

PARAMEDIC EDUCATION

Vascular Access

Anatomy, technique, complications, and the escalation

General practice reference — always defer to your local protocol and medical director

What we are covering

- 1 Review venous anatomy and the physics that govern flow through a catheter
- 2 Select the right fluid, gauge, and site for the clinical problem in front of you
- 3 Perform venipuncture with aseptic technique and secure a reliable line
- 4 Recognize, prevent, and manage the complications of peripheral access
- 5 Apply an escalation pathway — reassess, use ultrasound, or move to intraosseous

Why we establish access

Established indications

- Cardiac arrest and peri-arrest resuscitation
- Volume replacement in shock or hypovolemia
- Medications with no reliable alternative route
- Titrated infusions requiring a controlled rate
- Anticipated deterioration during a long transport

Weak indications

- “Just in case” on a stable patient with no drug or fluid need
- To satisfy a habit, a checklist, or a receiving facility preference
- When an oral, IN, or IM route would work as well
- When starting it delays a time-critical intervention or transport

Every catheter is a break in the skin barrier and a device the hospital must manage. The indication should survive being said out loud.

Choosing a route

Route	Best for	Trade-offs
Peripheral IV	Default for nearly every patient	Fails in shock, dehydration, and scarred veins
External jugular	Critical patient, no peripheral option	Positional; needs a supine, tolerant patient
Intraosseous	Arrest, shock, failed or impossible PIV	Painful when awake; requires pressure infusion
Existing device	Port, PICC, dialysis catheter already in place	Usually outside EMS scope; infection risk
Alternative routes	IN, IM, SL, nebulized, PO	Slower and less titratable, but often sufficient

The best route is the one that delivers the drug the patient needs in the time frame the patient has.

Venous anatomy that matters

The upper extremity map

- Dorsal metacarpal network — small, mobile, easily accessed
- Cephalic — runs the radial forearm into the upper arm; the classic workhorse
- Basilic — ulnar side, large but rolls and sits near nerves
- Median cubital — bridges the AC; large, but overlies the brachial artery and median nerve

Why veins behave the way they do

- Three layers — intima, media, adventitia. Thin walls collapse under low pressure
- Valves appear at branch points; a catheter tip against one will not flush
- Veins are held loosely in subcutaneous tissue — this is why they roll
- Cold, hypovolemia, and catecholamines all constrict them

Choose a straight segment between bifurcations — that is where the vein is widest and valve-free.

Choosing the fluid

Fluid	Composition	Use it for	Watch for
0.9% NaCl	Na, Cl	Universal default; drug compatible	Hyperchloremic acidosis at volume
Lactated Ringer's	Na, K, Ca, lactate	Trauma, burns, large-volume resuscitation	Calcium; check drug compatibility
Balanced crystalloid	Physiologic electrolytes	Increasingly favored for large volumes	Availability varies by service
D5W	Free water + dextrose	Drug dilution, not volume expansion	No meaningful intravascular expansion



Prehospital fluid is a bridge, not a treatment. In hemorrhage, the fluid the patient needs is blood — volume buys minutes, not correction.

Compositions are approximate and vary by manufacturer. Fluid choice is a protocol decision.

The physics of flow

Doubling the radius multiplies flow roughly sixteenfold.

Doubling the length halves it.

GRAVITY FLOW, APPROXIMATE

14 G	~330 mL/min
16 G	~215 mL/min
18 G	~105 mL/min
20 G	~65 mL/min
22 G	~35 mL/min

DRIP RATE FORMULA

gtt/min = (volume in mL × drop factor) ÷ time in minutes

DROP FACTORS

Macrodrop 10, 15, or 20 gtt/mL — printed on the package. Microdrop 60 gtt/mL for pediatrics and titrated infusions.

WORKED EXAMPLE

500 mL over 30 min with a 10 gtt/mL set: $(500 \times 10) \div 30 = 167$ gtt/min — effectively wide open.

Flow figures are manufacturer gravity ratings with water; real-world flow through a bent, taped, viscous line is always lower.

Choosing a catheter

Gauge	Typical use	Common site
14-16 G	Major trauma, massive hemorrhage, rapid volume	Antecubital or large forearm
18 G	Fluid resuscitation, blood product capable	Forearm, AC, large hand vein
20 G	Most medical patients and medication routes	Forearm, hand
22-24 G	Pediatrics, elderly, fragile or small veins	Hand, wrist, foot; scalp in infants

Smallest that works

Larger catheters raise phlebitis and failure rates. Use the smallest gauge that supports the therapy.

Catheter-to-vein ratio

The catheter should occupy no more than about a third of the vessel. Blood needs to flow past it.

A 22 G that works beats an 18 G that blows. Every time. Take the vein you can actually cannulate.

Set up before you glove

● IV solution

Right fluid, clear, no particulate, in date, ports intact.

● Administration set

Known drop factor, covers on both ends, clamp closed high on the tubing.

● Catheter

Right gauge, package sealed, hub loosened with a twist before insertion.

● Start kit

Antiseptic, gauze, tourniquet, transparent dressing, securement, tape.

● Sharps container

Open and within reach before the needle is ever uncapped.

● PPE

Gloves minimum; eye protection whenever blood may spray.

Tear your tape and open your dressing first. Chasing supplies one-handed with a flashing catheter is how lines get lost.

Aseptic non-touch technique

Protect the key parts

- Key sites: the prepped skin and the puncture wound itself
- Key parts: catheter hub, tubing spike, connector, syringe tip
- Nothing that touches a key part may touch anything else first
- Keep caps on until the moment of connection

Where field technique breaks down

- Hand hygiene skipped entirely between patients
- Re-palpating the prepped site with an ungloved or unprepped finger
- Tape torn with teeth, or pre-stuck to a dirty rail or thigh
- Catheter or dressing laid on the stretcher, floor, or patient's clothing

Field-placed lines are frequently removed and replaced on ED arrival — clean technique is the argument for keeping yours.

Skin prep: friction, not geometry

What most of us were taught

Concentric circles, working outward from the puncture site. This appeared in the CLSI venipuncture standard for 38 years without a single supporting citation.

Where the standards are now

CLSI dropped the pattern requirement in 2017 and now requires friction only. INS specifies back-and-forth for at least 30 seconds, per the chlorhexidine manufacturer's instructions.

● Friction beats pattern

Roughly a fifth of skin flora sits in deeper layers. Pressure and scrubbing reach it; a light spiral does not. Head-to-head trials of the two patterns disagree, and one volunteer RCT found no difference at all.

● Dry time is the real win

Chlorhexidine-alcohol needs about 30 seconds; povidone-iodine 1.5 to 2 minutes. Let it dry untouched — never fan, blow on it, or wipe it off.

● Re-palpate means re-prep

Touching the site after cleansing recontaminates it. Prep again. This requirement has survived every revision.

Evidence base is surgical, central-line, and volunteer skin-colonization work — there is no prehospital PIV infection outcome data. Follow your system's validated skill sheet.

Finding the vein

Where to look, in order

- Forearm first — stable, comfortable, survives transport and transfer
- Dorsum of the hand — accessible but positional and painful
- Antecubital fossa — large and fast; reserve it for volume, contrast, or codes
- Work distal to proximal so a failed site does not burn the ones above it

How to make one appear

- Tourniquet snug enough to occlude venous return, never arterial — check the distal pulse
- Palpate rather than look; a good vein is soft, springy, and refills after compression
- Dependent position, warmth, and a light tap recruit veins. Slapping does not
- Release the tourniquet if the search runs past a minute, then reapply

Time spent finding a good vein is never wasted. Most missed sticks are site-selection failures, not needle-handling failures.

Sites and limbs to avoid

Dialysis access limb

No IV and no blood pressure on an arm with an AV fistula or graft. Use the other side. In arrest, consult medical control before considering it.

Injured or fractured limb

Delivery distal to injury is unreliable. Avoid burned, infected, or heavily edematous tissue.

Post-mastectomy or lymph node dissection side

Use the opposite limb whenever any alternative exists.

Over a joint or a flexion crease

Positional lines kink, infiltrate, and alarm the whole way to the hospital.

Lower extremities in adults

Higher thrombosis and infection risk. Acceptable in infants and in a genuine last resort.

Sclerosed or previously punctured segments

Hard, cord-like, or bruised veins will not take a catheter. Move proximal or to the other arm.

Ask about dialysis before you touch either arm — the fistula is not always obvious under a sleeve.

Prepare the fluid and set

- 1 Explain the procedure and confirm allergies; take PPE precautions
- 2 Check the solution: correct fluid, clarity, no particulate, in date, ports intact
- 3 Check the set: drop factor, untangled, covers on both ends, clamp closed high
- 4 Remove the drip chamber and bag port covers without touching either
- 5 Insert the spike with a twisting push until the inner seal is punctured
- 6 Invert the bag, squeeze the drip chamber, and fill it halfway
- 7 Open the flow, bleed every bubble from the line, then close the clamp

Air is the enemy

Invert every Y-port and flick the tubing as you prime. Bubbles hide at connectors and are far harder to chase once the line is on the patient.

Hang the bag high enough to develop pressure — chest height on a stretcher is not enough.

Perform the venipuncture

- 1 Tear tape and open dressing, gauze, and antiseptic before gloving
- 2 Apply the tourniquet 10–15 cm above the intended site; palpate and select
- 3 Prep with friction over an area larger than the puncture; let it dry fully
- 4 Open the catheter without contamination; inspect the tip and loosen the hub
- 5 Anchor: grasp below the site and pull the skin taut with your non-dominant thumb
- 6 Warn the patient, then insert bevel up at roughly 10–30° for a superficial vein
- 7 Advance until flashback appears in the chamber, then drop the angle nearly flat

Anchor hard

Rolling veins are unanchored veins. Traction with the non-dominant thumb does more for your success rate than any other single habit.

Stop for these

Shooting or electric pain means nerve contact — withdraw at once. Bright red pulsatile return means artery — remove and hold pressure five minutes or more.

Advance, connect, secure

- 1 Advance the whole unit a few millimetres further to seat the catheter in the lumen
- 2 Hold the stylette still and thread the catheter off it until the hub meets skin
- 3 Occlude the vein with a fingertip just proximal to the catheter tip
- 4 Withdraw the stylette and drop it straight into the sharps container
- 5 Attach the primed tubing or saline lock, maintaining a clean hub
- 6 Release the tourniquet — before you open the flow, not after
- 7 Open the clamp and watch for free flow with no swelling or resistance
- 8 Apply the transparent dressing and securement device, then label it

Label every line

- Date and time of insertion
- Catheter gauge
- Number of attempts
- Your initials

Secure, confirm, hand off

● Secure properly

Transparent semipermeable dressing over the insertion site so it stays visible, plus a securement device or tape bridge on the tubing. Never tape over the puncture itself.

● Confirm patency

Free gravity flow, no swelling, no pain on flush, no resistance. A line that will not flush is not a line — recognize it now, not during a code.

● Build in slack

A loop of tubing anchored to the limb takes the pull when the stretcher moves. Most field lines are lost to traction, not technique.

● Reassess continuously

Check the site at every vitals set and before every push. Swelling, coolness, or a sluggish drip means stop.

● Document

Site, gauge, attempts, who placed it, fluid and rate, patient response. Attempts matter to the receiving team.

● Hand off clearly

Tell the nurse the gauge, the site, whether it was a clean placement, and whether it flushed. Say if asepsis was compromised.

When the vein will not cooperate

Hypovolemic or dehydrated

Veins are flat, not absent. Warm the limb, hang it dependent, and go distal first.

Elderly, fragile skin

Veins roll and tear. Smaller gauge, shallower angle, firm traction without over-stretching.

History of IV drug use

Expect fibrosed segments. Palpate for soft, compressible sections; ask the patient where their veins work.

Obesity or edema

Press and hold to displace fluid, then reassess. Consider a longer catheter or ultrasound.

Moving ambulance

Stop the truck or wait. A failed stick en route costs more time than the pause would have.

Two failed attempts

Hand off to your partner or escalate. Repeated attempts damage veins and destroy patient trust.

A common standard is two attempts per clinician, then escalate to a more skilled provider or a different route.

Ultrasound-guided peripheral access

~1.8x

relative improvement in
first-attempt success

The gap it closes

Landmark first-attempt success in difficult-access patients runs roughly 35–57%. Ultrasound moves that substantially in trial after trial.

What the evidence supports

- Meta-analyses consistently show higher first-attempt and overall success in difficult-access patients, with fewer punctures and shorter procedure times
- Benefits extend to pediatrics, where landmark success rates are lowest
- Longer dwell times and fewer downstream central lines — the hospital feels the benefit too
- INS advises escalating to ultrasound after one or two failed conventional attempts
- It is a trained skill, not a rescue trick — structured training and supervised reps are the precondition

Adopt only within your scope and with a credentialing pathway. Prehospital-specific outcome data remain thinner than the ED literature.

External jugular cannulation

Technique

- Supine, head slightly down and turned away from the side you are using
- The vein runs from the angle of the jaw toward the mid-clavicle
- Occlude just above the clavicle to distend it — this is your tourniquet
- Enter almost parallel to the skin, pointing toward the shoulder
- Secure well; there is no limb to splint against

Cautions

- Not for the combative or the awake-and-unwilling patient
- Avoid with suspected cervical spine injury or a collar in place
- Air embolism risk is real — keep the site below heart level and occlude the hub
- Neck hematoma can compromise the airway
- Confirm it is in your scope before you practice it

In practice, most services that carry an IO driver reach for it before the EJ. Know both; choose deliberately.

Mechanical complications

Complication	Recognize	Manage
Infiltration	Swelling, coolness, taut skin, sluggish flow	Stop, remove, elevate, restart elsewhere
Extravasation	Same signs with a vesicant drug infusing	Stop immediately; aspirate if able; notify ED urgently
Hematoma	Immediate swelling and bruising at the site	Release tourniquet, remove, hold direct pressure
Nerve contact	Shooting, electric, or radiating pain on insertion	Withdraw at once; document; do not re-attempt there
Arterial puncture	Bright red, pulsatile, pressurized return	Remove; hold five minutes or more; reassess distal perfusion
Occlusion or dislodgement	Will not flush, or the hub has backed out	Do not force. Remove and replace.

Infiltration is common and forgivable. Missing it for twenty minutes is neither.

Infectious and embolic complications

Phlebitis

Redness, warmth, tenderness, or a palpable cord along the vein. Can be mechanical, chemical, or bacterial. Discontinue, warm compress, document.

Catheter-related bloodstream infection

A downstream consequence of field asepsis. Rare from short-dwell PIVs, but the reason clean technique is non-negotiable.

Air embolism

Sudden dyspnea, hypotension, altered mental status. Clamp the line, place left lateral with head down, high-flow oxygen, transport now.

Catheter fragment embolism

Caused by rethreading a stylette into a partly withdrawn catheter. Never do it. If it happens, apply a proximal tourniquet and notify the ED immediately.

Speed shock

Systemic reaction to a drug delivered too fast. Slow or stop the infusion, support ABCs, reassess the push rate.

Local site infection

Purulence, warmth, erythema at an existing site. Do not use it. Choose a fresh site with full aseptic technique.

When to stop sticking and start drilling

1

Attempt

One or two peripheral attempts by the most capable provider present.



2

Reassess

No success, no visible target, or the patient cannot wait any longer.



3

Drill

Proximal humerus or proximal tibia.
Same drugs, same doses, comparable delivery.

Go early when

Cardiac arrest • profound shock • no visible or palpable target • the drug cannot wait

Do not drill when

Fracture in the target bone • infection over the insertion site • IO or attempted IO in that bone within 48 hours • prior orthopedic procedure, prosthesis, or joint at the site • landmarks not identifiable

Landmarks: humerus and tibia

Proximal humerus

- Adduct the elbow and internally rotate: hand over the abdomen, or palm turned out with the thumb down
- Palm on the anterior shoulder — the “ball” under your palm is the target, palpable even in obese patients with deep pressure
- Palpate deeply up to the surgical neck. It feels like a golf ball on a tee; the site is 1–2 cm above where they meet, on the greater tubercle

45° to the anterior plane, aimed posteromedially

Proximal tibia

- Extend the leg fully
- Adult: about 2 cm medial to the tibial tuberosity — or roughly 3 cm below the patella and 2 cm medial — on the flat aspect of the bone
- Infant or child: about 1 cm medial to the tuberosity, or 1 cm below the patella and 1 cm medial. Pinch the tibia to find its borders

90° to the bone

ALSO AVAILABLE

Distal tibia — about 3 cm proximal to the medial malleolus in adults, 1–2 cm in children, on the flat center aspect. • Distal femur (infant and child) — leg outstretched and straight, just proximal to the patella by no more than 1 cm and 1–2 cm medial to midline.

Landmarks and angles follow the Arrow EZ-IO procedure guidance. Confirm against the device your service actually carries.

Placement, step by step

- 1 Prep the skin with the same asepsis you would use for an IV
- 2 Select the needle set by weight, anatomy, and tissue depth
- 3 Attach the needle set to the driver and remove the safety cap
- 4 Insert through the skin at the correct angle until the tip meets bone
- 5 Confirm the 5 mm black line is visible above the skin before drilling
- 6 Drill with steady, gentle pressure; release on the give or at the hub
- 7 Stabilize the hub, remove driver and stylet, sharps immediately
- 8 Apply the stabilizer dressing over the catheter hub
- 9 Attach the primed extension set with the clamp open
- 10 Treat pain before the flush in the responsive patient
- 11 Flush firmly — 5–10 mL adult, 2–5 mL infant or child; may take several
- 12 Infuse under pressure, immobilize the limb, reassess the site often

REMOVAL

Attach a sterile luer-lock syringe as a handle, keep the catheter in alignment, and rotate clockwise while pulling straight up. Never rock or bend it.

Needle selection and pain control

Manufacturer guidance

Needle set	Considered for
15 mm · pink	Patients approximately 3–39 kg
25 mm · blue	Patients 3 kg and greater
45 mm · yellow	Proximal humerus at 40 kg+, or excessive tissue over any site

WEIGHT STARTS IT — THE BLACK LINE DECIDES IT

The ranges overlap on purpose. With the tip touching bone, the 5 mm black line must be visible above the skin. If it is not, the needle is too short.

Pain control for the responsive patient

THE FLUSH IS THE PAINFUL PART

Insertion is usually tolerable. Forcing fluid into the marrow is what hurts. Treat it before the flush, not after the patient screams.

TYPICAL SEQUENCE

Prime the extension set with 2% preservative-free, epinephrine-free lidocaine. Infuse slowly, allow it to dwell in the IO space, then flush. A smaller repeat dose is commonly given afterward and may be repeated as needed.

Confirm every dose and dwell time against your own protocol — the manufacturer explicitly defers to it.

Pediatrics and complex patients

Infants and small children

Small gauges, generous immobilization, and an assistant. Dorsum of the hand and foot, saphenous, and scalp veins in infants.

The critical child

Low threshold for IO. Landmark success rates are worst in this group and the clock is shortest.

Dialysis patients

No IV and no cuff on the access arm. Their access is their lifeline; treat it that way.

Oncology and long-term therapy

Implanted ports and PICCs require non-coring needles and specific training. Usually outside EMS scope.

Obesity

Longer catheters and ultrasound solve most of this. Deep veins reached with a short catheter dislodge quickly.

Anticoagulated patients

Expect prolonged bleeding and larger hematomas. Hold pressure longer than feels necessary.

Six things to carry out the door

1 The indication should survive being said out loud — access is never the goal by itself.

2 Assemble, prime, and bleed the line before you touch the skin.

3 Friction, coverage, and full dry time. The pattern was never the active ingredient.

4 Anchor the vein, enter shallow, drop the angle at flashback, then thread.

5 Two attempts, then escalate — a partner, ultrasound, or the drill.

6 Secure it, label it, and reassess the site at every single vitals check.