3

IV ACCESS AND MEDICATION ADMINISTRATION

One of the major differences between the care of the medical patient and that of the trauma patient is the ability to make a significant impact on the patient's condition through the use of medications. In the medical patient, medications are used to control cardiac dysrhythmias, correct shock, relieve pain, and more. Immediate correction of urgent traumatic conditions is largely surgical. The use of IV and other methods of medication administration is an important difference between basic and advanced field providers. Not only does the advanced training provide the skills necessary to gain intravenous access and administer medications, it should also provide the clinical decision-making skills to identify when vascular access and medications are necessary.

Topics that will be covered in this chapter are:

- Medication Administration
- Medication Administration Methods
- Venous Access
- Delivering Medication by Injection
- Other Methods of Medication Administration

CASE STUDY

Your advanced life support unit is dispatched to a call for a "man down." Fire department EMTs are on the scene rapidly and radio you that the patient is in cardiac arrest.

Upon arrival at the scene, you and your partner gather your equipment, including cardiac monitor and defibrillator, drug box, and airway supplies. Since you already know you'll be working a cardiac arrest, you put on gloves and protective eyewear.

The EMTs have defibrillated the patient with two sets of three shocks each. They report that the 59-year-old male patient had collapsed after dinner, without warning. The EMTs continue CPR while your partner prepares to defibrillate again. You prepare to intubate the patient. The patient's cardiac rhythm converts to asystole.

You intubate the patient. Your partner sets up a bag of normal saline and attempts an IV in the patient's left arm. The IV attempt is unsuccessful.

What should you and your partner do next for this patient?

INTRODUCTION

The two main purposes of this chapter are to review medication administration procedures and to discuss the decision-making process necessary when deciding whether or not to use these advanced skills. The information in this chapter, combined with the other procedural and clinical topics in other chapters, will help provide information for forming such clinical decisions.

MEDICATION ADMINISTRATION

Medication administration is a great responsibility. While medications can correct life-threatening heart dysrhythmias, reverse diabetic conditions, and relieve pain, they can also cause serious complications or death if administered improperly or to a patient who has allergies to a medication. Some common rules are taught to any medical professional who has the responsibility for administering medications. These are often referred to as the "five rights":

- *Right medication*. Am I administering the correct/intended medication?
- *Right dose*. Am I administering the right amount of the medication? Is the medication's concentration correct? Is the rate of administration correct?
- *Right route*. Am I administering the medication via the right route? (Some medications, when delivered by the wrong route, have much different effects than intended.)
- *Right patient*. Am I administering the medication to the patient who needs it and for whom it is intended?

The Five Rights

Right medication
Right dose
Right route
Right patient
Right time

- *Right time*. Will the patient benefit from this medication at this particular place and time? Is this medication clinically indicated for the patient's current condition?

Most of the other chapters in this textbook deal with the last two items (right patient, right time). The first three items (right medication, right dose, right route) relate to the actual administration of a medication, the subject of this chapter. Administering a medication should always be taken seriously.

A final right, right documentation, has also been suggested. There are few situations where documentation is more important than medication administration. Remember to document the IV attempt(s), location, catheter gauge, fluid administered, amount of fluid administered, and type of administration set. For any medication administration, note the date, time, medication, amount, route, site, and effects of the medication. Always document any problems, errors, or complications noted during care.

MEDICATION ADMINISTRATION METHODS

There are many methods of administering medications. *Parenteral* routes (those not utilizing the digestive system) are the most common in the emergency setting. The oral, sublingual, and rectal (*enteral*) routes are used for specific situations.

parenteral routes routes of medication other than by the digestive tract, including intravenous, intramuscular, subcutaneous, intraosseous, transdermal, endotracheal, and inhalation.

The main principle to remember when administering medications in the emergency setting is: Medications administered close to the central circulation are absorbed rapidly and reliably. As distance increases between the administration site and the target organ, the absorption time increases and the reliability of absorption decreases.

Medication administration routes with some of the pros and cons of each are summarized here.

enteral routes routes of medication through the digestive tract, including oral, sublingual, and rectal.

- *Intravenous*. A mainstay of advanced emergency care, aseptically started peripheral IVs provide rapid, predictable absorption with minimal complications.
- *Intramuscular*. Used more frequently in routine medical care, IM injections provide a predictable but slower absorption rate than IVs. IM injections may be used when IV access cannot be obtained (e.g., Glucagon).
- *Subcutaneous*. Subcutaneous injections are used to obtain intentionally slower absorption for prolonged effect. Epinephrine has been injected via this route for conditions such as anaphylaxis.
- *Endotracheal*. This route provides rapid absorption of certain medications (epinephrine, lidocaine, atropine, and naloxone). Most sources recommend an increase in concentration and/or volume of any drug administered by the endotracheal route.
- *Intraosseous*. Used largely in pediatric patients, this route is used when IV access cannot be obtained. Some recent medical literature re-explores the use of intraosseous infusion in adults.
- *Inhalation*. Drugs that affect the respiratory system act rapidly and efficiently when administered by this route. Inhaled drugs may be administered via aerosolized treatments and inhalers.
- *Transdermal*. Some medications, such as nitrates, are effectively absorbed through the skin. This route provides constant, prolonged administration of the medication.

Medications administered close to the central circulation are absorbed rapidly and reliably. As distance increases between the administration site and the target organ, the absorption time increases and the reliability of absorption decreases.

- *Oral*. With the exception of activated charcoal and syrup of ipecac, most oral medications are not even considered for use in an unstable patient. Absorption from the digestive tract of an unstable patient ranges from unpredictable to absent, as does the ability of the unstable patient to swallow or to protect the airway from aspiration.
- *Sublingual*. Some medications are efficiently absorbed from under the tongue. These include nitroglycerin and nifedipine. Sublingual injection (injection into the vascular area under the tongue) may also be used for some medications.
- *Rectal*. Medications may be absorbed through the rectal mucosa. One indication for this route is Valium administration for a seizure patient when IV access is not possible.

VENOUS ACCESS

Note: Always use appropriate body substance isolation techniques when performing any procedure that has the potential to expose you to a patient's blood or other body fluids.

Decision Making

Clinical Insight

Clinical judgment includes when to start an IV or give a medication—and when *not* to. It is sometimes more difficult to decide that a patient doesn't need the IV or medication than when he does. Use the entire clinical picture in your decision making. Err on the side of caution if in doubt.

There are many factors that influence the decision to initiate IV access and administer medications. The most obvious and important consideration is: What decision will benefit my patient the most?

Considerations for the use of (or decision not to use) IV or medication therapy include:

- Standing orders
- The need to administer medications or deliver a fluid challenge
- Your perception of the patient's stability
- Benefit vs. risk analysis
- Consultation with medical direction

A term for the combination of these considerations is "clinical judgment." It is a main purpose of this text to provide practical information on a variety of adult medical emergencies that will help enable you to make appropriate decisions regarding patient care procedures such as IV therapy.

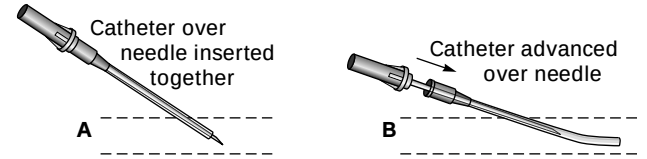
Peripheral and Central Lines

peripheral veins the veins of the arms and legs and the external jugular vein.

central veins veins that are part of the central circulation, including the internal jugular vein and the subclavian vein.

The two main types of venous access are peripheral and central. *Peripheral venous* access is widely practiced in the out-of-hospital setting. Medications and fluids are administered into veins of the arms and legs as well as the external jugular vein. Peripheral IV access is relatively safe, easy, and effective in the prehospital setting.

Central venous IVs are not common in the field. There is a higher risk of serious complications with central cannulation, and the technique is difficult to master, especially when not performed frequently. This text will focus on peripheral venous cannulation because of the predominance of this procedure in the field. If you are allowed or required to do central IVs, knowledge and practice are essential. Please refer to the many excellent sources of in-depth information available on this topic.



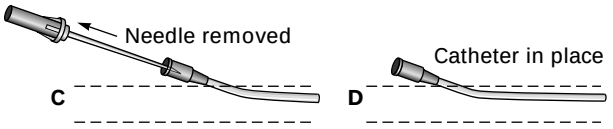
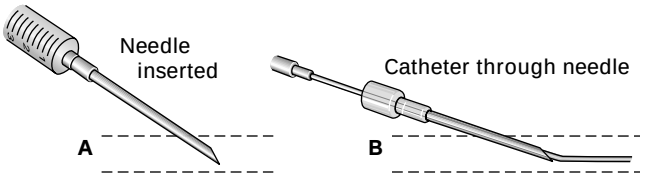


FIGURE 3-1
Insertion of catheter-over-needle device.



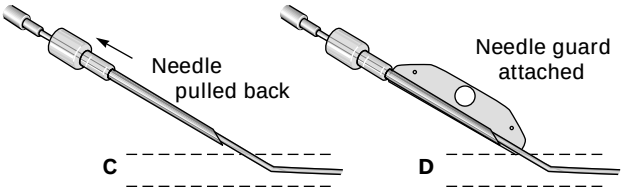


FIGURE 3-2
Insertion of catheter-through-needle device.

Three general types of intravenous needle or catheter are available:

- *The catheter-over-needle device* (Figure 3-1). This is by far the most common device used for peripheral venous cannulation. The catheter is placed over the needle, and needle and catheter are inserted simultaneously into the vein. The needle is removed and the catheter remains in place.
- *The catheter-through-needle device* (Figure 3-2). A catheter is fed through a larger bore needle into the vein. This method is used frequently for central venous cannulation.
- *The hollow needle or "butterfly."* This type is used primarily in pediatric patients. The metal needle remains inside the patient's vein. This leads to a higher rate of infiltration and damage to the vein.

Performing Venipuncture

Once a decision is made to initiate intravenous therapy, several other considerations exist. These include:

- *Where will I start the IV?* For patients who require a medication or fluid bolus, veins closest to the central circulation are largest (larger bore IVs may be used) and provide an efficient route for the medications to reach the central circulation (Figure 3-3 A to C).
- *What catheter size and type will I use?* Choose an IV catheter that will be functional in a worst-case scenario. Often IVs are started as a "precaution," but are not large enough to handle the type of administration that turns out to be needed (e.g., a fluid challenge or large-volume injection such as D_{50}).

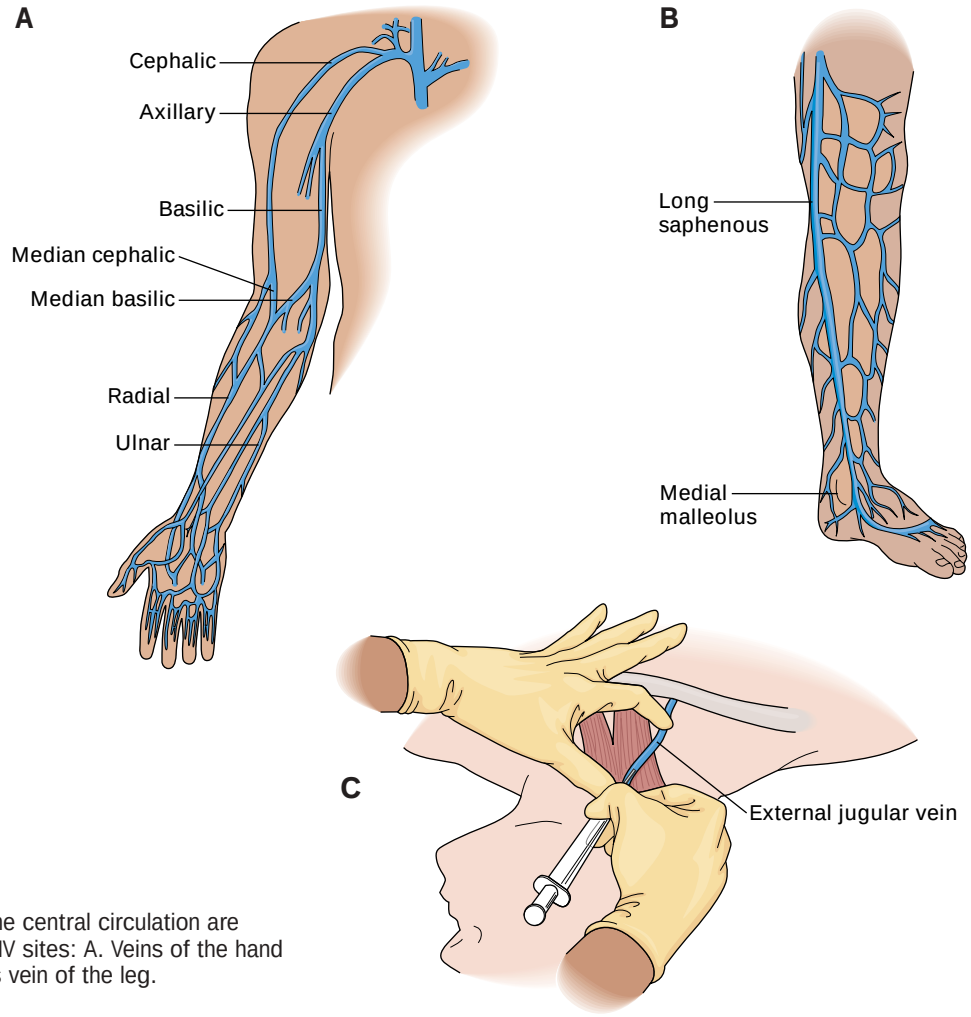


FIGURE 3-3
Peripheral veins closest to the central circulation are generally the most effective IV sites: A. Veins of the hand and arm. B. Long saphenous vein of the leg. C. External jugular vein.

Clinical Insight

We pride ourselves on the ability to start an IV in the worst of situations—and many consider missed IVs as the ultimate failure in patient care. It will happen. When it does, remember that there are many facets of patient care, including excellent BLS, compassionate emotional care, and alternative methods of administering medications. Don't lose sight of the end goal because of problems on the way there.

- *Where should I perform the venipuncture?* Examine the benefits and risks of starting the IV at the scene versus en route to the hospital. While this is often a consideration in trauma, there are also medical applications. You will also find that getting the patient into a suitable position will improve your chances for success in starting an IV. If you are in a very cramped space or have to reach across a patient, moving the patient to the stretcher or a different position will be very beneficial. Starting the IV in the ambulance may expedite transport and increase the equipment you have available. However, starting an IV in a moving ambulance can be challenging.
- *If the first IV is unsuccessful, how many will I try?* In this case, weigh the benefits versus the risks and delays in continued attempts to gain access. Criteria for determining this include time, patient stability, alternative routes of medication administration available, and the patient's comfort and consent. Also, the more attempts that are made, the fewer the options that will be available for ED personnel to obtain peripheral venous access.

Patients who are candidates for thrombolytic therapy should not receive multiple venipunctures unless necessary to stabilize a critical condition, because thrombolytic drugs decrease clotting and increase the danger of serious bleeding from any wound.

Procedure for Peripheral Venipuncture

To perform a peripheral venipuncture (Figure 3-4 A to F):

1. Take body substance isolation precautions.
2. Choose an appropriate IV solution for the patient's condition.
3. Attach IV tubing to the bag and run fluid through the tubing.
4. Determine where you will be starting the IV. Choose a peripheral site to look for a vein.
5. Apply a venous tourniquet (the obvious exception is for the external jugular, where the proximal portion of the vein is occluded by pressing on it with a finger). This should not eliminate all blood flow, just impede the return of venous blood, which will engorge the veins.
6. Choose a vein. Vein choice is important. Choose a vein that appears to be anchored. Superficial veins may look large and tempting but may roll.
7. Cleanse the skin over and around the vein with an antiseptic wipe.
8. Insert the needle and catheter, bevel up. When you enter the vein you will feel a "pop." You may also see a flash of blood in the hub of the catheter.
9. When you have felt the pop, advance the needle and catheter slightly to assure that you are in the vein. You may attach a small syringe to the catheter and withdraw blood to verify placement in the vein.
10. While grasping the hub of the needle, advance the catheter over the needle and into the vein.
11. Completely remove the needle. Remove the tourniquet. Be sure that one hand is holding the hub of the catheter so it does not become dislodged from the vein.
12. Attach the tubing to the catheter and begin the flow of fluids. Observe for signs of infiltration.
13. Be sure to dispose of the contaminated sharp in an appropriate container. Do not recap needles.
14. Cover the site where the catheter enters the skin with a sterile dressing or sterile commercially available device. Secure the catheter and tubing to prevent accidental displacement.
15. Monitor the IV site, tubing, and any drip medications for complications.
16. Document IV location, catheter size, fluid, and time.

Procedure for External Jugular Cannulation

As has been mentioned throughout this chapter, peripheral IVs placed closest to the central circulation are the most effective. Though located in the neck (Figure 3-5A), the external jugular vein is considered a peripheral site. This site is used in cardiac arrest or when other peripheral sites cannot be obtained in critical situations.

To perform an external jugular cannulation (Figure 3-5B):

1. Take body substance isolation precautions.
2. Place the patient in a Trendelenburg position. Turn the patient's head to the opposite side.
3. Cleanse the injection site with an antiseptic wipe.
4. Place one gloved finger on the proximal portion of the external jugular vein just above the clavicle to occlude blood flow.

PERIPHERAL VENIPUNCTURE PROCEDURE

FIGURE 3-4A Cleanse the site with an antiseptic.

FIGURE 3-4B Insert the needle and catheter, bevel up, until a pop is felt. Advance the needle and catheter slightly to assure placement. Then thread the catheter over the needle into the vein.

FIGURE 3-4C Remove the needle and insert a syringe to withdraw blood and verify placement in the vein. Discard the needle properly.

FIGURE 3-4D Attach the tubing to the catheter.

FIGURE 3-4E Begin the flow of fluids. Observe for signs of infiltration.

FIGURE 3-4F Secure the site.

A B

FIGURE 3-5
The external jugular vein is considered a peripheral IV site. A. Location of the external jugular vein. B. Cannulation of the external jugular vein.

5. Using a 14- or 16-gauge catheter, align the catheter with the vein. The catheter should be pointing in the direction of the shoulder. Puncture the vein midway between the angle of the jaw and your finger, which is acting as the tourniquet.
6. Continue the procedure as you would for any other peripheral IV. Note: Some recommend attaching a syringe to the needle so that IV placement can be checked.

Heparin or Saline Locks

When continuous IV fluids are not necessary, but occasional medication drips or boluses may be needed, heparin or saline locks are used (Figure 3-6). These devices also decrease the risk of accidental fluid overload or electrolyte derangement. If seated in a suitable vein, and if protocols allow, blood may be withdrawn from the lock.

Complications associated with intravenous therapy are rare and include extravasation (infiltration), hematoma, local infection, phlebitis, sepsis, and embolization.

Complications of Intravenous Therapy

Complications associated with intravenous therapy are rare and include extravasation (infiltration) of IV fluids, hematoma, local infection, and phlebitis. More serious complications such as sepsis or embolization are possible.

FIGURE 3-6
A heparin or saline lock regulates IV flow and decreases the risk of accidental fluid overload or electrolyte derangement.

Extravasation is an occasional complication. The use of butterfly catheters and the use of catheters near a joint increase the risk of extravasation. Depending on the size of the patient and the location of the IV, up to one liter of fluid may leak unnoticed into surrounding tissue. Hypertonic solutions and those with extreme deviations from the body's pH may cause pain and tissue damage or tissue death.

Complications may also occur if the IV bag and tubing are not monitored. A "runaway IV" (one that is flowing wide-open) may quickly overload the medical patient with fluid. Kinked tubing will prevent fluid and medications from reaching the patient. When troubleshooting problems, be sure to check the entire length of IV from the bag to the catheter.

Intravenous Solutions

Intravenous solutions are classified in many ways. Some intravenous solutions are crystalloids, meaning they have small molecules and a low osmotic pressure. These solutions are typically used in the field. Normal saline and lactated Ringer's solution are crystalloid solutions commonly used for patients in shock.

Colloid solutions have large molecules and a higher osmotic pressure. These solutions will remain in the vascular space and are theoretically best in situations where fluid resuscitation is required. Unfortunately, most colloid solutions (whole blood or packed red blood cells, plasma, and plasma substitutes) are expensive, have strict requirements for temperature, and limited expiration dates, which make use in the field impractical.

Solutions are also classified by their tonicity (hypo-, hyper-, or isotonic):

- *Hypotonic solutions* have a lower solute concentration than the body's cells. One hypotonic solution, for example, is ½ normal saline.
- *Hypertonic solutions* have a greater solute concentration. An example of a hypertonic solution is 50% dextrose (D_{50}).
- *Isotonic solutions* have a solute concentration equal to the body's cells. Lactated Ringer's solution and normal saline are examples of isotonic solutions.

The final method of classifying solutions is by their content (dextrose, saline, lactated Ringer's solution, and so forth). This classification also helps to determine an appropriate solution. For example, stroke and head injury patients are not given dextrose-containing solutions, while diabetic patients may benefit from the dextrose.

Flow Rates

microdrip set an intravenous administration set that delivers one milliliter with 60 drops of fluid.

macrodrip set an intravenous administration set that delivers one milliliter with 10 or 15 drops of fluid.

Intravenous solutions are delivered through administration sets. These sets are either microdrip or macrodrip. With a *microdrip set,* 60 drops equal one milliliter. With a *macrodrip set,* 10 drops (or 15, depending on the set) equal one milliliter. It is essential to know the type of set you are using in order to calculate the flow rate of an IV and to accurately deliver any medications by intravenous drip or piggyback.

To calculate a flow rate in gtt (drops) per minute, use the following equation:

$$\text{gtt/min} = \text{volume to be infused} \times \text{gtt/ml of administration set} \div \text{time of infusion in minutes}$$

For example, if you were to deliver 100 ml per hour using a macrodrip set:

$$\text{gtt/min} = (100 \times 10) \div 60$$

Result: approximately 17 gtt/min

IV BOLUS OR "PUSH" ADMINISTRATION PROCEDURE

FIGURE 3-7A Draw up the correct amount of medication (or verify the amount in a preloaded syringe).

FIGURE 3-7B Cleanse the injection site.

FIGURE 3-7C Insert the needle into the medication port. Pinch the tubing above the port.

FIGURE 3-7D Inject the medication at an appropriate rate.

IV Administration of Medications

The preferred route of medication administration is through an IV line. With the exception of central lines, peripheral IV lines are the most dependable and rapid way of administering medication to the critical or potentially unstable patient. Because this method of administration provides rapid access to the patient's circulation, the potential hazards are also greater. Errors in medication, dose or concentration, or undiscovered allergies may prove rapidly fatal. Caution must be taken in all parts of the preparation and actual administration of the medication.

IV administration provides rapid access to the circulation, so potential hazards are also greater. Caution must be taken in preparation and administration.

IV Bolus or "Push" Administration In this method, the given dosage of medication is administered all at once, as a *bolus*. The steps for IV *push* medication administration, listed below, assume that an IV line has already been established (Figure 3-7 A to D). Remember: *Always take appropriate infection control precautions and use sterile technique.*

bolus a concentrated dose of medication given rapidly by intravenous injection.

push the method of administering a bolus of medication intravenously in one rapid dose.

1. Identify the drug to be administered. Verify the need for the drug, the route, concentration, dose, expiration date, and clarity of the liquid. Check for allergies and contraindications. Verify that the IV line is patent and running.
2. Draw up the correct amount of medication (or verify the amount in a preloaded syringe).

3. Choose a port in the IV tubing. The one closest to the point of entry into the patient is usually preferred. Cleanse the port with an antiseptic wipe.
4. Carefully insert the needle of the syringe containing the medication into the center of the port. Pinch the tubing above the port to prevent backflow.
5. Inject the medication. Be sure to inject the medication at an appropriate rate. Some medications (e.g., adenosine) require very rapid administration, while others (e.g., morphine, verapamil) are administered slowly. Medications will be moved to the circulation faster if a saline flush (approximately 20 ml) is used after administration.
6. Discard the sharp in an appropriate container.
7. Monitor the patient, the IV and drip rate, and the patient's reaction to the medication frequently.
8. Record the time of administration and any reactions (or lack of reactions).

Note: Many medications are now administered using a needleless system. This has become an OSHA requirement.

IV Drip or "Piggyback" Administration Medications that are beneficial to a patient as an IV bolus may be additionally beneficial when given as a *drip*, that is, in smaller amounts over time. A prime example is lidocaine which is given by bolus, followed by a drip. Many other medications can also be given via drip, including, epinephrine and nitrates, and it is the only route of administration for medications such as dobutamine and dopamine.

drip slow intravenous administration of a medication, one drop at a time.

Since syringes or vials containing medications to mix for IV drip administration contain a higher concentration of medication than IV bolus medications, never administer a medication designed exclusively for drip use directly into a vein.

Remember as you read the following steps (Figure 3-8 A to D) that an IV drip, or *piggyback*, requires two full IV setups (bags, tubing, alcohol wipes, etc.)—one being the original IV set-up with fluid running at a TKO (to keep open) rate, the other being the medication infusion set-up that will be "piggybacked" onto the first set-up via a port in the tubing of the original IV set-up.

piggyback IV drip administration of a medication achieved by inserting the drip medication administration set into a port in the original intravenous line.

1. Be sure the original IV line is patent, dependable, and flowing properly. Without this line, the piggyback drip will not be possible.
2. Inject the drip medication into the second IV bag. Be sure to use the proper amount and concentration of the medication to get the correct mg/ml in the drip bag. As with any medication administration, use sterile technique. Cleanse the port on the IV bag, then insert the syringe with the medication. Verify the expiration date on both the drip fluid and the medication. Allow the medication to properly mix with the fluid.
3. Assemble the IV delivery tubing with the freshly mixed drip bag. Flow the fluid through the tubing to eliminate bubbles.
4. Place a sterile needle on the end of the tubing attached to the piggyback bag. Cleanse a port on the original IV tubing and insert the needle attached to the drip tubing. Secure the tubings so the needle does not become dislodged. (Some agencies and hospitals use "needleless" systems for drips and medication administration.)
5. Open the flow on the drip tubing and watch for IV flow in the drip chamber. Close the flow on the original IV. The only fluid being delivered to the patient is now from the piggybacked IV drip with medications added.

Syringes or vials containing medications to mix for IV drip administration contain a higher concentration of medication than IV bolus medications. Never administer a medication designed exclusively for drip use directly into a vein.

IV DRIP OR "PIGGYBACK" ADMINISTRATION PROCEDURE

FIGURE 3-8A Inject the correct amount of the drug into the IV bag and allow the medication to mix with the fluid in the bag.

FIGURE 3-8B Attach a sterile needle to the tubing from the piggyback bag and insert it into a cleansed port on the original IV tubing.

FIGURE 3-8C Adjust the flow rate.

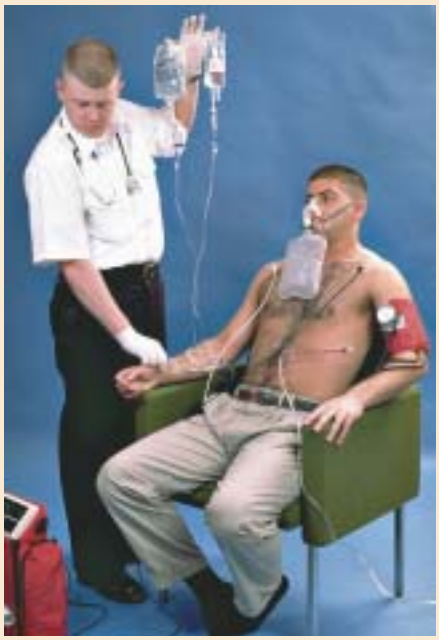


FIGURE 3-8D Monitor the patient

6. Set the flow rate to deliver the medication amount you wish to deliver over the appropriate time.
7. Carefully label the IV bag with the medication, concentration or amount of medication in the bag, the date and time started, and your initials. In patients where there are multiple lines and drips running, it may also be beneficial to use a small piece of tape to label the tubings near the patient since they are not always easily traced back to the bag. Not all medication boluses may be administered into IV solutions containing drip medications, because some medications have an adverse interaction.

Calculating Flow Rates for IV Drip Medications Complex IV drip calculations can bend even the best EMS minds under pressure. Fortunately, many IV drip solutions have been devised in round numbers and divisible figures to make these calculations easier. Moreover, a multitude of field guides, charts, and software provide pre-calculated information to providers administering drip medications. In reality, these practical charts can prevent errors in calculation. They do not eliminate the need for careful selection, mixing, and administration of the medication—potential areas for other human errors in this complex task.

Medication dosage guides, charts, and software can prevent errors in calculation. They do not eliminate the need for careful selection, mixing, and administration .

Since practicing calculation will promote understanding and help prevent errors, it will be reviewed here. The two essential determinations are:

1. ***How many mg/ml is my IV solution?***
   Using a popular example, 2g of lidocaine (2000 mg) is injected into a 500 ml bag of D_5W. This provides a concentration of 4 mg of lidocaine per ml of D_5W (4 mg/ml).

2. ***How much fluid will I have to run at this concentration to get the desired dose?***
   Using a 60 gtt/ml microdrip set, 60 gtt/min (1 ml/min) would deliver 4 mg of lidocaine to the patient per minute.
   Therefore:
   15 gtt/min = 1 mg/min lidocaine
   30 gtt/min = 2 mg/min lidocaine
   45 gtt/min = 3 mg/min lidocaine
   Dopamine is a more challenging example, where the medication dose must be calculated based on µg/kg/min. Using 400 mg of dopamine (400,000 µg) in a 500 ml bag of D_5W, we obtain a concentration of 800 µg/ml. If we are looking to administer 5 µg/kg/min to a patient who weighs 75 kg, our calculation would be as follows:
   To determine the amount of dopamine that would be administered per minute we would multiply $5 \times 75 = 375$. This is the number of µg × the weight of the patient in kg to determine how many mg per minute we will administer to this patient. (Be sure to use the patient's weight in kg: 1 kg = 2.2 lbs.)
   The further math may be done in a number of ways. A simple proportion comparing mg and drops will develop an answer rapidly:

375:800 as X:60

This statement says that 375 µg is to 800 µg as X gtts are to 60 gtts (1 ml). To work this out, set it up as an equation:

$$\frac{375}{800} = \frac{X}{60} \quad \text{(cross multiply to get)} \quad 800X = 22500$$

$$\text{Then} \quad \frac{22500}{800} = 28.125$$

So you would administer 28 gtt/min to this patient.

If you used your practical senses even before going to the math, you would have realized that 375 µg/min is almost half of 800 µg/min. This means that if you delivered 30 gtt/min (half of 60 gtts, which would equal 400 µg) you would have been mighty close. Unfortunately "mighty close" is not always acceptable in medicine. This does, however, give you a way to check and see if your answer is in the ballpark.

None of the mathematical formulas for figuring dosages are known for accuracy when sirens are wailing and calculations are being performed in a moving ambulance. Use the math calculations you have learned and your common sense to check the reasonableness of the dosages you will administer . . . but experienced care providers and emergency department personnel frequently use the charts!

DELIVERING MEDICATION BY INJECTION

While intramuscular, subcutaneous, and other forms of injection are frequently given in the non-emergent health care setting, field use of these injections is usually limited to occasions where an IV cannot be obtained or for specific medications that cannot be administered intravenously.

Injections into muscle and subcutaneous tissue have benefits such as predictable absorption and longer duration of action. These attributes generally apply to the healthy patient. When patients are suffering shock or where other medical conditions exist, however, the absorption may become slowed, unpredictable, or even non-existent.

In the healthy patient, injections into muscle and subcutaneous tissue have benefits such as predictable absorption and longer duration of action. In a patient suffering shock or another medical or traumatic emergency, absorption may become slowed, unpredictable, or even non-existent.

Intramuscular Injection

Intramuscular injections are delivered into muscle, using a 1½ inch, 21-gauge or similar needle (Figure 3-9). The needle must be long enough to be sure the medication is delivered into the deep muscle tissue. The length and gauge of the needle may vary. If a viscous material such as an oil is to be injected, a larger-gauge needle may be used. The size of the patient and the amount of subcutaneous tissue varies from patient to patient. This will affect the choice of needle length and technique.

Intramuscular injections, depending on the site chosen, may be used to deliver 1 to 5 ml of medication.

The deltoid (arm) injection site is isolated by locating the acromial process on the lateral side of the arm. Choose a location 1–2 inches (2–3 finger widths) below the acromial process. Visualize an inverted triangle with the wide base below the acromial process and the point one-third of the way down the humerus (Figure 3-10). Only about 1 ml of medication may be injected into this site. Beware of the radial nerve when injecting into the deltoid muscle.

Injection into the buttocks is most frequently into the gluteal muscles. There are two methods of isolating this injection site. The first is to draw an imaginary line from the posterior superior iliac spine to the greater trochanter of the femur (Figure 3-11A). The injection would then be given in the area on the lateral side

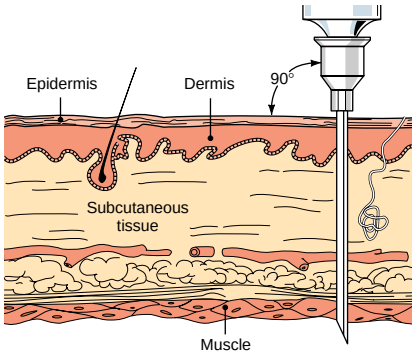


FIGURE 3-9
Intramuscular injection is made at a 90° angle into the muscle. Draw back the plunger slightly to assure that the needle is not in a blood vessel.

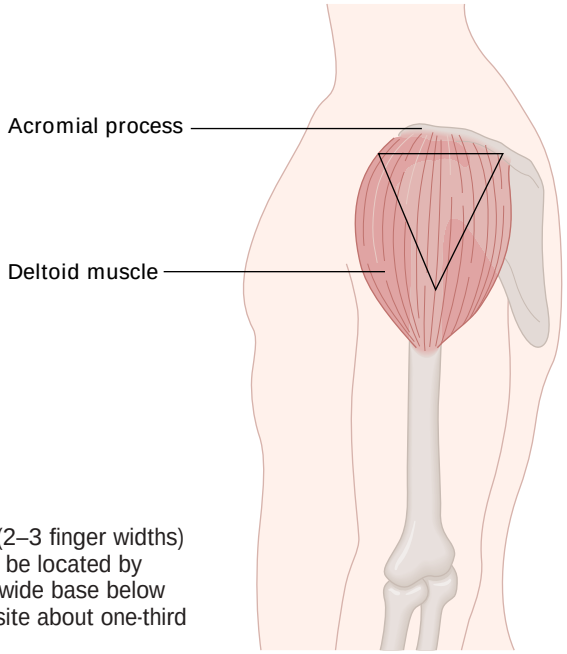


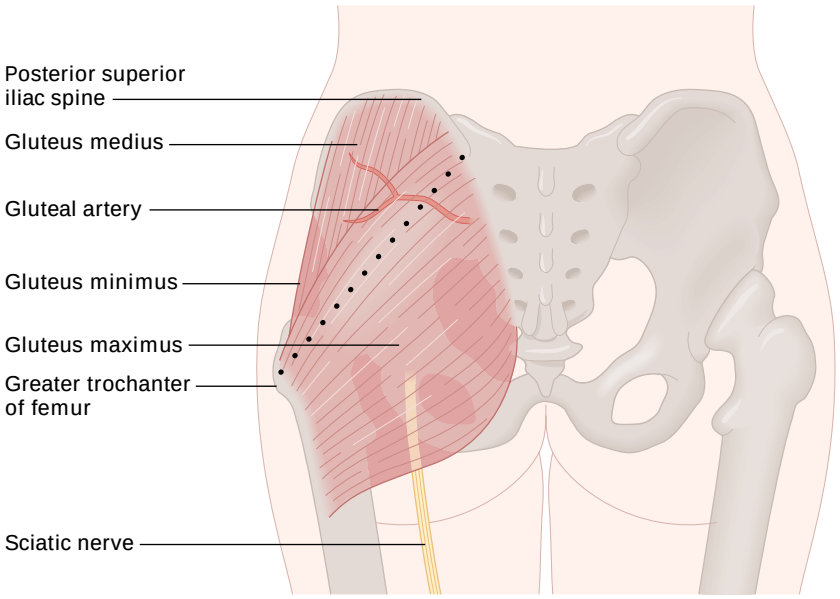
FIGURE 3-10
The deltoid injection site is 1–2 inches (2–3 finger widths) below the acromial process. It can also be located by visualizing an inverted triangle with the wide base below the acromial process and the injection site about one-third of the way down the humerus.

(up and out) of that line. The second method is to divide the buttocks into four quadrants. The injection is given in the upper, outer quadrant 2–3 inches below the iliac crest (Figure 3-11B). Intramuscular injections may also be performed in the rectus femoris and vastus lateralis muscles of the thigh. These sites are often used for self-injection or the injections delivered to the pediatric patient.

Intramuscular injections are delivered at a 90-degree angle to the skin. This is in contrast to the subcutaneous which is delivered at 45 degrees and the intradermal at 15 degrees (Figure 3-12).

To perform an intramuscular injection (Figure 3-13 A to F):

1. Take body substance isolation precautions.
2. Gather the equipment and medications. Draw the medication into the syringe (or prepare the preloaded device).
3. Prep the site of injection with an antiseptic wipe.
4. Insert the needle at a 90-degree angle into the muscle tissue beneath the skin.
5. Draw back slightly on the plunger of the syringe to assure that you are not in a blood vessel. If you see blood flow into the syringe, remove the needle—do not inject the medication. Choose another site.
6. Inject the proper dose into the muscle.
7. Remove the needle and cover the puncture site, if necessary. Dispose of the sharps properly.
8. Monitor the patient and record the administration time and effects.



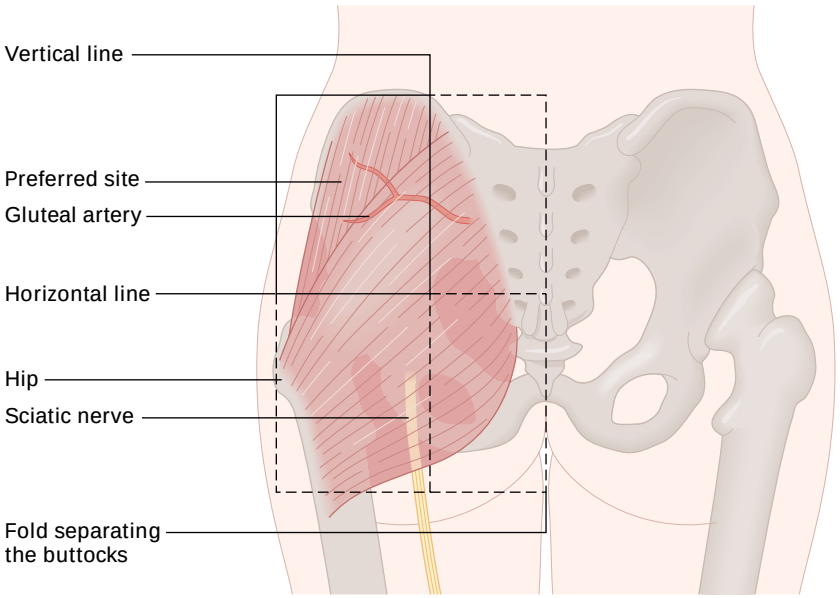


FIGURE 3-11
Locate the gluteal injection site by either of two methods: A. Draw an imaginary line from the posterior superior iliac spine to the greater trochanter of the femur, and inject on the lateral (up and out) side of that line. B. Divide the buttocks into quadrants and inject in the upper, outer quadrant 2–3 inches below the iliac crest.

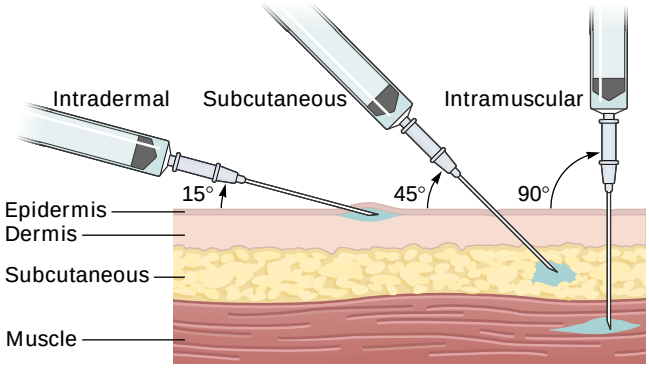


FIGURE 3-12
Intramuscular injections are delivered at a 90° angle to the skin, subcutaneous injections at a 45° angle, and intradermal injections at a 15° angle.

INTRAMUSCULAR INJECTION PROCEDURE

FIGURE 3-13A Check the medication.

FIGURE 3-13B Draw the medication into the syringe.

FIGURE 3-13C Prep the site of the injection.

FIGURE 3-13D Insert the needle at a 90° angle. Draw back slightly on the plunger and observe for blood. If none is seen, inject the medication.

FIGURE 3-13E Remove the needle and cover the puncture site.

FIGURE 3-13F Monitor the patient.

Subcutaneous Injection

Subcutaneous injections are delivered into the fatty tissue under the outer layers of the skin, using a 5/8 inch, 25-gauge needle and a tuberculin or other syringe with a relatively small volume (Figure 3-14). Subcutaneous (called "sub-Q" and abbreviated "SQ") injections involve small quantities of medications, usually 0.5 to 1 ml of fluid. The medication most commonly administered subcutaneously in the field is 1:1,000 epinephrine.

The subcutaneous route provides slower absorption of medication than the intravenous route. This may be beneficial in cases where the medication should be absorbed over time. The subcutaneous route also poses fewer risks (e.g., the risk of striking blood vessels and nerves or causing tissue trauma) than other injection routes. While we discuss the relatively slow speed of this route in relation to the needs of the critical patient, we should also note that, in most cases, subcutaneous injection provides more rapid action than the oral route.

There are many locations around the body where subcutaneous injections may be performed. The most common is the fatty tissue of the upper arm. This location provides easy access and requires minimal clothing removal.

The most common location for subcutaneous injection is the fatty tissue of the upper arm.

To perform a subcutaneous injection (Figure 3-15 A to F):

1. Take body substance isolation precautions.
2. Gather the equipment and medication. Draw the medication into the syringe (or prepare the preloaded device).
3. Prep the site of injection with an alcohol swab.
4. Grasp the fatty tissue of the upper arm (or another appropriate location).
5. Insert the needle into the skin at a 45 degree angle.
6. Release the grasp of the fatty tissue, making sure the needle remains in the subcutaneous tissue.
7. Draw back slightly on the plunger of the syringe to assure that the needle is not in a blood vessel. If you see blood flow into the syringe, remove the needle—do not inject the medication. Choose another site.
8. Inject the proper dose into the patient.
9. Remove the needle and cover the puncture site, if necessary. Dispose of the sharp properly.
10. Monitor the patient and record the administration time and effects.

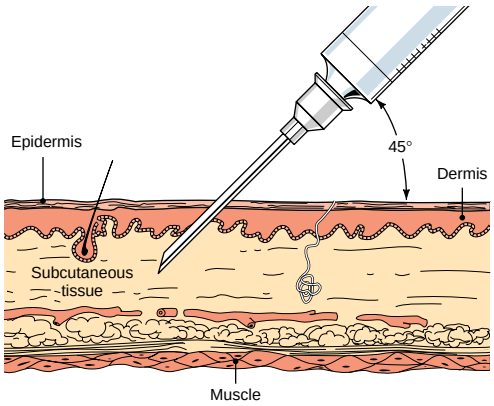


FIGURE 3-14
Subcutaneous injections are delivered at a 45° angle into the fatty tissue beneath the outer layers of the skin. Draw back the plunger slightly to assure that the needle is not in a blood vessel.

SUBCUTANEOUS INJECTION PROCEDURE

FIGURE 3-15A Check the medication.

FIGURE 3-15B Draw the medication into the syringe.

FIGURE 3-15C Prep the site of the injection.

FIGURE 3-15D Insert the needle at a 45° angle. Draw back slightly on the plunger and observe for blood. If none is seen, inject the medication.

FIGURE 3-15E Remove the needle and cover the puncture site.

FIGURE 3-15F Monitor the patient.

OTHER METHODS OF MEDICATION ADMINISTRATION

Endotracheal Administration

Medications may be administered through the endotracheal tube. This is usually performed prior to an IV line being established or when an IV cannot be started in the patient who requires intubation. The route of administration and the drugs that are routinely administered suggest that cardiac and respiratory arrest are the most common clinical situations in which this procedure is used.

The medications that may be administered through the endotracheal tube are lidocaine, epinephrine, atropine, and naloxone. The administration of diazepam (Valium) endotracheally is controversial; it is not recommended that diazepam be administered via this route.

Generally, medications administered via the endotracheal route are given in 2–2.5 times their usual strength. The recommended dose of atropine is 1.0–2.0 mg. The medication should be diluted in saline to bring the volume up to 10 ml of liquid (if necessary) to assure adequate delivery of the medication to the lungs. The solution is injected directly into the tube between ventilations. The resumption of ventilations helps to deliver the medication. Several authorities recommend three to four successive ventilations to distribute the medication into the lungs.

Clinical Insight

To remember which medications are commonly administered through the ET tube, you can "lean" on the mnemonic LEAN, standing for lidocaine, epinephrine, atropine, and naloxone.

Sublingual Administration

Medications such as nitroglycerin may be administered sublingually. The vascular oral mucosa provides access for the medication to be absorbed into the circulation. Some risks are worthy of noting here.

Patient compliance is always an issue in the sublingual administration of medications. Lack of understanding, language or hearing barriers, or anxiety can cause the patient to swallow the medication rather than let it dissolve under the tongue. Nitroglycerin will also lose potency in a brief time, especially if exposed to light. Current recommendations are that tablets be replaced every 6 months. The patient doesn't always do this. If the cardiac discomfort is not relieved by the patient's nitroglycerin, and the date of the prescription cannot be verified, a trial with current stock medication from the ambulance or emergency department may be worthwhile. For patients experienced in taking nitroglycerin, a headache or a bitter taste may also indicate potent medication. Sublingual nitroglycerin sprays have a longer shelf life than tablets. With proper instruction, the compliance problems may also be reduced.

Patient compliance is always an issue in the sublingual administration of medications.

Be sure to monitor the patient carefully after administering nitroglycerin as it may result in a sudden drop in blood pressure. Nitroglycerin is contraindicated in hypotensive patients.

Oral Administration

Oral medications are not frequently given in the field. This is due to the prolonged and unpredictable absorption experienced by patients in shock and the potential

inability of the patient to swallow or to protect the airway from aspiration of the medication. Obvious exceptions are medications that are used in oral poisonings: syrup of ipecac and activated charcoal.

Oral medications are the mainstay of medical maintenance at home. The importance of oral (or any) medications in the accurate medical history cannot be overemphasized.

Rectal Administration

Most drugs that are administered rectally are given via this route because other routes are unavailable. Two examples are diazepam, given rectally when an IV cannot be obtained in an actively seizing patient; and promethazine (Phenergan) when the patient cannot tolerate oral medications because of vomiting.

Rectal administration is performed with a 14-gauge IV catheter (needle removed) attached to a syringe containing the medication. Insert the catheter into the rectum and inject the medication. Remove the catheter and hold the buttocks together to retain the medication for absorption. You may also use a lubricated syringe (needle removed) or a pediatric ET tube to introduce the medication. In this method, remove the 15/22 mm adapter from the ET tube and attach the syringe containing the medication to the proximal end.

SUMMARY

Administration of medications to patients suffering medical problems is a critical part of prehospital care by advanced field care providers. The most common route of administration in the prehospital setting is the intravenous route. Other routes of administration are used in special circumstances. Parenteral routes (those outside the digestive tract) include intravenous (IV), intramuscular (IM), subcutaneous (SQ), endotracheal, intraosseous, inhalation, and transdermal. Enteral (digestive tract) routes include oral, sublingual, and rectal.

Decisions about whether to administer medications in the prehospital setting require clinical judgment that should involve consideration of standing orders, the needs and stability of the patient, and benefit vs. risk analysis. The five “rights” must always be assured: right medication, right dose, right route, right patient, right time.

Administration of medications always places the provider at considerable risk of contact with the patient’s body substances, so it is essential always to use appropriate body substance isolation techniques when establishing an IV line, placing an endotracheal tube, or performing any of the tasks involved in medication administration.

CASE STUDY FOLLOW-UP

You are at the scene for a 59-year-old male who collapsed suddenly after dinner and is in cardiac arrest. Fire department EMTs have already arrived and defibrillated the patient with two sets of three shocks. They continue CPR while your partner prepares to defibrillate again. You prepare to intubate the patient. The patient's cardiac rhythm converts to asystole. You intubate the patient. Your partner sets up a bag of normal saline and attempts an IV in the patient's left arm. The IV attempt is unsuccessful.

The EMTs continue resuscitation as you administer epinephrine down the endotracheal tube. Your partner evaluates for other potential IV sites but cannot find any sites in the arms. Standing orders allow for external jugular cannulation for patients in cardiac arrest where other sites cannot be found. With oxygenation and epinephrine, the patient returns to ventricular fibrillation. After an additional shock, you repeat epinephrine and administer lidocaine down the tube.

The external jugular IV attempt is successful, and further medications are administered by this route. You and your partner move the patient to the ambulance as the resuscitation continues. En route to the hospital, the patient regains a pulse but does not have any respiratory effort. You continue ventilations and careful monitoring of the patient.

The patient continues to maintain a pulse with a blood pressure of 90/50 and is admitted to the coronary care unit. Respirations have not resumed, and the patient is placed on a ventilator. The patient suffers a second cardiac arrest in the CCU the next day. He dies after a lengthy resuscitation effort.

In this case, intravenous lines and medication administration were important parts of the patient's care. Your advanced life support team worked together to get all of the advanced life support tasks—manual defibrillation, intubation, and intravenous line—completed efficiently. When things don't go as we might like, for example when an IV is missed, alternative methods are used for medication administration. While cardiac arrests are not the most common call, this was a case where IV and medication skills were effectively integrated to give the patient the best possible chance for a positive outcome.

FURTHER READING

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