe. Make sure the most superficial part of TP is in the middle of the screen, mark the middle of the probe
- Extend the horizontal line to cross a vertical one- this is a TP tip skin projection. Mark the future needle entry 5 mm below the cross mark.
- **Measure skin to TP and skin to lung distance from skin entry point**.
- Put the transducer axially on the future entry spot: midline of transducer at the vertical skin line, and upper edge of transducer on the same level as horizontal line-look at the screen(the correct expected image will confirm correct marking one more time, if needed adjust marking) If needed, tilt the transducer slightly up to visualize tip of TP and note skin to TP distance) and then “untilt it” to view TPVS below TP (Skin to lung distance). Remember the angle of the probe tilt (future needle angle should be close to it) **Calculate SLD and Delta, set IA and SA in your mind**.
- **Numb the skin entry point and start probing with a search needle.** Change your point of view. “Eye grip” on the SLD, mild cranial angle- try to land on TP. While locating TP with search needle do not advance past SLD. if no TP on the first pass, adjust trajectory as needed (usually angle more cranially). Note the needle depth when it is on the bone –it should be as expected (If not reassess). After landing on bone inject LA then try to walk off down 1 cm deeper and inject LA, then return search needle tip back on TP(you may leave needle in until it replaced by block needle)

Reinforcing steps one more time (memorization and visualization are recommended)

- **Landing on TP with the block needle**
- Grasp a needle with recommended grip and set your finger stoppers at SLD (based on the search needle depth) Pop the skin and establish required angle based on search needle, then pull the search needle out
- After contacting TP with block needle and adjusting it to make it stable if needed, take off your finger stoppers from the needle shaft and note the depth of the needle at the skin, make a mental note on the maximum depth and then put your finger stoppers back on the needle shaft at 1 cm from the skin.
- **Initial advancement past TP**
- If patient is not obese just start walking off down TP until needle tip slides below it. If needed use tissue shift and pry trick to keep the final needle angle correct Needle must be close to perpendicular to surface (or minimal 15-30 degree angle) at the end of the IA.
- Feel for engagement and SCTL penetration during needle advancement below TP. Stop advancing when fingers touch the skin
- If patient is big instead of walking needle off the TP, pull needle back and angulate 15-30 degree down to the SLD pass

- **Stylet out check for badness and LOR with saline**, If LOR positive, skip the next step
- **If no LOR start SA.** Check the needle depth at the skin again and recall what was the set maximal one (how much more can you go?)
- Start incremental advancement 2/2/1 mm (or whatever delta dictates) checking for LOR every step. Stop when get LOR or reach max SA whatever comes first. Confirm with US after loss or after reaching max SA.
- **Confirm with US during saline injection (push hydrolocation on the simulator)**
- Place US probe about 1 cm medially from the needle and slightly tilt it laterally, look at the screen and adjust the probe (slide up/down, tilt less or more)
- **When happy with US confirmation push the button “needle in place” on the simulator**

Review questions

- Repeat by heart main steps of the block.
- Go over the detail description of the steps and make sure that you understand the meaning of detailed description.