Peripheral intravenous catheterization: A manual for the beginner

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I. INTRODUCTION:

It is a truth universally acknowledged that most medical trainees learn intravenous catheterization from other trainees. A vicious spiral ensues in which poor techniques become institutionalized. Ultimately, poorly trained novices, taught by other poorly trained novices, accept a 50% success rate. As the trainee practices bad techniques over and over again, patients suffer; trainee confidence suffers, and the spiral continues.

What role does the experienced clinician play? Usually that of the *deus ex machina*, the hero or heroine who rescues the patient and trainee by wading through the bruises to place a catheter in the last remaining vein. All too often, the clinician works quickly and silently, with the trainee left to wonder how the clinician made the technique look easy. And the next attempt made by the trainee is no better than last one.

My experienced colleagues place intravenous catheters every day with nearly 100% success rates. Why do their skills go unshared with trainees who thirst for that kind of proficiency? Probably a combination of factors:

1) Many experienced clinicians take their skills for granted.

2) Some do not appreciate the myriad of subtleties that make them successful.

3) Most importantly, teaching takes time. In a busy anesthesia practice, who can afford to take ten minutes to teach a trainee when experienced clinicians can place the catheter themselves in 30 seconds?

The trainee who seeks education from textbooks will be disappointed. Entire chapters are devoted to central venous catheter placement, pulmonary artery catheterization, and sophisticated nerve blocks but a paragraph discussing intravenous cannulation is a rarity.

The goal of this essay is to provide a detailed teaching reference on the essential aspects of a successful approach to placing intravenous cannulas. My colleagues adept at intravenous catheterization may find much with which to disagree. If they are inspired to teach their own techniques, future trainees will benefit all the more.

This work began as a one-hour lecture to medical students with a chalkboard and a few props. In ideal circumstances, hands-on supervision of catheter insertion immediately followed. In lieu of the chalkboard, props, and hands-on supervision, the reader is provided with photographs and illustrations. The essay also preserves the question and answer format from the lecture. Commentary of lesser interest is indented; readers in a hurry will be forgiven for skipping these sections.

Interspersed within the text are some *Pretty Good Rules*, italicized to emphasize their import. They are listed here, in the text, and in the summary. Memorize them, apply them, and profit.

Pretty Good Rules:

- *Start with the most distal site, not the easiest site*.
- *Enter the vessel exactly along the axis of the vessel.*
- *Enter the skin well distal from where you plan to enter the vein.*
- *After flashback, advance the entire device further before attempting to thread the catheter*.
- *Do not let up on traction with the nondominant hand until the catheter is threaded into the vessel.*
- *Place the largest catheter the vessel will accommodate.*

II. SELECTING A SITE:

Where should I look for veins in the awake patient?

1. Arm versus leg.

In the supine patient at rest, flow in the superior vena cava distribution is greater than that of the inferior vena cava. Therefore, drugs given into leg veins will be less dilute and take longer to reach their intended site. Potentially corrosive drugs, such as potassium and some antibiotics, are more likely to cause thrombophlebitis when given in leg veins than arm veins. Furthermore, in the setting of abdominal trauma one may not be certain that the inferior vena cava is intact; drugs given in leg veins may never reach the heart at all.

There is a convenience factor both to the patient on the ward and the anesthesiologist in the OR. Mobile patients who must take IV bags with them will have an easier time when walking with tubing attached to an arm than a leg. In the OR, most procedures are performed with the anesthesiologist at the head of the bed; an IV catheter in an arm is easier to police and, if necessary, replace than one in the leg.

However, if the primary purpose of the IV catheter is to provide a means for fluid resuscitation in a patient without abdominal trauma, or for the induction of general anesthesia, then a temporary catheter in a foot vein will suffice until more a convenient substitute can be found, especially later under general anesthesia.

2. Hand versus antecubital fossa

The antecubital fossa lures many beginners because it frequently presents large highly visible veins. I do not advise beginners to start here. The location is inconvenient for the patient since it impairs movement at the elbow and if the patient does flex the joint, there is a high likelihood of kinking or displacing the catheter.

But the greater danger is failing. If the antecubital veins are punctured but a catheter is not placed successfully, all distal veins become unreliable: fluid infused distally may extravasate when it reaches these puncture sites.

If IV catheterization in the hand fails, one can still make additional attempts further downstream (i.e., more proximally). The antecubital fossa should ideally be reserved for one's last attempt, not one's first.

Pretty good rule: *Beginners should start IV catheters at the most distal site, not the easiest site*.

What can I do to make arm veins distend?

1. Tourniquet

Place the tourniquet on the forearm rather than the upper arm. This hastens distension of the hand veins, our initial target, and also spares the beginner the temptation to attack the antecubital veins first.

As a courtesy to the patient, place the knot of the tourniquet over the relatively hairless portion of the arm, the volar aspect, to reduce the chance of incorporating hair into the knot.

2. Dependency

Letting the arm dangle below the level of the patient's stretcher or bed provides two benefits.

a) Veins distend, even without a tourniquet. To demonstrate on yourself, hold one hand over your head and let the other hand hang down. See the difference in vein size?

b) Imagine your patient is a teenager in his first trip to a hospital and the IV catheter in front of him is the largest needle he has ever seen in his life. Holding his hand in front of his face while you insert this needle

into his flesh will likely make this a far more exciting procedure than either you or your patient want. Allowing the arm to dangle at the side takes the procedure site out of the patient's line of vision and thereby reduces some of the emotional responses to IV catheterization, both yours and the patient's.

3. Tapping the vein

This is a favorite method. Tapping on a vein releases histamine; the tourniquet produces venous stasis so the released histamine sits in the vessel and dilates it. Tapping on visible veins frequently makes them larger; tapping on areas without visible veins may make one visible.

> Remember that tapping and histamine release can be uncomfortable to the patients, so alert the patient of your plan beforehand and advise them that this process may sting.

> 4. Making a fist

> I do not advise this technique, though it does work. First, to be effective your patient must be awake, cooperative, and English speaking; many patients will not satisfy one of these three requirements. Second, making a fist focuses the patient's entire concentration on the IV cannulation site, heightening the chances of unwanted emotional responses (see above paragraph).

> Instead, you may wish to have the patient make a fist with the contralateral hand, directing all their attention away from you, while you use the other methods described here to distend the vein.

> 5. Other techniques

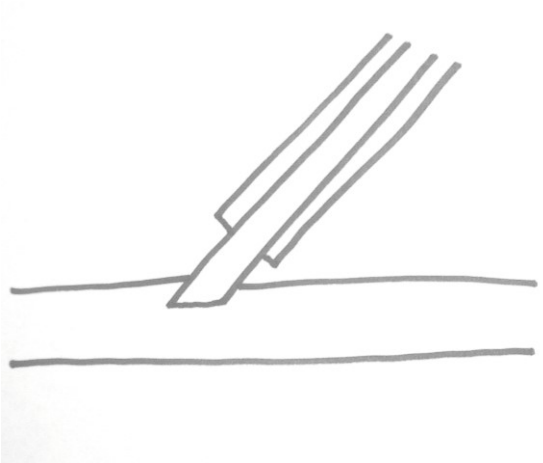
> These include heat packs, nitroglycerin ointment, and the like. As these are not commonly available on short notice in areas when we usually start IVs, little more need be said here.

III. FUNDAMENTAL PRINCIPLES

What is the best angle to enter a vein?

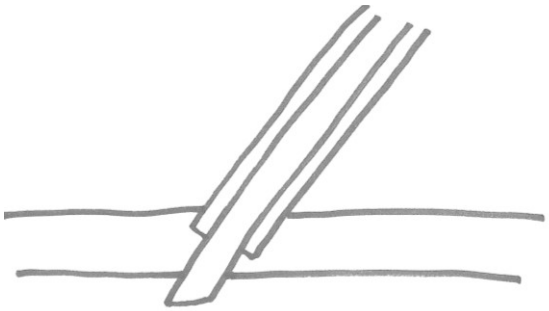
Beginners usually answer this question with "between forty-five and fifteen degrees from the axis of the vein." This is a good answer. But not the right one.

Entering a vein at any angle generates a critical problem. When the catheter-over-needle assembly first enters the vessel, the needle is in the lumen but the catheter is not. If one attempts to slide the catheter off the needle in this position, the catheter will not enter the lumen. You become a member of the "I hit it but couldn't thread it" Club. [**Illustration 1**]



[**Illustration 1**: Approaching from the side of the vessel, the needle is in the vessel; the catheter is out.]

It is absolutely critical, once blood in the flashback chamber announces that the needle is in the vessel, to advance the entire assembly further so that the catheter is also in the lumen. If the cannulation angle is steep, there is a high probability that when the catheter enters the lumen, the needle will exit the back wall of the vessel. [**Illustration 2**] If one attempts to slide the catheter off the needle in this position, the catheter will not enter the lumen. You become a member of the Club.

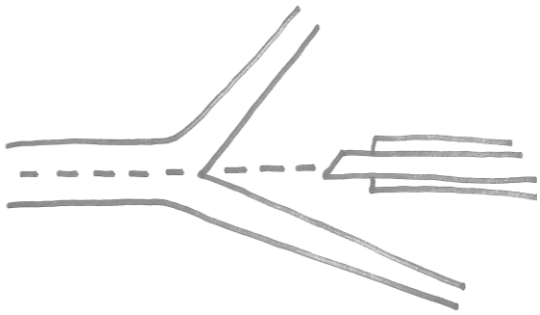


[**Illustration 2**: Advancing the device after approaching from the side of the vessel, the catheter is in the vessel, the needle is out.]

The shallower the angle, the greater the chance that when the device is advanced after the needle enters the vessel, both needle and catheter remain within the vessel. Taking this concept to its logical conclusion, one realizes that the ideal angle to enter a vein is exactly along the axis of the vein.

Pretty good rule: *Enter the vessel exactly along the axis of the vessel*.

How can one enter the vessel exactly along the axis of the vessel? The optimal site is a Y intersection where two veins unite. [**Illustration 3**] By aiming for the center of the Y, one is able to follow this rule. Do not be distracted by asymmetric angles: you are not trying to bisect the angle; you are directing the IV catheter device exactly along the axis of the downstream vessel.

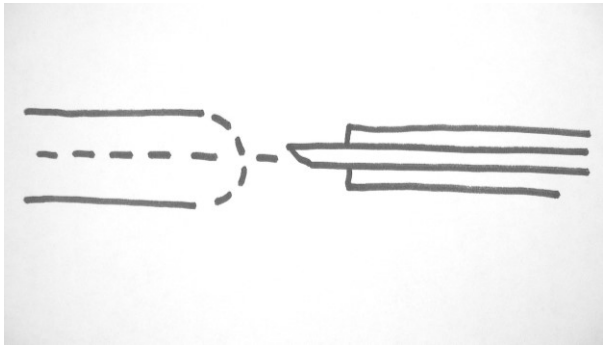


[**Illustration 3**: Approaching the vessel at a Y, the device is aligned with the axis of the vessel.]

What if I can't find a Y?

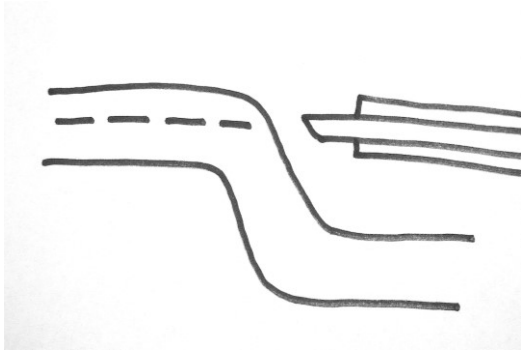
"Seek and ye shall find." However, should no Y be available, there are alternatives.

- Occasionally a vein emerges out of deeper tissue, presenting a straight section downstream but no Y upstream. Puncture the skin well distal to the emergence site, along the axis of the vessel. As the needle approaches, the vein may dimple downward before it is punctured, but the device will eventually enter along the axis of the vessel, albeit further downstream than originally planned [**Illustration 4**].

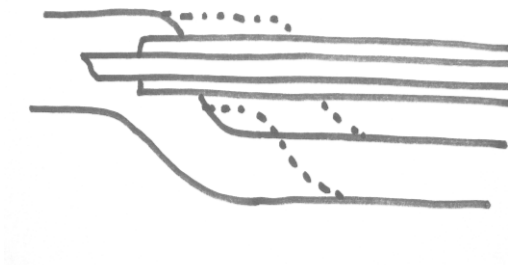


[**Illustration 4**: The device enters a vessel with no visible distal portion along the axis of the vessel.]

- Sometimes a vein may form an S curve, with a straight downstream portion [**Illustrations 5, 6**]. Approaching the vessel along the axis of the downstream portion permits one to enter the vessel along the axis, much like the situation above.



[Illustration 5: Approaching a straight section with an S curve, along the axis of the vessel.]



[Illustration 6: Approaching a straight section with an S curve, the device displaces the vessel but still enters the vessel along its axis.]

The straight portion of the vein is much shorter than the catheter. Should I look elsewhere?

The straight portion of the vein downstream from the puncture site need only be long enough to accommodate the tip of the needle and the initial portion of the catheter. The soft plastic catheter will find its way downstream without requiring a length of straight vein as long as it is.

Why not cannulate the vein from the side?

While possible, this approach is fraught with hazard. All veins roll. Consequently, a common result of entering the vein from the side is that the needle has distorted the vein (it rolled) and left the catheter outside. To proceed is to court membership in the Club.

Entering a vein at a Y prevents it from rolling away from the needle. The approaching device is self-centering and prevents the vessel from rolling.

Why can't the catheter be threaded after the initial puncture and flashback?

When blood is first seen in the flashback chamber, the needle is in the lumen but the catheter is not. The device absolutely must be advanced further along the axis of the vessel. How far? This depends on the gauge of the catheter. A 20-gauge catheter requires only a millimeter or so to get the catheter into the vessel. A 14-gauge catheter may require almost a centimeter.

We therefore understand why beginners are more successful with smaller gauge catheters: small catheters may allow cannulation with sloppy technique. If the tip of a small catheter enters a large vein, the device can be inserted the few microns without puncturing the back wall, even at angles grossly aberrant from the axis. Larger catheters, however, demand perfect technique.

Pretty good rule: *After flashback, advance the entire device further before attempting to thread the catheter*.

LOCAL ANESTHESIA

Why should I use local anesthetic?

Most trainees reading this essay will have the option to use local anesthetic. Please do so. This provides two benefits:

- Large catheters are no more painful to insert than small catheters.
- If patients are especially sensitive, they flinch when the local anesthetic enters the hand, not when the clinician is attempting to enter the vein.

What local anesthetic should I use?

The anesthetic of choice is 1% lidocaine without epinephrine: Lidocaine is the fastest acting of our local anesthetics. Solutions more concentrated than 1% are unnecessary. Epinephrine will constrict vessels when we want vessels to distend.

How should I inject the local anesthetic?

Injecting the local anesthetic into the superficial epidermis layer instead of the underlying dermis has two disadvantages:

- The tight wheal causes more pain on injection, and

- The anesthetic solution does not diffuse.

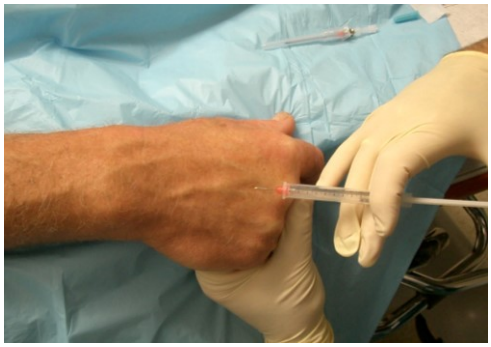
Therefore, injecting into the slack tissue under the epidermis reduces pain and distributes anesthesia along the planned path of the needle as well as the entry site.

Hold the syringe with one hand in such a fashion that the solution can be injected with one hand, leaving the other hand to hold tension on the skin. A one-handed injection reduces the time the needle is under the skin without anesthesia, making the experience less painful for the patient. Attempting to aspirate before injecting is unnecessary: one ml of 1% lidocaine injected intravenously will not produce therapeutic blood levels, let alone toxic blood levels.

Where should I inject the local anesthetic?

It is only logical that the local anesthetic should be injected where the needle will enter the skin. Therefore, it behooves the clinician to determine exactly where along the axis of the vessel that the needle will enter the skin, and only then inject the local anesthetic.

The optimal site for injecting local anesthetic and entering the skin is illustrated [**Illustration 7**].



[**Illustration 7**: Local anesthetic is injected well distal from the intended venous puncture site along the axis of the vessel]

Note that the local anesthetic and subsequent skin puncture site is situated at least a centimeter distal from the chosen vessel puncture site, along the axis of the vessel. *The needle does not enter the skin where the needle will enter the vessel*. There are sound reasons for this:

- Injecting the local anesthetic may puncture the vein, leaving you with a hematoma rather than a clean Y-intersection.

- Even if a hematoma is avoided, the resultant local anesthetic wheal may obscure the Y-intersection.

- Most importantly, if the anesthetic is successfully injected at the planned vessel entry site without hematoma or obscuring wheal, the clinician has no alternative but to enter the vessel from above, missing the axis of the vessel, entirely negating the purpose of entering at a Y-intersection, and gaining unwanted membership in the Club.

Pretty good idea: *Enter the skin well distal from where you plan to enter the vein*.

MANUAL SKILLS

Is this a sterile procedure?

A sterile prep and technique are not necessary in patients without compromised immune systems. However, it is our duty to protect patients and ourselves by respecting the potential for infection.

- This is a clean procedure: use alcohol to prepare the patient's skin and then avoid touching the puncture site again. If you must palpate the puncture site, wipe it again with alcohol before inserting the needle.
- The portion of the catheter from the tip to the hub is packaged sterilely. Respect this by touching the device only from hub of the catheter to the end of the flash chamber (see illustration 10 below).
- Wear gloves. Always. It is too easy to transfer hepatitis from patient to clinician and from clinician to patient (Ross RS, et al. N Engl J Med 2000;343:1851-4). Find a size with optimal fit. Tug the fingers of the gloves to avoid unsightly and clumsy appendages at your fingertips. Wear gloves.

What's the best way to hold the patient's hand?

The nondominant hand of the clinician holds the hand of the patient beyond the knuckles and flexes the fingers tightly at the hand. The thumb tenses the skin of the dorsum and the fingers steady the palm underneath. This achieves two goals:

- The nondominant thumb of the clinician is below the horizon of the hand. This allows the catheter to be dropped to the axis of the vein without bumping into the thumb.

- Flexing the patient's fingers tenses the skin distal to the cannulation site, helping to immobilize and straighten the chosen vein.

To complete maximal tension on the vein, the clinician's nondominant hands also flexes the patient's hand at the wrist [**Illustration 8**]. Tension on both distal and proximal ends of the chosen vein provides the best possible target.

[**Illustration 8:** Holding the patient's hand with both the knuckles and wrist flexed, and with the thumb below the horizon of the knuckles. Note that this clinician is left-handed.]

These principles apply to other cannulation sites. The nondominant hand places traction on the distal end of the vein, sufficiently distant from the skin puncture to avoid interference with positioning the catheter with the dominant hand. At some sites, it may be helpful to bend the catheter and needle gently to get the

cannulating hand above the traction hand. If done, ensure that the catheter can pass easily off the curved needle. It is distressing to discover after entering the vessel that the catheter cannot be moved off the bent needle.

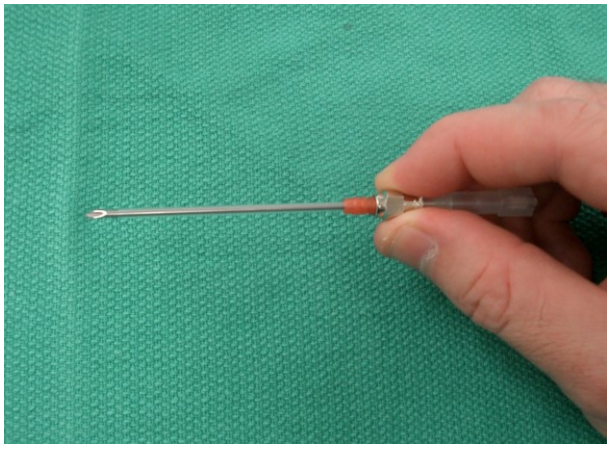
It is important that traction on the vessel be maintained not only for the initial puncture and insertion of the device into the vessel, but also while threading the catheter off the needle and into the vessel.

Pretty good rule: *Do not let up on traction with the nondominant hand until the catheter is threaded into the vessel*.

How should I hold the catheter over needle assembly?

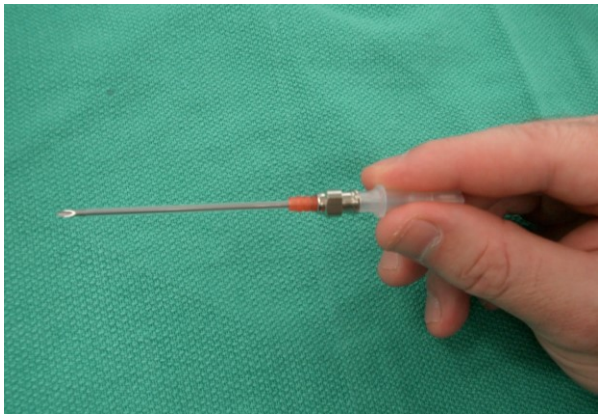
For standard catheter-over-needle assemblies:

Do not hold these devices by the hub of the catheter [**Illustration 9**]. This grip may push the catheter off the needle, leaving the blunt end of the catheter rather than the sharp tip of the needle to lead the device under the skin. Similarly, holding the device by the cap at the end of the flashchamber is also unwise; the cap may be pulled off and produce an unwanted profusion of blood once the vein is entered.



[Illustration 9: Not a good way to hold the device. The fingers may advance the catheter off the needle unintentionally and prematurely.]

Hold the device by the hub of the needle to avoid these complications. The thumb and forefinger should not obscure the flash chamber [**Illustration 10**]; this allows the clinician to visually appreciate when the needle enters the vein.



[Illustration 10: A better way is to hold the device by the plastic portion of the needle, not the hub of the catheter. Note that the flash chamber is visible to detect blood return when entering the vessel.]

For "Safety Catheters:" (Please see last section for meaning of quotation marks)

Hold these devices by the thumb and middle finger. If the forefinger is used, the clinician will discover that it is easy to dislodge a device from the vein attempting to free the index finger to insert the catheter off the needle. During initial passage of the device under the skin, the forefinger should be kept curled and off the insertion tab of the catheter. [**Illustration 11**]. This prevents unintended and premature passage of the catheter off the needle before the device enters the vein.

[Illustration 11: A better way to hold the Safety Catheter, between the middle finger and thumb with the index finger off the plunger.]

When will I know that the needle tip has entered the vein?

- As the needle approaches the distended vessel along the axis of vessel, the distended vein will dimple.
- When the needle enters the vessel, the dimpled vein will snap back to its original distended state,
- A pop will be felt as the needle penetrates the wall, and
- Blood will return into the flash chamber.

At this point, the tip of needle is in the vessel, *but the tip of the catheter is not*. It is critical to insert the device further along the axis of the vessel sufficiently far to insure that the tip of the catheter as well as the tip of the needle is within the lumen of the vessel.

How can I find the needle tip while passing it toward the vein?

It may be difficult to determine the location of the needle tip once under the skin. First, insure that the needle tip has penetrated the hard epidermis and entered the dermis before leveling out and advancing toward the vessel. If the needle tip cannot be appreciated under the skin as it is advanced, it is likely that the device is aimed too deeply; correct this by dropping the proximal end of the device to create a shallower angle with the skin. If the tip is creating a tight white wheal, the device may be aimed too shallowly; to avoid the needle exiting the skin, raise the proximal end to lower the distal end. Ideally, the tip will create a gentle burrow as it travels. At any point after entering the dermis, halting the advance and lowering the proximal end of the device can locate the tip. The distal tip will make a white wheal as it is raised. Once the tip is located, adjustments in direction can be made. Be sure to return the tip to the appropriate level afterwards.

Both the needle and catheter are inside the vessel – How can I advance the catheter off the needle?

A tricky question. There are two techniques:

- Immobilize the needle with the thumb and middle fingers and use the index finger to thread the catheter off the needle [**Illustration 12**].

[Illustration 12: Immobilizing the needle with thumb and middle finger and advancing the catheter off the needle with the index finger.]

- My preferred technique, and usually easier for the beginner: immobilize the catheter with the index finger and pull the needle back with the middle finger and thumb [**Illustration 13**]. Then, thread the catheter and needle *together* into the vessel. Although the needle stiffens the catheter, it seldom prevents passage. Because the needle tip has been withdrawn into the catheter, it will not puncture the vessel.

[Illustration 13: The index finger fixes the catheter; the middle finger & thumb withdraw the needle. Then the catheter and needle are advanced together.]

At this point, one can appreciate the value of keeping the vein and skin tense with the non-dominant hand to maximize the chances of the catheter following the straight section of vein.

SECURING THE CATHETER

The catheter is threaded fully. What do I do next?

Congratulations. Now comes the easy part.

- With the dominant hand, unknot the tourniquet.

- Move the thumb of the non-dominant hand over the site of the tip of that catheter to occlude the vein. This will prevent back-bleeding. Note that the catheter cannot be compressed, only the vein at the catheter tip.
- With the dominant hand, remove the needle. *Place the needle back into the sheath*. Aren't you glad you placed the empty sheath next to the patient's hand before you inserted the needle?
- Connect the IV tubing first with one hand, then with both hands to fasten the Luer lock of the hub to the tubing.

Who cares about the dressing afterwards?

The primary purpose of applying a dressing to the catheter is to prevent the catheter from being dislodged. Therefore, use a large adhesive dressing with the IV tubing looped on itself to place as much tubing under the adhesive as possible. The loop allows the tubing to travel up the arm, toward the head of the OR table or toward the IV pole, without kinking. The loop should be entirely under the dressing to prevent a passing stethoscope from catching an unsecured loop and pulling the catheter out.

The distal tip of the catheter identifies the site under the skin where the catheter will infiltrate should this happen. Therefore, secure the IV tubing away from the tip of the catheter so as not to obscure this important location **[Illustration 14]**. For similar reasons, avoid placing tape over the tip of catheter. In fact, avoid placing tape anywhere downstream from the catheter to avoid the annoyance of creating a constrictive dressing, preventing the intravenous fluid and drugs from reaching the central circulation.

[Illustration 14: The dressing contains as much tubing as possible, with no protruding loops and with the entire downstream portion of the cannulated vein clearly visible.]

I didn't follow your instructions and now the catheter won't thread. What should I do?

There are two options for redeeming the situation, though success is now unlikely.

- Insert the needle back fully into the catheter. Continue passing the device forward, angling the point back toward the vessel. If you have chosen a long catheter, it may still be possible to re-enter the vessel downstream from the original intended site. The fact that the catheter will have passed completely through the vein before re-entering it downstream will not affect its utility.

- Leave the catheter in place but remove the needle. If copious amounts of blood emerge, you may be able to pass the catheter further into the vein. Most likely, this will not work but it is worth a try before going to the next step.

If neither of these two maneuvers work, abandon that site. Do not attempt to remove the needle and then pull the catheter back until blood returns. A through-and-through technique will not work on peripheral veins. Do not even try.

Instead, work on damage control. Avoid the temptation to pull the entire device out of the skin and hold pressure. While this will eventually need to be done, it need not be done right away and certainly should not be done if it delays your continuing attempts to place an urgent IV catheter. Without dropping the tourniquet, try the following:

- Remove the needle and place it back into the sheath, leaving the catheter in place.
- Prevent backbleeding from the open catheter by removing the distal cap from the needle hub or folding over the catheter or both. Place a small piece of tape over the catheter to prevent dislodgement.
- Move to another (more proximal) site and place the IV.
- If that site also proves a failure, repeat above steps 1 though 3 until successful.

When should you remove all those folded, taped, and useless catheters? *When you have nothing better to do*. If starting an IV line is critical to patient well-being, do not delay this essential procedure. Seconds do not count when removing a blown catheter.

COURTESY AND EQUIPMENT

How can I make this experience easy for the patient?

Sticking needles into a patient is not something patients look forward to. We clinicians can blunt some of the helplessness many patients feel during any invasive procedure by following simple but sometimes not obvious rules:

- Introduce yourself and explain what you plan to do. Assure the patient that you will use local anesthetic and that you will tell the patient before doing anything uncomfortable. This includes tightening the tourniquet, tapping the vein, tensing the skin, injecting local anesthetic, and inserting the catheter over needle assembly through the skin.
- To reduce catching the patient's hair when you apply the tourniquet to the forearm, ask the patient to rotate the arm so you place the knot over the relatively hairless portion of the arm.
- Place all equipment beside the patient rather than on the patient. Do not use the patient's chest, abdomen, or crotch as a table. Ask the patient to move to one side of the bed if necessary to gain room for your tools.
- Let the patient know not to move the operative limb until you complete the dressing. Then remember to let the patient know when it is safe to move.
- When finished, explain to the patient that all sharp objects are gone and that there is only a soft plastic tube remaining. Let the patient know that it is safe to move the limb as long as care is taken not to catch the tubing on anything.
- IV fluid is at room temperature; your patient will be warmer than that. Explain that it is normal for the patient to feel cold downstream from the infusion site.

- Tell the patient that the IV now means most medications can be injected into the tubing without further needle sticks.

How can I set up my equipment to make the process easier?

It is embarrassing to successfully thread the catheter and then have it dislodged while wrestling with the IV administration set.

- Before spiking the administration set into the bag, close the roller clamp completely. Then fill the drip chamber at least half way to prevent air from being entrained when flushing the tubing.

- If possible, hang the IV solution bag from a pole attached to the bed or stretcher. This avoids moving the patient to another room and leaving the IV solution bag, administration set, and IV catheter behind.

- Hang the IV solution bag as high as practical so that the solution flows freely when the tubing is attached to the catheter and the roller clamp is released.

- Slide the roller clamp to where you can reach it without stretching while staying at the cannulation site.

- Tighten all connections and turn all stopcocks off to the ports as necessary.

- Loosen the cap at the end of the tubing so it can be removed with one hand.

- And check to see if you have inadvertently tied a knot in the tubing while removing it from the package.

- Once the catheter-over-needle assembly is out of the sheath, place the sheath close to your working site so you can replace the needle in the sheath afterwards without stretching.

ADVANCED CONCEPTS

A note on safety catheters:

"Safety" catheters were introduced with the intention of reducing the number of needle stick injuries in clinicians. It would be wonderful indeed if they in fact made the workplace safer for us. Unfortunately no studies to date validate fewer needle sticks with safety catheters. On the contrary, one study demonstrated that clinician exposure to patient blood increased four-fold with the use of retractable needle devices (Cote CJ, et al. Anesth Analg 2003;96:387-391).

If "safety" catheters merely increased blood exposures without decreasing needle sticks, that would be reason enough to avoid them. However, many "safety" catheters have other attributes unrelated to safety that make them undesirable:

- They are much sharper than conventional catheters. This increases the chance of passing the catheter completely through the vein without appreciating it. By the time blood return is seen in the flash chamber, the vein may already be skewered.

- The devices are heavily weighted toward the proximal end, making it almost certain that the device will tip precariously if one lets go, inadvertently or vertantly.

- Disengaging the needle from the catheter without backbleeding requires three hands. Two-handed clinicians will discover that one either sheds blood from the catheter or risks dislodging the catheter entirely.

I recommend, in the absence of evidence that safety catheters increase anyone's safety, that they be reserved for occasions when cannulating the vein is not important (i.e., never) and that conventional catheters be used until a truly safer catheter is proved effective.

Should I use a long catheter or a short catheter?

Poiseuille's law (below) tells us that laminar flow through the rate-limiting portion of a conduit is inversely proportional to its length; e.g., halving the length doubles the flow. Ergo, some would say, use the shorter catheter to permit greater flow.

However, if the catheter is the largest size the vessel will accommodate, *the catheter is no longer the rate-limiting portion of the conduit*. It is the downstream vessel that limits maximal flow.

Note that this presumes one has placed the largest catheter possible. Poiseuille also tells us that flow increases proportional to the fourth power of the radius; e.g., doubling the radius increases the flow sixteen fold:

$$\text{Flow} = (\text{Pressure gradient})\ \pi\ (\text{radius})^4 / 8\ (\text{length})\ (\text{viscosity})$$

Clearly if one is concerned with maximal flow through a catheter, it is far more important to place a wider catheter than a short one.

Are there disadvantages to shorter catheters? Here are two:

- A shorter catheter may not permit a second chance at cannulating a vein downstream if the initial attempt goes through the vessel (see "Either because I didn't follow your instructions, or in spite of following them, the catheter won't thread off the needle. What should I do next?").

- A shorter catheter is more likely to be dislodged after being secured.

What if the vein has a short straight section preventing me from passing a long catheter fully to the hub?"

No law obligates one to thread the catheter fully. If a segment of the catheter remains outside the skin but the tip is far enough in the vessel to be reliable, the catheter is usable. If one uses a short catheter, one is limited in how far the catheter can be threaded no matter how long the vessel is. A long catheter maintains the option to thread the catheter partway and still have it be reliable or insert it to its greatest length.

What size catheter should I place in a patient?

Trick question. The answer is another Pretty Good Rule: *Place the largest catheter the vessel will accommodate*.

- It makes no sense to wrestle a 14g catheter into a 20g-sized vein. Disaster is certain.

- It likewise makes no sense to place a 20g catheter into a 14g-sized vein. When was the last time one heard, "Darn, this IV runs too well. I wish we had a smaller catheter."?

There is another reason for placing large catheters routinely. Large catheters are more difficult to place because they require meticulous technique. If one practices large catheter placement only when absolutely necessary, one is unlikely to gain sufficient experience sufficiently quickly to master this important skill.

Placing large catheters electively and daily increases the chance of success when attempted urgently.

I would like to practice these principles, but I don't want to make patients or myself suffer while I learn. What can I do?

This is a generous comment that appreciates the challenge of a teaching institution. Every expert started as a beginner and became expert only with practice. How can we respect the comfort of patients who are subjected to care by beginners?

The best place to practice IV cannulation is in the operating room on anesthetized patients after the operation has begun.

- These patients already have IV catheters in place. A second catheter may be beneficial to the patient but is not essential. Success is therefore not critical.
- These patients will not be uncomfortable during the procedure because they are under anesthesia. No pain to the patient; no stress to the beginner.
- Presuming the IV cannulation attempt does not interrupt either the operation or anesthesia care, the beginner may take as much time as necessary.
- General anesthesia dilates peripheral veins and makes locating and cannulating veins that much easier.

SUMMARY

Here are the *Pretty Good Rules* for beginners to follow:

- *Start with the most distal site, not the easiest site*. You can always work you way downstream (i.e., moving more proximally). However, veins punctured in failed cannulation attempts are unreliable: nothing upstream is trustworthy.
- *Enter the vessel exactly along the axis of the vessel.* As the angle of approach deviates from this axis, the chances of failure increase. Entering the vein along the axis of the vein maximizes the likelihood that advancing the device far enough after initial puncture will keep the point of the device in the lumen, and not exit the back wall.
- *Enter the skin well distal from where you plan to enter the vein.* Attempting to enter the skin at the site where you plan to enter the vessel obligates you puncture the vein from above, not along the axis of the vessel. Give yourself running room to get the device under the skin and leveled out well away from the planned vein puncture site.
- *After flashback, advance the entire device further before attempting to thread the catheter*. Absolutely the most important of the Pretty Good Rules. No matter how small the catheter, the initial entry of the needle into the vessel still leaves the catheter outside the vessel. If you have entered along the axis, you will have room to advance the device far enough to get the catheter in the vessel as well as the needle.
- *Do not let up on traction with the nondominant hand until the catheter is threaded into the vessel*. Make life easy on yourself. Traction on the vessel keeps it straight while you thread the catheter in peace.

- *Place the largest catheter the vessel will accommodate*. This Pretty Good Rule becomes more important as confidence, experience, and proficiency increase. You gain valuable experience and future patients who might need the biggest catheter possible will be thankful for your prior experience.

Go and apply these principles. Your patients will thank you.

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