Central Venous Lines, from www.icufaqs.org

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Hi all – another one! As usual, please remember that these articles are not a final reference of any kind. They are supposed to represent information given by a preceptor to a new orientee, and reflect my own understanding, which is, well…I'm getting old, you know? Please let me know what's wrong, or missing, and I'll fix it right away. Thanks!

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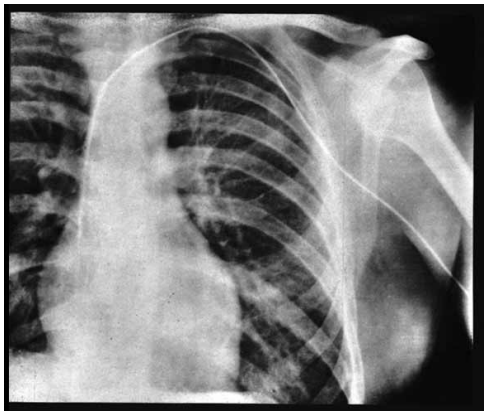
1: What is a central line?

By the time they get to the MICU, most people have a pretty good idea of what central lines are - basically great big IV lines that go into great big veins. We use central lines for all sorts of things, in all sorts of places, so it makes sense to go over the basics of what, where and why.

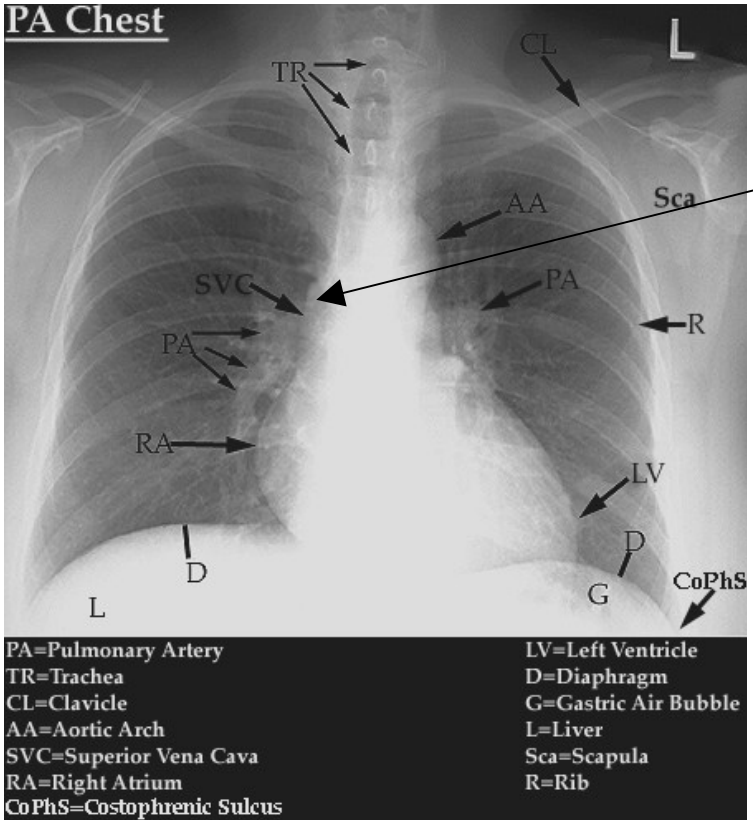


This is apparently the first central line ever, in a film from 1929. Dr. Werner Forsmann, over in Eberswald, Germany, had the sudden inspiration one day, I guess, that the thing to do was to thread a urological catheter up into his arm as far as he could, and then to run down to the x-ray room, where he had to fight his way past a couple of concerned colleagues to shoot a picture of himself…

See it there – the white line? Where's the end of the line – the tip?

So Werner – is the line in good position?

1-1: How do I know if my line is in the right position?



Here's how you tell. The tip is supposed to be in the SVC – if it's as far as the RA, then it's in too far.

Right about here…

No big mystery… but what if the blood in the line is really bright? Hmm…

A good rule of thumb for any central line that you put into a patient, whether in the neck, the chest, or even in a femoral site – **always, always transduce it before you use it**. We've seen a couple of femoral **arterial** lines lately that were placed in hypoxic patients – so the blood return was dark, right? Wasn't venous….do you want to infuse pressors downstream from an arterial stick site towards a patient's leg? Didn't think so…

So: should we use Werner's line, or not?

www.vh.org

1-2: How do I know if my line is central or not? And what does "central" mean, anyway?

Central means that the line is in a large enough vein, in the central circulation, that it's safe to deliver drugs that might not be safe if given through smaller peripheral ones. Pressors are a good example – it's not that giving levophed through a hand vein will immediately injure the patient, or that it won't work – but what if the IV infiltrates?

http://www.malpracticeweb.com/uch_ka.jpg

This person apparently had an IV in the foot, was getting potassium in some form or other, and wound up with skin grafting for an infiltration…now imagine if it had been levophed! Ugly.

Femoral venous lines are considered central because they go into such large vessels - as long as the team is sure they're in the vein! (It's usually easy to observe the color of the blood aspirated from the new line - dark is a good clue, but not always! What if the patient isn't breathing?)

Neck and chest lines are a little trickier - the way I was taught, the tip of the line is supposed to be beyond the third rib to be central. Take another look at the x-rays above - in our unit, the rule is that the tip of the line should be in the superior vena cava, a little above the right atrium (not in the atrium itself). Every chest or neck line that's inserted in a non-coding patient must have its position verified by chest xray before it can be used. (Suppose the line turned upwards on insertion, towards the patients brain? This has actually been known to happen! Do you want to be remembered as the person who infused pressors upwards towards your patients' brain?)

Update – yup, I heard that this happened not too long ago, but got caught by x-ray. (Yow!)

2: What are the parts of a central line?

This depends of course on what kind of line you're using - we use four kinds, mainly: introducers, multilumen CVPs, PICC lines, and PA lines. I'll go over each kind as we go along. The main things you want to think about though, include: how many lumens am I going to have available for what I'm probably going to need to give? How big is this line? - meaning, is it large enough bore for me to infuse volume rapidly if I need to? Where do the ports come out on the line? Which ports am I going to transduce, what should they be seeing, and what if they're not seeing what they're supposed to?

3: What are central lines used for?

3-1: Pressors

The first central-line thing that comes to the mind of the ICU nurse is the use of pressors. Pressors are vasoactive drugs - that is, they cause blood vessels to do things. (They also cause the heart and lungs to do things, but those are covered in the “Pressors and Vasoactives” FAQ file, so go over and have a look at that one sometime.) The most common effect of pressors that we’re shooting for in the MICU is to cause arterial vasoconstriction: the vessels tighten up. Suppose you ran levophed through a small peripheral line and it infiltrated. That patient might wind up with a vasoconstrictive injury to the arm - maybe lose the arm, which is technically referred to as a “bad thing”. Unless the patient’s in a code situation, in which it might be “maybe lose the arm or certainly lose their life” - pressors must run through a central line.

Having said that, we do run dilute solutions of dopamine and phenylephrine peripherally when we have to, but only until central access becomes available. Make sure there’s a good blood return in any peripheral vein you use for this purpose, and use big ones – this is why the Great Nursing Supervisor gave us antecubs.

3-2: Special concentrations of meds

Some meds come up in highly concentrated versions that are meant only for running through a central line - the one I always think of first is potassium. We give 20 meqs of potassium per hour, maximum, whether peripheral or central, but the central mix of that dose would be 50cc, while the most concentrated peripheral mix would be 80 meq in a liter of IV fluid. So that dose of 20 meqs would be what - 250cc. Is your patient “fluid sensitive”? - i.e., in CHF, or renal failure, or both? I’ve seen peripheral antibiotic mixes come up from pharmacy that mix one dose in 500cc - if you can’t diurese your patient, what will you do when two hours of K^+, and one dose of antibiotic pushes him into failure? Lots of things to think about. Try to remember to see the forest through all those trees: keep in mind: “What is basically wrong with my patient?”, and “How is this central line going to help him?”

3-3: Volume, blood

Or you may have the opposite problem. Your patient is dry - maybe hypotensive - maybe she’s dehydrated, maybe dilated and shocky, maybe she’s lost a lot of blood somewhere. Now you want to do the other thing - you want to give large volumes of IV fluid, or blood, or FFP, or all three - rapidly! This is also an excellent situation for a central line.

3-4: TPN.

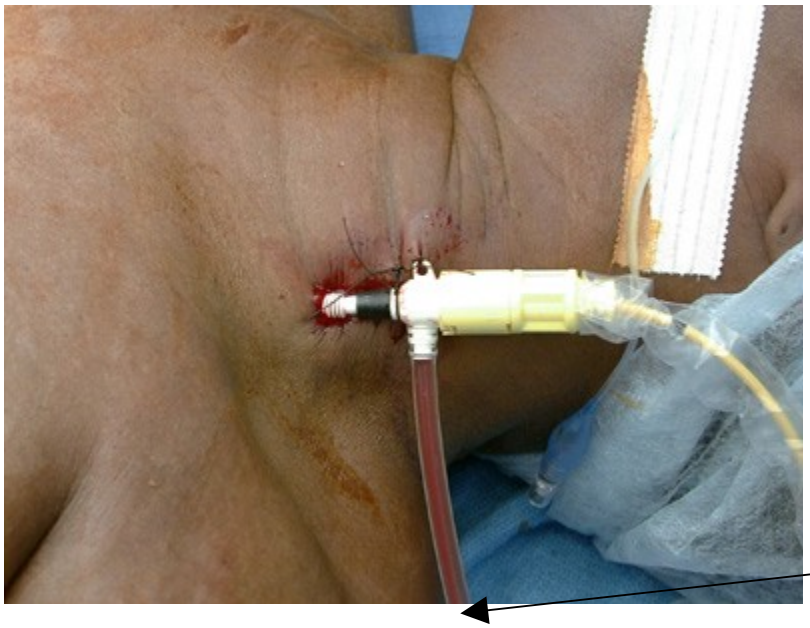
TPN requires central access. This stuff is so concentrated that peripheral veins just can’t take it for very long. Folks on long-term TPN usually wind up with some kind of long implanted line like a PICC.

4: What kinds of central lines will I see in the MICU?

4-1: Introducers:

These are the real large-bore lines - the ones that go into patients who need fluid resuscitation of one kind or another. Our introducers look like the letter “L” - one arm of the L goes into the patient, and the other arm comes off at a right angle. This second part is made of clear tubing, and you’ll see right away that it’s really big - this is the line that you’ll transfuse your patient through when they’re acutely GI bleeding. (Of course, that’s only one lumen - where are you going to give the other IV fluids, the octreotide, the levophed, the FFP and the platelets at the same time? Got to think of these things!)

Another word about introducers - these are also the lines that are inserted in preparation for PA line placement. At the place where the two arms of the L come together, there is a small white cylinder that sits in line with the part going into the patient. In the top of the cylinder is a small black membrane - this is where the PA line goes in.



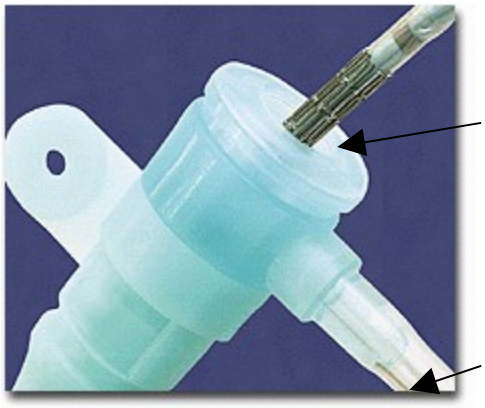
It takes a little practice to sort it all out…

The introducer is shaped like a capital "L" – one part goes into the patient, the other is the "sidearm".

A PA line has been threaded into the introducer, through the membrane, and click-locked into place – it has a clear sheath around it…

Here's the sidearm.

Oy! Put a tegaderm over that site, you dopes!
www.med.umich.edu/.../anesthesia_glossary-70.jpg



Here's the angled part, blown up.

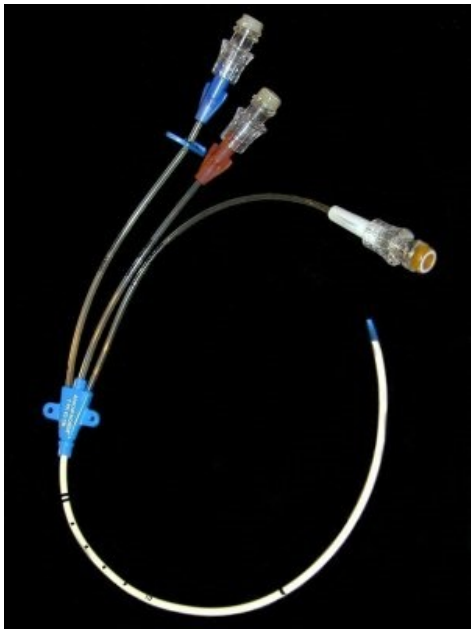
The membrane is in here – in the picture, a line is being threaded through it…

This bit is the "sidearm", the large bore line that you can infuse through…

http://www.cardiva.biz/products/p044-7.gif

This is important: the cylinder membrane will not seal up after the PA line comes out. Which means that what bad thing could happen once the PA were removed? Who said "air embolus"? Very good. Either cover this membrane after it's been pierced with a tegaderm, or plug it up with an obturator - a little plastic device that slides into the line, and which screws down on the cylinder to seal it up.

4-2: Multilumen CVPs:

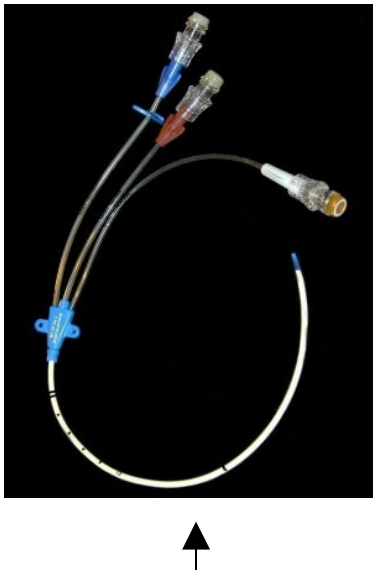


These are the most common central lines that you'll see here in the MICU. Everybody knows that "lumen" means "tube", right? For some reason we stock both 3- and 4-lumen catheters, but it would be a real mistake to pass up the chance for 4 when the team has grabbed a 3-port kit. There really is no difference in the insertion technique, and if your patient has no other access - make sure you get all the lines you can!

http://www.cc.nih.gov/vads/lines.html

A couple of things about multilumen CVPs:

The ports are described as proximal, medial and distal - these are the reverse of proximal and distal as regards the patient. In other words, the ports are proximal or distal in relation to the site where the line goes into the patient. So the lumen that opens up at the very tip-end of the catheter - that's the distal port, because it opens the farthest away from the insertion point. The medial port is the next one backwards, and the proximal port is the one closest to the skin. Make sure that the team has checked: you should never infuse anything through a port that doesn't have a blood return.



The brown port opens up distally, at the tip.

The blue port is the medial one, opening up somewhere along here…

And the white port opens up proximally - here somewhere…

If you do use the central line for TPN - which you should! - then that lumen is tied up for good. If the patient becomes critical enough, then you can take the TPN down and use the port for something else, but you can't use the port for TPN again - the patient will need a new line. Policy.

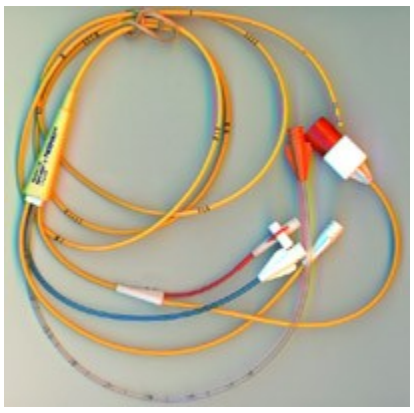
We usually hook up the distal port to the transducer for reading CVP's, because the medial and proximal ports can snuggle up to the vessel wall and give weird waveforms. We also use the distal port for giving blood products, simply because it's big: the distal port is a 16-gauge lumen, while the other two are 18's. So plan a little - always save a port - maybe one of the medial ones - on a newly placed central line for TPN (even if the patient isn't on it yet. They may be soon…)

If your patient has an introducer and you're strapped for access, you can ask the team to insert a multilumen catheter through the membrane, as if it were a PA line. This situation might come up if, for example, your postop patient went right through 3 liters of normal saline and 4 units of red cells and was still hypotensive. You still want to give blood products - where will you hang the neo that the team wants you to give?

However – think about this for a second… suppose you insert a standard triple-lumen line into an introducer. If you picture this in your head, you'll see that the proximal and medial ports open up inside the length of the introducer…hmm. That could mean that fluid infused into those ports might decide to flow backwards up into the introducer, or downwards, which is the way you'd prefer…

So – they've come up with a nice fix. There's a special version of the triple lumen catheter meant for exactly this situation: all the ports open up at the tippy end of the line. Make sure you use one of these in this situation.

4-3: PA lines:

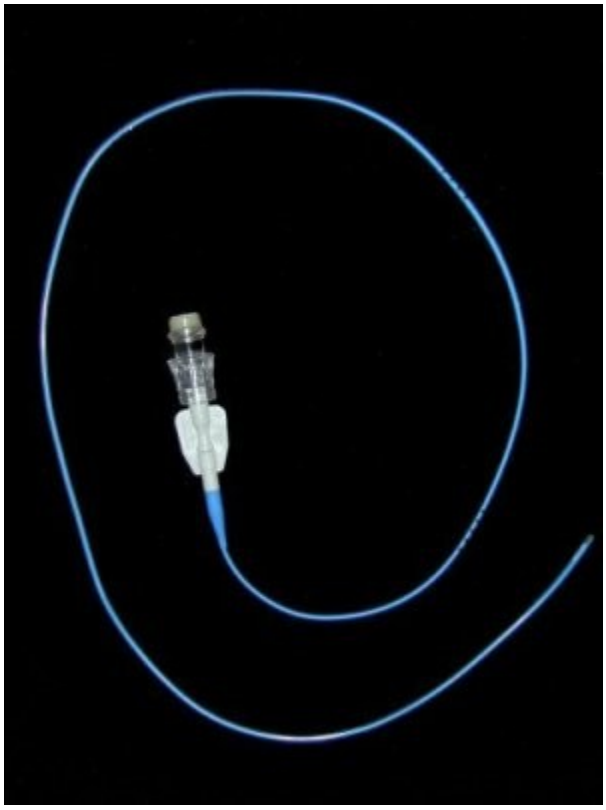


These are the "big guns" of the central line world, and they have a whole FAQ to themselves. Briefly, these lines are inserted through an introducer, and advanced through both chambers of the right side of the heart, and on into one of the pulmonary arteries. Commonly what we'll do is rig compatible vasoactive drips together, running through the introducer. This leaves a port free on the PA line - there's usually a free white port for infusions.

All of these central lines are supposed to come out within roughly a week of insertion.

4-4: PICC lines:

PICC stands for Percutaneously Inserted Central Catheter - these are very long, very thin lines that are usually inserted at the bedside by the IV team. Their distal end is also supposed to end up in the SVC, and must be confirmed by x-ray before it can be used. PICCs come in single and double-lumen varieties - try to make sure that no one goes to the trouble of placing one of these in your patient that only leaves you with a single line! Sometimes PICCs are placed by the interventional radiology team if the veins aren't accessible any other way. PICCs can stay in for a long time - months, anyhow. Anybody know, exactly?



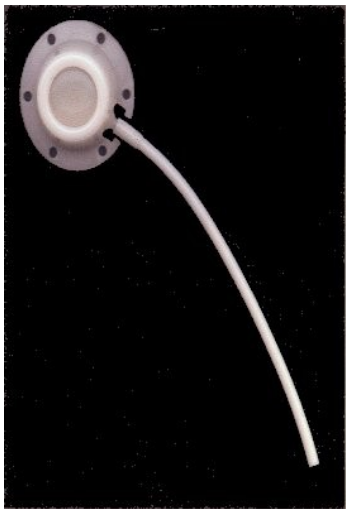
Hmm – only one line?

I guess they still make single-lumen PICC lines, which seem like a fairly dumb invention to me, since the standard is dual… I mean, why go to all that trouble if you're only going to wind up with one access point?

http://www.cc.nih.gov/vads/lines.html

4-5: HICKMAN® Catheters, Tesio catheters, portacaths, Quintons

These are some of the rarer lines that you'll see - HICKMAN® catheters are surgically implanted lines that are designed for situations like home TPN, while Tesio catheters are put in for dialysis access.



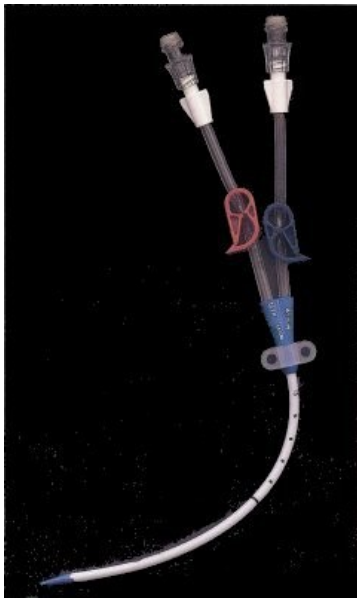
Here's what a portacath looks like… they get accessed using a gadget called a "huber needle", which goes through the skin, and into the reservoir hub of the line.

The huber needle has a luer-lock connection…

http://www.avidmedical.com/oem/Graphics/HUBER5.jpg

We usually wind up calling a nurse from one of the onc floors to place for us, since they get certified to access these lines, and we don't. Some portacaths come in double-lumen flavor (that's my kind!), and the needles have to be precisely placed, as they access the separate infusion lines. Get a pro to help you out with this.

http://www.cc.nih.gov/vads/lines.html



Quinton catheters (I'm not sure if this is a Quinton exactly, but it's the same idea) are short lines with two ports - the line is shaped like a Y, with the single end in either a femoral or a sublcavian vein. Both access ports come out into the same vessel - sometimes people get confused and think that these are actually two separate lines. These are used mostly for short-term dialysis, like CVVH.

It's important to remember that dialysis access catheters are instilled with something to keep them from clotting after the run is done – sometimes it's a citrate solution, sometimes it's very concentrated heparin - if you need to use these lines for emergency access you can, but **don't forget to aspirate the ports first!** (And be prepared for the renal docs to be pretty upset with you…)

http://www.cc.nih.gov/vads/lines.html

4-6: Arterial and venous cath lab sheaths.

Patients will come back from cardiac cath/angioplasty/stent /IABP procedures with these lines in place. They're usually single-lumen lines, and you can certainly use them as you need to: femoral venous sheaths are considered central, and femoral arterial sheaths should be transduced, and can be used as a-lines. Intra-aortic balloon pumps are very central lines - but you probably shouldn't even begin to think about them until you go to balloon school…

5: Where do central lines go?

There are really only a couple of places these lines go in: neck, chest, and groin.

The neck sites are usually either the right or left internal jugular vein, as here…

http://www.visualsunlimited.com/browse/vu100/vu1000.html
The chest sites are the subclavians, and the last are the fems. You may see a patient come back from the cath lab with a PA line inserted femorally - in my experience these tend not to stay in place very well. Once in a really blue moon you'll see a PA line threaded brachially.

Something to remember when the team is choosing an insertion site: how much PEEP is your patient on? High levels of "forward pressure" from a vent, whether it's in the form of pressure support, pressure control, PEEP, or combinations of them can hyperinflate the lungs, and the apices will, I'm told, rise up higher in the chest. These are not the patients to give a subclavian line if it can be avoided - the risk of "dropping the lung" - causing a pneumothorax, which then might require a chest tube, becomes lots higher!

6: Who puts in central lines?

http://cache.corbis.com/agent/12/71/23/12712317.jpg

It depends on what kind of line it is. Introducers and multilumens are inserted by interns with a junior resident present, or by juniors on their own, or seniors likewise. PA lines are put in by the pulmonary/critical-care fellows, or by residents under their direct supervision. PICC lines - IV team, or interventional radiology. HICKMAN® and Tesio catheters are put in by surgeons, and Quintons are put in by the renal team: renal fellows or attendings.

7: How should I get my patient ready for central line placement?

There are a number of things to think about. First: how critical is the situation? Is the patient acutely hypotensive? - this person needs a femoral line, because you don't want to have to stand around until the x-ray is shot, processed, and read before you start pressors - the difference in time may make all the difference between "taking a hypotensive kidney hit" or not!

Next: is the patient oriented? Not oriented? Agitated? Will she be able to lie still, maybe with her face covered by drapes, while the line goes in? Does she need sedation? Restraint? Neither? Both? Careful, clear communication with the team, and thinking a little ahead will save you from seeing your patient abruptly sit up, fling sterile equipment everywhere, and make the resident accidentally spear you with a finder needle.

Next: labs. Is the patient anticoagulated? On heparin? Is the heparin still running? Should it be turned off? Reversed? Should the patient get FFP? Platelets?

Last: make sure that you've passed the team the right line. Try to make sure that if they're doing a multilumen placement, that they're putting in a line with four lumens instead of three - it makes no difference in the procedure, and it may make the difference between your patient getting TPN or not. Not trivial!

8: How is the insertion done?

All these line insertions are done using the Seldinger technique. The basic idea here involves a couple of steps, but the same technique is used for putting in all kinds of vascular catheters:

First: a small-gauge needle and syringe are used to find the vessel that you want to use. This is done by locating the anatomical landmarks that indicate where the site ought to be, and then carefully inserting the needle while holding back pressure in the syringe. Clearly, if bright red, pulsatile blood appears in the syringe, the needle may not be where you want it to be. Pressure may have to be applied for a while, and you're going to want to observe the patient's neck/chest/fem to make sure a hematoma isn't developing. (Did she get all her FFPs?)

Once the finder needle is in the right vessel (blood nice and dark?), a second, larger needle is inserted next to the first one, also into the vein – this one is large enough that a short sterile wire can be passed through it into the vessel. The first needle comes out.

If this is a neck or subclavian insertion, you have a specific position to take while the wire is being threaded into the vein, which is at the foot of the bed, watching the cardiac monitor. If the wire is threaded into the RV and tickles the endocardium, lots of nice ventricular arrhythmias can result – usually you'll see single or double PVCs, you may see short runs of VT, or you may see a pretty long one! Your job is to be watching for these, and to clearly call out what you see – remember that the team is looking at the insertion site, not at the monitor. At the first sign of significant ectopy, suggest that the team pull the wire back a bit, which will usually fix the problem. It's nice to know that the patient's electrolytes were optimized before this happens…

Holding the wire – if they let go of the wire, all kinds of interesting unpleasant things can happen - the team takes out the second needle. At this point a small scalpel is used to make the insertion opening just a little bit bigger – then a dilator goes over the wire, and finally the central line is threaded down over the wire. Keep watching the monitor for ectopy! Once the line is in what ought to be the right position, which varies with the size of the patient, it's sutured to the skin with a little tabbed flag thing. Now you slap a clear adhesive dressing on the site, make sure it's nice and air-occlusive, and call for a stat chest film to show if the line is in the right position or not. Remember - <u>you cannot use the line until the film is read</u>. Something to remember – this is a golden opportunity for blood cultures! Get the team to draw them for you off the new line.

Placing the line over the wire is simple enough if the line is a single lumen introducer, but if a multilumen line is being used, it pays to remember that the line is going to have to pass through the distal opening – the one at the tip-end of the catheter. On our lines, this is the brown port – the cap comes off, the tip of the catheter is threaded onto the wire, and the line is slid down as the wire is slid out. Make sure the caps go back on any open ports! (Air embolism – ack!)

9- What things do I need to watch for during insertion?

Putting the line into a central artery is always a big one. Sometimes it can be hard to tell which vessel you're in, if your patient is hypotensive, maybe hypoxic (why?). One trick is to transduce the line and have a look at the pressure in it: this is a legitimate move if you're not giving anything through the line yet. Hook your transducer to the distal port, zero and level the setup, and have a look. Art-line waveforms and CVP waveforms really don't look anything like each other (you need to learn to tell the difference!) Another trick is to send a blood gas spec off the line – mark the slip "?Arterial vs Venous" – venous BG's are low-O2, high-pCO2, and it shouldn't be hard to tell.

Runs of ectopy are bad. Watch carefully.

Pneumothorax happens now and again. How much PEEP did you say your patient was on? The post-insertion film should show this developing – if this is going to occur at all, in my experience it's usually right away.

10: How can I tell if any of the bad things are happening?

If hitting a central artery is going to cause a problem you'll usually see a hematoma forming. The patient may need to have a coagulopathy treated with FFP – maybe a sandbag on the site for a while, depending on where it is. Make sure the team is aware of what you want to do and why.

Ectopy in these situations usually stops when the wire is pulled back. Sometimes the line itself may be in too far and cause tickling – ask the team how deep they think the line should go if the patient is very small. If the line isn't inserted all the way, that's okay, but make sure the team can aspirate blood from all three ports before they suture the line in place.

Pneumothorax ought to be, but isn't always, very evident. Sometimes they don't get very big, sometimes they're very dramatic. Any time your patient has a big change in respiratory status it's usually an excellent idea to ask about getting a chest film. Pneumos do unpleasant things, and it's worth the time to go over and look at the FAQ on Chest Tubes to review what they are, how to be ready for them, and what to do if you think one is occurring. The X-ray FAQ has some neat images on the subject too.

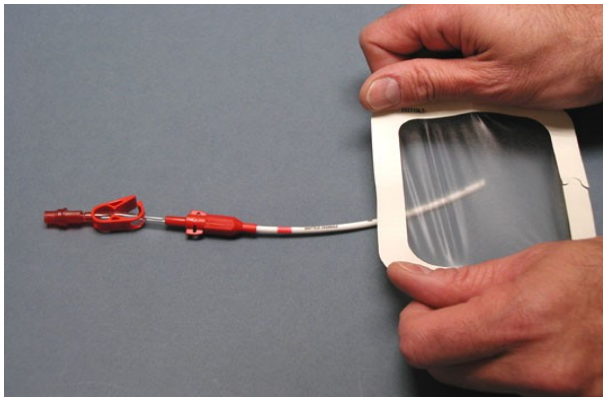
11: The line is in. Can I use it now?

The short answers: femorals, yes (assuming the placement went easily), anywhere else, no. Wait for the film. Unless it's a code.

A critical point: **always** transduce any central line before you use it – would you want to infuse pressors into a line headed towards your patient's brain? What a headache… **this goes for femoral lines too** – pressors infused towards a patient's leg can cause the loss of the limb…

12: What kind of dressing goes on a central line site?

We clean around the site working outwards with betadine and alcohol, then we apply a small sterile pad, covered by an occlusive clear sticky sheet. We tape the edges down, date the dressing, and change it every 72 hours, unless it gets wet, or displaced. (Is it 96 hours now?)



This is almost like one of those things: "How many errors can you find?"

No cap on the line? Clamp is open? Line not sutured in place? No little sterile gauze under the tegaderm?

And what's this? – how many times have we told them: "No more practice insertions in the pool table, dammit!"

http://www.venousaccess.com/New%20Pics/sticky%20side%20down.jpg

13: What does "air-occlusive" mean?

This means that the dressing won't allow air to get into the patient through the venous insertion site. Air embolism is a very unhappy thing – sometimes pressures in central vessels can actually go negative – for example during a vigorous inspiration. If the site is open to the air, a whole big hunk of atmosphere can get sucked into right into the vena cava, and get nicely pumped along through the RV into the lungs – this would be a pulmonary embolism of gas, rather than clot. The thing to try to do is to put the patient into Trendelenburg, with the right side up – the idea is to try to trap the gas bubble in the RV, from which hopefully an interventional cardiology person can remove it. I've never seen this done.

14: How does the transducer setup work?

There's a pretty detailed description of how transducers work, and how they look at the patient and talk to the monitor, in the "New In the ICU" FAQ. Briefly, the transducer is a gadget that looks at a pressure of one kind or another coming from the patient: arterial, central venous, PA, sometimes LA, sometimes urinary bladder – and translates the readings from physical to electrical. The electrical signal goes up and down just as the physical pressure does, and reads out on the monitor, going left to right, like an EKG trace does.

15: How often does the setup have to be changed?

Nowadays we change them every 96 hours – four days. Unless they get contaminated. If your patient has a CVP replaced for suspicion of infection, I would not use the setup connected to it even if it had been made that day – I'd make a new one.

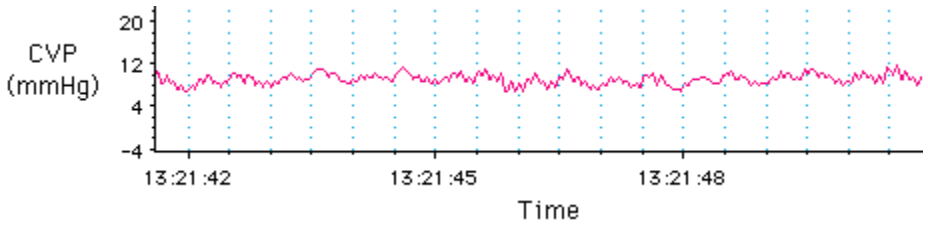
16: Can I draw labs off of a central line?

Yes. I use a vacutainer at the stopcock site, discard a red 5cc tube, and then go on as though I was using an arterial line.

17: What does a normal CVP trace look like? What does TR look like?

I really need to buy a scanner. A CVP trace looks a lot like a wedge trace – it's wavy, and doesn't go up and down very much. There are waves in the trace that you can learn to analyze, that are generated by the chambers of the right side of the heart contracting in sequence: a-waves from the atria, v-waves from the ventricles, and there's a c-wave in there somewhere, which I forget what that one is. The main idea is that you always want to read the tracing at the end of expiration.

Here's a pretty good CVP trace – this patient is probably holding her breath, since there's no respiratory variation (meaning the whole wave goes up and down some with inspiration and expiration). What number would you put on this patient's CVP – check the scale on the left – about 10?



TR stands for tricuspid regurgitation. Everybody remember that the tricuspid valve is the one between the chambers on the right side of the heart? The valve is made up of several leaflets that are supposed to close up nice and tight when the RV contracts, to prevent the contraction from pumping blood backwards into the RA. If the valve leaflets don't close up properly, then the squeezing RV pumps some blood forward into the PAs, and some backwards into the RA through the opening in the valve – this is the regurgitation. Nice name. Anyhow, this has a very characteristic appearance on the CVP trace – big deflections up and down amidst an otherwise CVP-ish looking baseline. I'll try to get a scanner…

Here's a not-too-hard puzzler: you guys are all pros at PA placement waveforms now, right? You all know what RV pressures look like then, on the monitor? So, suppose you were transducing the distal port of your brand new CVP line, and you saw an RV trace? What would you think about the positioning of that line? What should probably be done to fix it?

18: What are normal CVP numbers?

I think it was in the file on arrythmias that we pointed out that "context is everything" – that's true in CVPs too. You could pick some numbers and call them normal, and you'd be right – say you put a CVP in me. I'm 46 now, but I'm pretty healthy, I don't smoke, don't drink… I swear sometimes, but that's about it. So my pulmonary pressures aren't going to be high, as in smoker's lungs. And my portal pressures aren't going to be high, as though I were a cirrhotic alcoholic. Chronically high lung pressures reflect back into the RV, raising the right-sided pressures (which is what the CVP is in the first place, right?), and high portal pressures reflect into the vena cava, also raising the CVP. So my CVP might fall in the "average normal" range of , say, 6-12 mm Hg. A high CVP might be 20, meaning maybe overhydrated, and a low one might be 2, meaning dry. Does the person with the CVP of 20 have wet lungs? Is the person with the CVP of 2 making any urine?

19: What does PEEP have to do with it?

(Didn't Tina Turner sing that song when she was a respiratory therapist?) Absolutely everybody remembers that PEEP stands for Positive End-Expiratory Pressure, right? Meaning, this patient is either on a vent, or on some kind of sealed face-mask device (I hate those – what if the patient vomits into it?) that is maintaining a positive, measured forward pressure into the lungs, even at the end of expiration. Any forward pressure like that is going to increase the intra-thoracic pressure, and is going to cause central pressure readings to <u>falsely rise</u> as a result. So the CVP will rise, the wedge pressure will rise – but this does <u>not</u> mean the patient is "fuller" of circulating volume than they were before!

In the old days they taught us a formula: for every 5cm of PEEP above the first 5, you should subtract 3 from your wedge reading. So, let's take the example of Mrs. Ventilofsky. Here she is, on the respirator, and she's got a PA line in, and she's really hypoxic, so she's on 20cm of PEEP, and her wedge pressure is 10. She's got a terrible x-ray, they think she's probably in CHF, so they want to diurese her. Should we? We need to think about her volume status.

Okay, so, let's do the PEEP calculation thing. Take away the first 5 from the 20cm that she's on, that leaves 15, right? For every 5cm of PEEP that's left, take away 3. So 15 is, uh, three units of 5, right? For each unit of 5, take away 3 from the wedge. So that would be 3 times 3, correct? Nine, to subtract from her – wait a minute, her wedge is only 10 to start with! Hmm. Maybe she is, as we say in Boston, "wicked dry" already. Has she been making urine? Maybe we need to think some more about what's really wrong with this lady's lungs before we diurese her into pre-renal ATN…

20: How should I set the CVP limits?

What you want to know in this case is not so much that the pressure is rising or falling dramatically – because as a rule CVPs don't do that too much – but that the line might disconnect. I set the low pressure limit just below the mean reading, which does the job.

21: What does it mean if the CVP is going up? Down? Sideways?

Well, the idea is that if the CVP is going up, that your patient should be getting "fuller" of circulating volume, right? So down would mean "emptier", or "more dry", and sideways would mean no change. The problem is that it's not always so simple. Remember the three parts of a blood pressure: pump, volume and arterial squeeze? Okay, try to visualize the circulation on a movie screen. See the heart there in the middle, pumping? And the arterial system all around, squeezing? You can't really visualize how full the system is of volume, so try imagining the heart with a number in it, which we'll call the CVP. We could talk about wedge this way too, obviously, but for now we'll stick with the CVP.

So your patient is hypotensive – there could be a number of reasons for that. Is she dry? Septic? Cardiogenic? Let's pick the dry scenario – say an elderly person who hasn't been feeling well, hasn't drunk much in the past week, comes in with a low pressure. The team puts in a CVP line, and you transduce it, and the number is one, maybe two.

Sounds dry. Is she making any urine? A little, maybe 20 cc per hour, very concentrated. What's her sodium? Aha, 155 – is that high or low? High, right – the normal range is what 135-145? So higher is drier, right? – the idea being that the concentration of sodium goes up because the amount of water that it's floating around in has gone down. Right? So there's more little sodium things per cc now, 'cause there's less water for them to float around in. (Sodium things?…)

Same for the red cells. Less water component in the blood, more cells per cc. So what does the hematocrit do? Goes up, right – look the lady's crit is 49! Yup, the whole picture fits together, she's dry. Consult your movie screen. What do you see? What's the heart doing? Well, what will the heart do to compensate for loss of volume? The rate rises, correct. And what will the arterial system do to try to compensate for volume loss? Tighten up, very good. So on the screen, we see a rapidly beating heart, and narrowed, tightened arteries, and the single number inside the heart is a 1, or a 2. How will you treat her? (What would she be doing differently if she had been on Lopressor at home…?)

Let's try another one. What if she were septic? CVP might indeed be low – why? Which of the three parts of the blood pressure is affected in sepsis? – the one in the example above was volume, right? So that leaves pump and arterial squeeze. Which one is affected in sepsis? – arterial squeeze, right. How come? Remember the bacterial endotoxins that are produced in sepsis: they poison the arterial muscle layer so that the whole system relaxes, dilates. (My son says that dilate means to go to heaven after midnight. And that after you dilate, you barium…) The true volume doesn't change, does it? No – but the relative volume sure does – look at your screen. See the nice widened arteries? Where's all the patient's circulating volume going to go? Down into their legs, if they're standing up, which they're probably not, right?, being hypotensive and all. What's the heart doing? Tachycardic, right, and for much the same reason – not enough volume going around, although this time it's not because she lost any, it's because she's all dilated. She has a relative volume deficit. So her CVP will be low too. (And her wedge will be low as well, you PA-line guys out there…). How will you treat this situation? Take a look at the FAQs on "Pressors and Vasoactives" and "PA-lines" for more on the subject.

Here's another point worth mentioning about central pressures in general, meaning CVP and wedge pressures: pretty much anything that raises the patient's blood pressure is going to raise the central pressures too. Maybe not a whole lot, but some – this is where trending and ranges

come in. If you put your patient on a Neo drip, and her pressure goes from 75 up to 140 systolic, her CVP is going to go up, probably because as you tighten up her arterial bed, the relative volume increases, right? She seems fuller, because she's tighter. Did her urine output improve with the higher pressure? The whole point here is to try to learn to think systematically about your patient's volume status in a meaningful way. What's the heart doing, and why? What are the arteries doing? What's the real volume status? Which of the three is causing the problem?

Be patient with yourself. It takes time and experience to learn how to assess this stuff. We're talking a couple of years here, probably. And even then you can run into mixed situations that get really hard to figure out, such as a cardiogenic patient on a balloon pump who develops hardware sepsis…Learn to use all the tools you have available: from high tech - PA-lines are really helpful in figuring out volume situations - to low-tech: is she peeing? If there's no renal failure, then urine output is a really good clue. (They used to call a foley catheter the "poor man's PA-line".)

One more point about volume assessment – is the patient hot, or cold? Did he just come up from spending five hours in the OR with an open abdomen? His arterial bed will certainly be nice and tight, right? (High SVR, you PA-line guys.) As he warms up, what will happen? Right – he may lose pressure. Or a previously "normothermic" (whoa!) patient with a decent pressure might spike a fever and dilate – does he need volume? It's a lot to think about…get help!

22: What if I lose the CVP tracing on the monitor?

First off, make sure the line is still in the patient! If the line is okay, then you need to start troubleshooting. Here's how I do it – starting from the patient, work backwards along the line. Make sure everything is connected, make sure the stopcocks aren't closed, make sure the cable is still plugged into the transducer and the monitor. Is the scale on the monitor right? If the scale is set at 0-300 on a 2-inch hunk of monitor screen, a CVP of 8 won't show up at all. Whole setup is okay? Does the line maybe have a clot at the end? Are you going to forcibly irrigate it to find out? (Someone once called this "giving it a Canadian.")

No you should not – if you suspect that there's a clot at the end of a catheter, the only thing to do is to try to aspirate it back up the line, which sometimes you can actually do. Use careful sterile technique, and try this: unscrew the stopcock cap, screw on a small syringe, and gently aspirate. If you can't clear the line this way, clamp it, flag it "? clotted", and talk to the team…try transducing another lumen and see if you get a decent tracing.

23: What if the line becomes disconnected at the hub/stopcock/transducer?

This is why you tighten up the transducer setup when you first put it together – this really shouldn't happen. If someone else makes the setup for you, check it yourself again before it goes up.

This is also why you must remember, at the beginning of every shift, to **make sure that you have meaningful alarm limits set.** There is no reason to ever, ever forget this. Even if your patient is, say, someone who is being allowed to pass away, **you must check the alarm limits**, if only to lower them. I usually set the CVP "low" limit at zero, or a little higher – this will readily detect a line disconnect.

If the line does disconnect, assess quickly for the possibility of an air embolus. Is the patient bleeding outwards from the disconnected lumen? – definitely better than pulling air inwards! Has the lumen connector gotten contaminated? Cap it, flag it, don't use it, inform the team. If the line becomes disconnected farther away from the patient, you'll probably get blood backing up along the line – close the stopcock at the lumen connector, and make a new transducer setup. Has the patient lost much blood? Send a hematocrit…

24: What if the patient pulls out her central line?

The same concern about air embolism applies, as well as bleeding. In practice, this really happens very rarely. Use your assessment skills at all times to figure out if your patient needs safety measures applied. There's lots of discussion about sedation, restraints, and how to use them in the "Sedation and Paralysis" FAQ.

Slap an air-occlusive dressing on the site. (Don't really slap it!) Put the patient on their left side so that any air that may have been sucked into the circulation will rise to the right atrium and not go into the patient's circulation. Notify the team right away. Assess for blood loss, air embolus, local injury to the site if they've pulled their sutures…

25: How long do central lines stay in?

Like everything else, this is a topic of ongoing debate. I'm pretty sure that the current rules say that a percutaneous stick-at-the-bedside line is supposed to be changed after 7 days. Maybe ten days? Of course if it looks like the line has gotten contaminated, or if the insertion site looks infected, or even if the patient is just spiking fevers for otherwise unclear reasons, the line should come out sooner. You really don't want to leave this nice germ conduit going into the central circulation if you think it isn't clean.

You also need to think about where the line is: a femoral line that was put in emergently during some sort of near-code situation should probably come out as soon as more access can be put in – the fem is not the cleanest place in the world. Then again, I've had the teams tell me that a really well-prepped femoral line is just as clean as one in the neck or chest – things to keep in mind.

26: How do I know if the line should come out?

How long has it been in? How does the site look? Does the patient still need central access? Has she been spiking temps? Has the line been contaminated?

27: How do I take the line out? How do I culture the tip?

Nurses do take out central lines in our ICU, but if there's anything unusual about the situation – coagulopathy, pneumothorax, anything out of the ordinary, I'll usually ask the team to do it. In practice, it's simple enough: first, take out the stitches. I usually have a helper at this point. Have a sterile tube ready to put the catheter tip in. I put a sterile 4x4 on the sticky side of a clear adhesive dressing, which I hold over the line site with my left hand (not touching the site yet). Then - at end-expiration - with my right hand, I do a smooth pull to remove the line, and as the tip comes out of the site, the left hand slaps (!) the dressing over the site opening, and holds it down. The right hand is now holding the catheter up in the air, tip downwards. Your helper now holds the sterile tube up, slides the tip of the catheter into the tube, and uses sterile scissors to snip the end,remember to use a second sterile scissors, letting that end drop down. Cap the tube, hold the site for several minutes. (there is some data that it makes more sense to send a sample about an inch up from the tip for culture, as the tip has a great deal fo blood flowing past it.)

Assess the site. Any bleeding? Hold pressure for another 5 minutes. Still bleeding? Ask the team to come and have a look. You checked the coags before you pulled the line, right? Does the site need a sandbag? Is a hematoma forming?

28: What kind of dressing goes on the site after the line is out?

I use a large clear adhesive dressing over a gauze 4x4 for the site. If no bad things are happening, make sure the dressing is firmly in place, and come back and check it once or twice in the next half hour, then again maybe an hour later.

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