

Chapter 10

Preparation of Medications For Intravenous Administration

If it is apparent that cardiac arrest is likely to occur within a few hours (agonal respirations or agonal cardiac rhythms), it is appropriate to begin drawing up IV medications and preparing large bottles of solution (THAM, Dextran-40) for administration. *Mannitol may not be prepared until immediately prior to use, as it will crystalize in the bag or bottle and in the IV set.* Drawing up medications in advance will save a tremendous amount of time when legal death occurs, and will greatly reduce the risk of an error in preparing or administering the medication.

Packaging: Generalities

Drugs for intravenous administration are marketed in a variety of states (in solution, freeze-dried, etc.) and in a wide range of packaging materials. Drugs that deteriorate rapidly or which are unstable in solution are usually marketed in a powdered form, having been dried or freeze-dried (lyophilized). Such agents are then rehydrated and suspended in an appropriate vehicle solution immediately prior to administration. There are several strategies used to package materials prepared in this way.

Powders

The simplest and most common approach is to package the powder in an airtight vial with a rubber stopper which can be repeatedly pierced with a hypodermic needle. A syringe and needle are then used to add water or saline to the vial in order to rehydrate the preparation. Once the medication has been completely dissolved in the added liquid, it can be withdrawn and administered. For safety in transporting and storing, the single-dose or multidose rubber-capped vial is usually covered with a soft metal cap, or a plastic snap-off cap, which can be easily removed. The rubber part, which is the entrance to the vial, is thus exposed. Ostensibly, such caps protect the stopper and assure its sterility at the time of use. However, if time permits, it is desirable to swab and cleanse the stopper (use friction) with alcohol prior to withdrawing medication, since it is easy to contaminate the stopper during removal of the protective cap.

Once the vial has been prepared, add water or another appropriate solution via syringe and needle in the required amount, completely dissolving the medication. To facilitate removal of the drug from the closed container, inject into the vial an amount of air that is comparable in volume to the amount of liquid to be withdrawn. This increases the pressure inside the vial, and the drug can be easily withdrawn. If air is not injected first, a partial vacuum is created as fluid is withdrawn from the vial, because air cannot enter the vial to displace the fluid which is being withdrawn. This partial vacuum makes it difficult to withdraw the fluid.



Figure 10-1: *Snap-off protective plastic cover on multidose, stopped medication vial.*



Figure 10-2: *After removal of the protective cover (or for repeated entry into a multidose vial) the rubber stopper should be swabbed with alcohol.*



Figure 10-3: *Powdered medications may be dissolved by the addition of water, normal saline, or other appropriate diluent to the rubber-stoppered glass vial containing them.*



Figure 10-4: Medication may be withdrawn from rubber-stoppered vials by first injecting a volume of air equal to that of the medication to be removed. The vial is then inverted and medication is withdrawn by pulling back on the plunger of the syringe.

A second type of packaging for powders, known as the Mix-O-Vial, has come on the market in the past few years. Mix-O-Vials are two-compartment glass vials separated by a rubber plug and capped with a plunger-like rubber stopper. The top compartment of the vial contains the appropriate amount of water and the bottom compartment contains the medication. An initial twisting motion followed by firm downward pressure on the top plunger/stopper displaces the rubber plug which divides the two compartments and allows the water to flow into the medication compartment. Once the medication is dissolved in the liquid, it can be withdrawn with a syringe from the plunger/stopper. This system eliminates the need for a separate vial of water or saline to be available for rehydration of the powdered product. It has the added advantage of insuring that the proper diluent will be used, since some medications will form gels or insoluble precipitates if diluents with sodium chloride or water with preservatives are used.

A third type of packaging for powdered materials is the single-dose glass ampule. The ampule is a small, all glass vial; even the seal is glass which has been drawn up to a point and fused together. Most single-dose glass ampules have a constriction in the stem of the ampule which facilitates opening it. Before opening the ampule, make sure that all the product is in the ampule proper and not in the stem. Drug tends to become trapped in

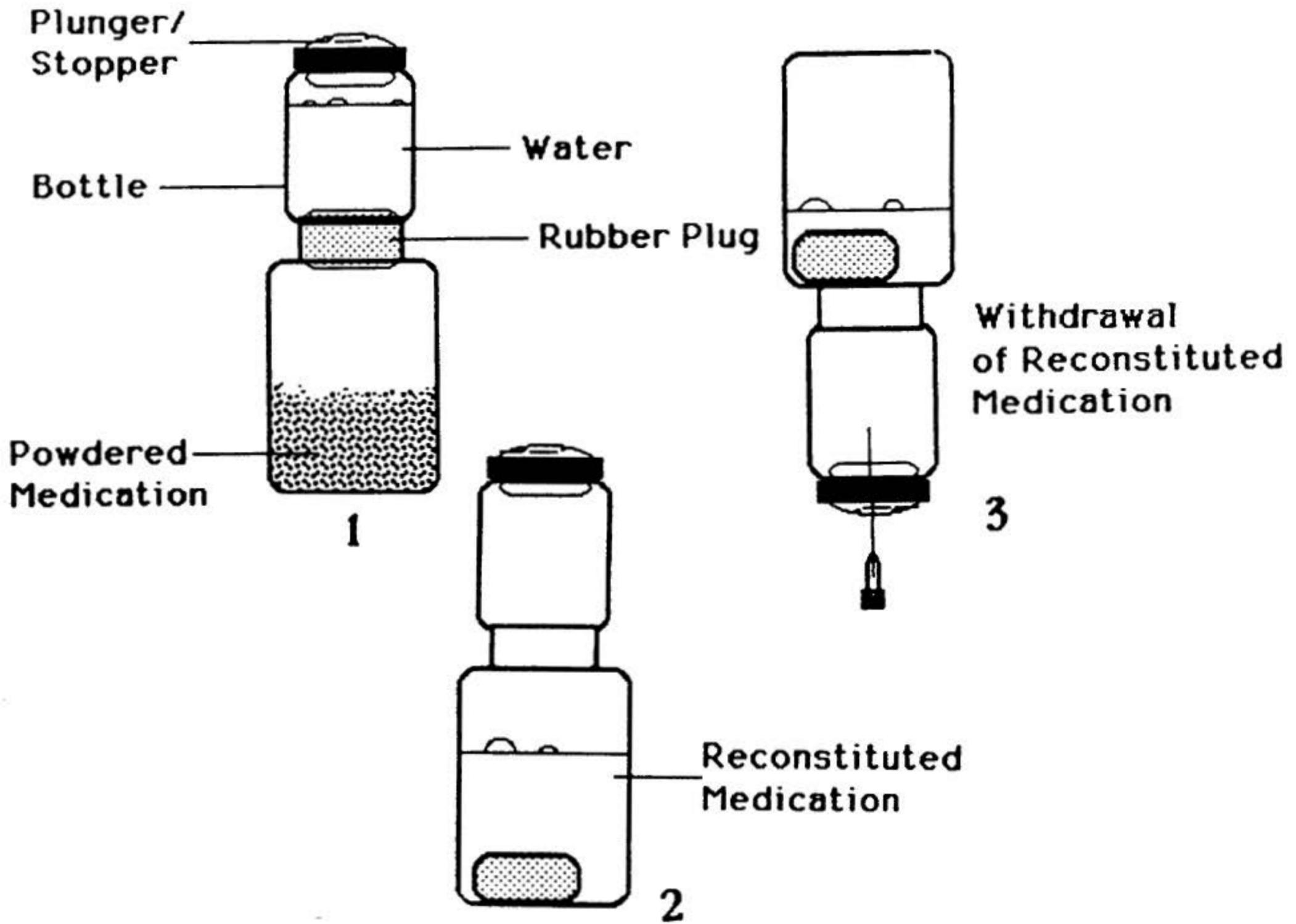


Figure 10-5: *Mix-O-Vial*

the stem, and it may be necessary to tap the stem several times in order to bring the drug down into the ampule proper. Product is removed from the ampule by breaking off the stem of the ampule. This is done by covering the stem with a gauze pad and grasping it (between thumb and forefinger), while holding the base of the ampule with the opposite hand, and then sharply snapping off the stem. The medication in the ampule is now in an open vessel. Water, saline, or other appropriate suspending media is added with a syringe and needle, and the vial is gently swirled to facilitate dissolution of the medication. To remove the medication, insert a needle (attached to a syringe) and withdraw the solution. Use care to avoid contaminating the needle by touching it to the outside of the ampule during insertion. The fluid being withdrawn from the ampule is immediately replaced by air, so there will be no resistance to its removal.

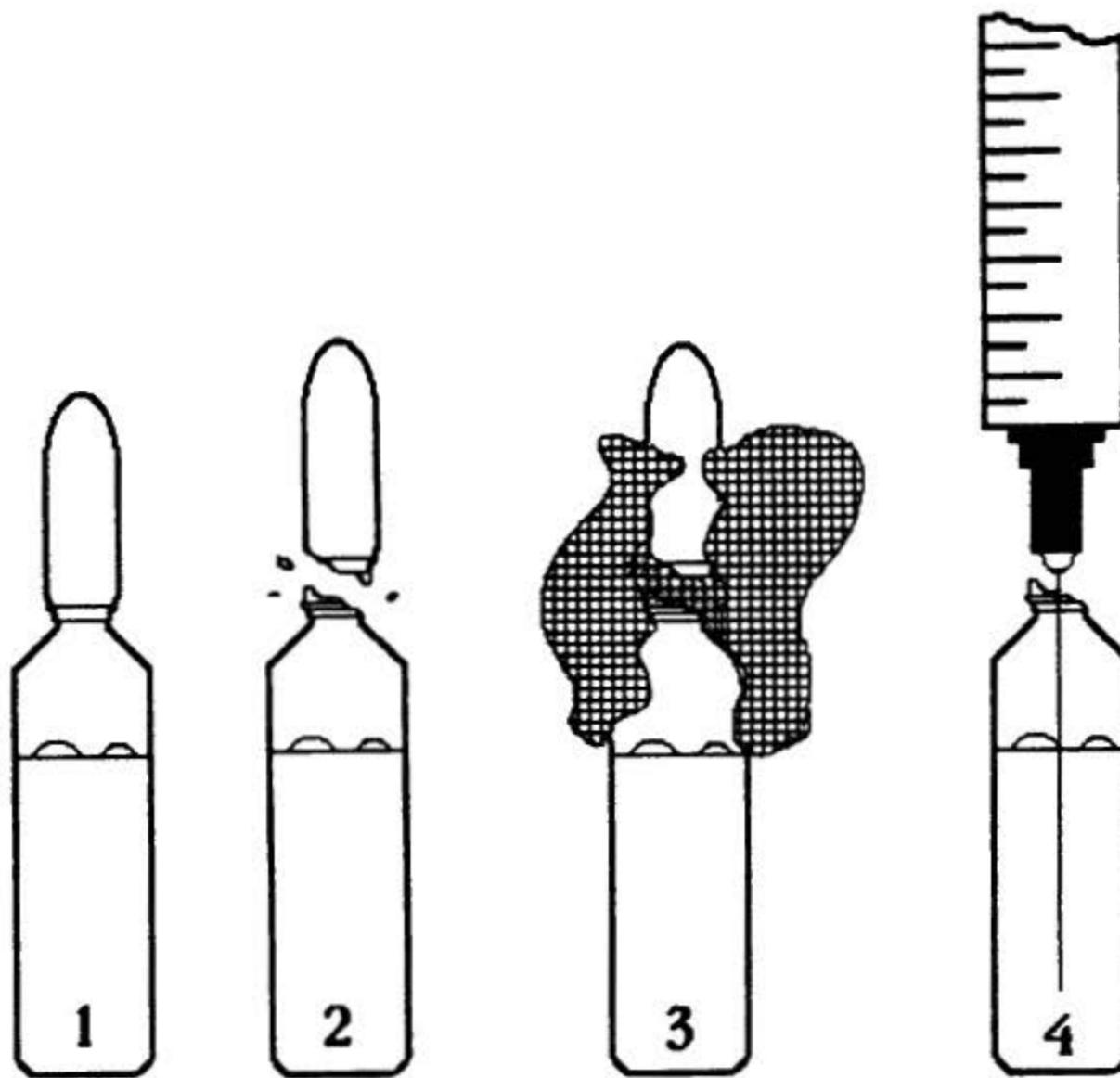


Figure 10-6: *Opening glass ampules: (1) Shake down medication from the tip and stem of the ampule. (2) Break off the top of the ampule along the score-line with a sharp snapping motion. (3) Use a sterile gauze square to protect the hands from glass fragments and to protect open ampule from bacterial contamination when the ampule top is broken. (4) Withdraw medication from the ampule using a syringe and needle.*

Liquids

Liquids may be packaged in five basic ways: in ampules and vials, as is the case with powders, in flexible plastic containers of a variety of sizes and configurations, and in vented and unvented glass bottles. The method of opening ampules for removal of liquid medications is the same as is used for powders (see above). Medication may be withdrawn from vials by piercing the rubber stopper which caps the vial and withdrawing the medication with a syringe and needle as detailed above.

Large volumes (which preclude administration via syringe) of liquid medications or solutions packaged both in glass bottles and in flexible plastic containers require the use of a length of flexible plastic tubing (known as an *IV administration set* or *IV line*) to conduct the medication, under the force of gravity, to the intravenous catheter. Such tubing has a penetrating device--or, "spike"--to enter the rubber stopper or nipple on the top of the container. The spike is attached to a plastic "drip chamber" 5 cc to 6 cc in volume. The drip chamber allows visualization of the liquid flow rate (by allowing the solution to drip or fall through air) and acts as a bubble trap to remove air which may be suspended in the liquid as it leaves the container. At the end of the tubing, distal to the drip chamber, there is a fitting with a standard male luer connector which is designed to mate with hypodermic needles or intravenous catheters.

Glass IV Bottles

The design of glass IV bottles is similar to that of rubber-stoppered glass vials. There is a protective metal cap that is easy to remove, usually by means of a metal tab. Be careful to pull the tab in the correct direction. A torn tab means pliers will be required to remove the cap. Removal of the protective cap exposes a rubber stopper which will vary in appearance depending upon whether the bottle is "vented" or "unvented".

Vented Glass IV Bottles

Vented bottles will present a stopper that is usually covered with a soft, flexible latex rubber disc. This disc is held tightly onto the underlying stopper by the vacuum present in the bottle. Pull upward on and remove the disc to reveal two openings in the stopper. One will be fairly large and will be penetrated by a rigid plastic or glass vent tube (to allow air to enter the container and displace liquid). The other will be somewhat smaller, designed to accept the male spike of the solution administration set. Vented administration sets designed for use on unvented bottles must never be used on vented bottles, as they greatly increase the risk of air embolism, should the a bottle be allowed to run dry.



Figure 10-7: *Flexible soft latex rubber cap covering rubber stopper of a vented glass IV bottle.*

After spiking the bottle with the administration set, invert and hang it on an appropriate pole or stand. Generally, a height of 3 ft. (1.0 meter) above the heart is an elevation sufficient to provide adequate pressure for reasonably rapid administration of medications. Before the solution set is connected to the patient, establish a level of fluid in the drip chamber adequate to prevent introduction of air into the tubing and consequent air embolism. Also, clear the tubing of and prime it with solution prior to connecting it to the patient's venous system.

Adjust the level in the drip chamber by squeezing the chamber between the thumb and forefinger, with the tubing distal to the chamber occluded with the flow rate adjustment clamp that is present on the line. The drip chamber should be between $\frac{1}{2}$ and $\frac{3}{4}$ filled. The tubing may then be primed with solution by opening the clamp and allowing solution to fill the line until it drips from the protective cap covering the male luer fitting at its distal end. With some types of administration sets, it will be necessary to remove or loosen the protective cap covering the male luer fitting in order to allow air to be displaced from the tubing as it is primed. Once this is done, the sterility of the male luer fitting should be protected by immediately recapping.

Figure 10-8: *Three types of clamps commonly present on IV solution administration sets.*

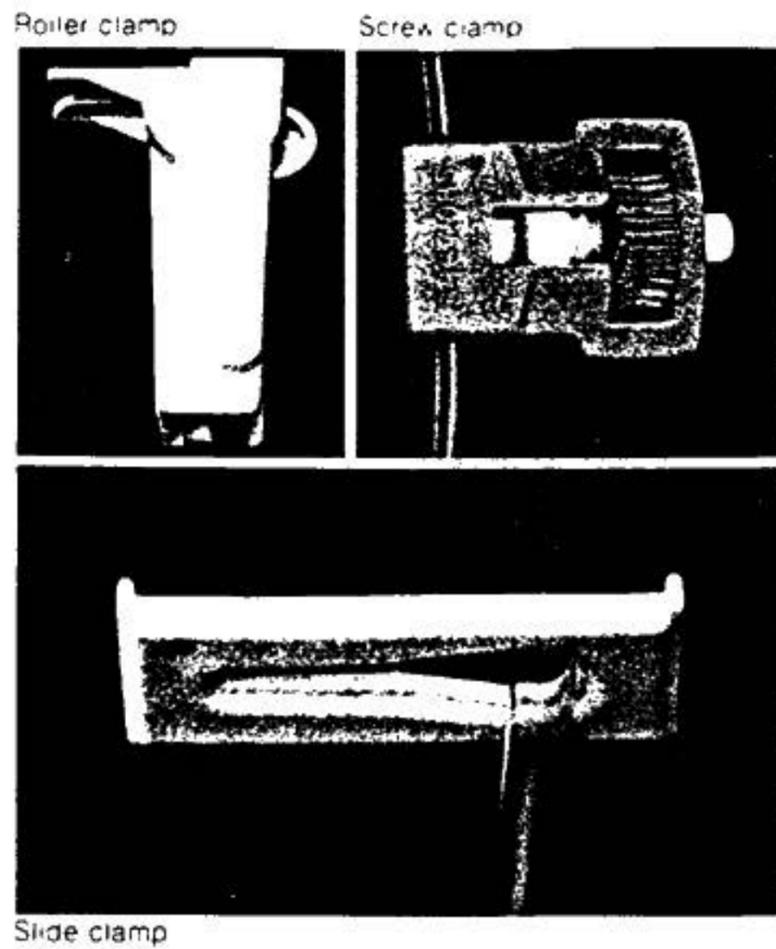


Figure 10-9: *Fill the drip chamber of the solution set approximately halfway by repeatedly squeezing and releasing the chamber.*



Figure 10-10: *Prior to connecting the solution administration set to the patient, purge it of air by allowing gravity to fill the tubing until fluid is flowing freely through the male luer fitting on the end of the set.*



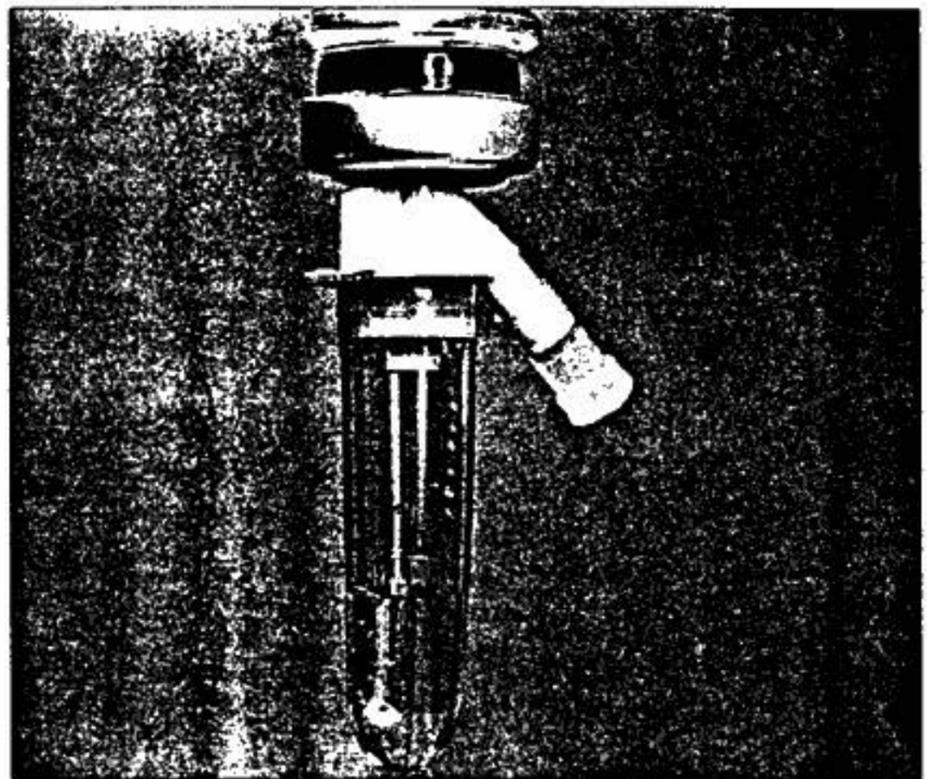
Unvented Glass IV Bottles

Unvented containers will present a rubber stopper (after removal of the protective metal cap) that is very similar in appearance to those present on rubber-stoppered medication vials. There will be no holes penetrating the stopper, only a raised or embossed "O" of rubber on the stopper to indicate where puncture of the stopper should be carried out with the spike of the solution administration set. The solution administration set for use on unvented containers has an integral vent built into the base of the spike above the drip chamber to allow air to enter the bottle. Unvented administration sets designed to be used on vented containers cannot be used on unvented bottles as they do not allow air to enter the container. If air cannot enter the container, a partial vacuum is created within a minute or two of beginning the infusion, which in turn prevents further removal of solution from the bottle.

Figure 10-11: *Spiking an unvented container with a vented IV administration set.*



Figure 10-12: *Vented administration set spiked into an unvented bottle. Air vent with 0.2 micron filter is present on the right above the drip chamber.*



In an emergency, an unvented solution set designed to be used on a vented bottle may be used on an unvented one through the expedient of creating a vent in the bottle stopper with a large bore (low gauge) hypodermic needle. The needle may be inserted through the stopper to allow air to percolate through the solution and thus vent the bottle. Two undesirable side effects of this technique are the increased risk of bacterial

contamination due to passage of unfiltered air through the fluid, and the escape of liquid inside the container through the needle. In the case of materials such as Dextran-40, even a small amount of spilled material may form a slick area on the floor, presenting a serious danger of falling injury to personnel.

The procedure for priming solution administration sets for unvented bottles is the same as for vented ones. A note of caution with administration sets for unvented bottles is to avoid contaminating the vent filter on the administration set with liquid or moisture of any kind. Such contamination will result in loss of gas permeability of the filter material and failure of air to enter the bottle and vent the system. Contamination of the vent filter may be remedied by replacing the entire solution administration set, replacing the contaminated filter with a filter from another set (this can only be done if the filter port is dry), or simply removing the filter and allowing unfiltered air to enter into the container (see above remarks concerning emergency use of unvented administration sets on unvented bottles for the drawbacks of this last approach).

Pressure Infusion With Glass IV Bottles

Rapid administration of IV fluids from unvented containers may be achieved by removing the filter covering the vent port on the administration set and attaching a 20 to 50 cc syringe filled with air. Air may then be injected into the bottle to increase the pressure and greatly speed the rate of the infusion. This technique should only be used with continual supervision of the fluid level in the bottle and with one hand poised constantly on the line clamp to shut off the flow of liquid in advance of emptying the container and drip chamber. Failure to observe these precautions carries a high risk of air embolism. A specific example requiring pressure infusion would be where the patient is severely volume-depleted due to dehydration or blood loss, and Dextran-40 must be given rapidly to restore the blood volume and thus perfusion pressure.



Figure 10-13: *Pressure infusion of contents by addition of air with a syringe to an unvented glass bottle through the vent port of the solution administration set. Medication may be added to glass IV bottles or IV solution withdrawn in a syringe by use of the vent port on the solution administration set in a fashion similar to that shown above for pressure infusion.*

Flexible Plastic IV Containers

IV solutions may also be packaged in flexible plastic containers (bags). The most common class of liquids packaged in this fashion are solutions of electrolytes or sugars (or mixtures of both) used for volume expansion, electrolyte replacement, or intravenous nutrition. Only unvented IV sets designed for use with vented glass containers may be used for flexible IV solution containers. Use of IV sets for unvented bottles (which thus contain a vent as an integral part of the IV set) on flexible plastic containers can result in increased risk of air embolism, since the flexible container may fill with air and then be squeezed or compressed accidentally during transport of the patient.

Figure 10-14: *Spiking a flexible plastic bag of IV solution in a hanging position.*

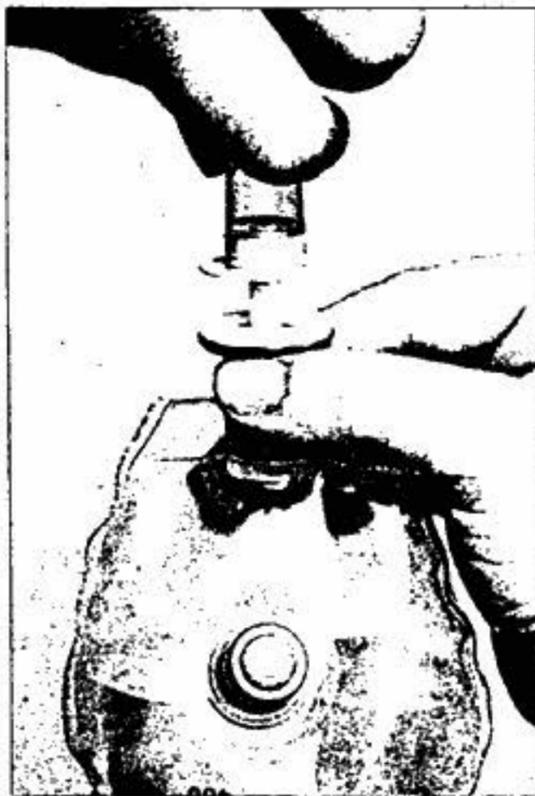


Figure 10-15: *Spiking a flexible plastic bag of IV solution in an inverted position.*

Solution can be withdrawn from flexible plastic containers in two ways: through a medication addition port (which is very similar to the top of a rubber-stoppered glass vial), or through a spike port or nipple on the bag. The spike port is a special site at the bottom of the container that has a protective plastic cap usually removed by grasping and exerting strong downward motion directly away from the port. Once the protective sleeve, cap, or cover is removed, a tube or nipple is exposed into which the spike on the administration set is inserted and retained. In contrast to glass bottles, bags are spiked with the container hanging on the IV pole or stand in the same position they will be used to deliver the infusion in. Once the container has been entered with the solution administration set, the procedure for priming the drip chamber and tubing are the same as with the glass containers discussed above.

Pressure Infusion With Flexible Plastic Containers

One advantage of flexible plastic IV containers is the decreased risk they present with respect to air embolism, particularly if any trapped air has been expressed from the bag by inverting it and expressing the air through the administration set prior to beginning the infusion. Another advantage is the ability to provide rapid infusion of medications under pressure without the attendant risk of air embolism present with glass bottles. This may be achieved by directly squeezing or compressing the bag either by hand or with a pressure infuser designed for this purpose.

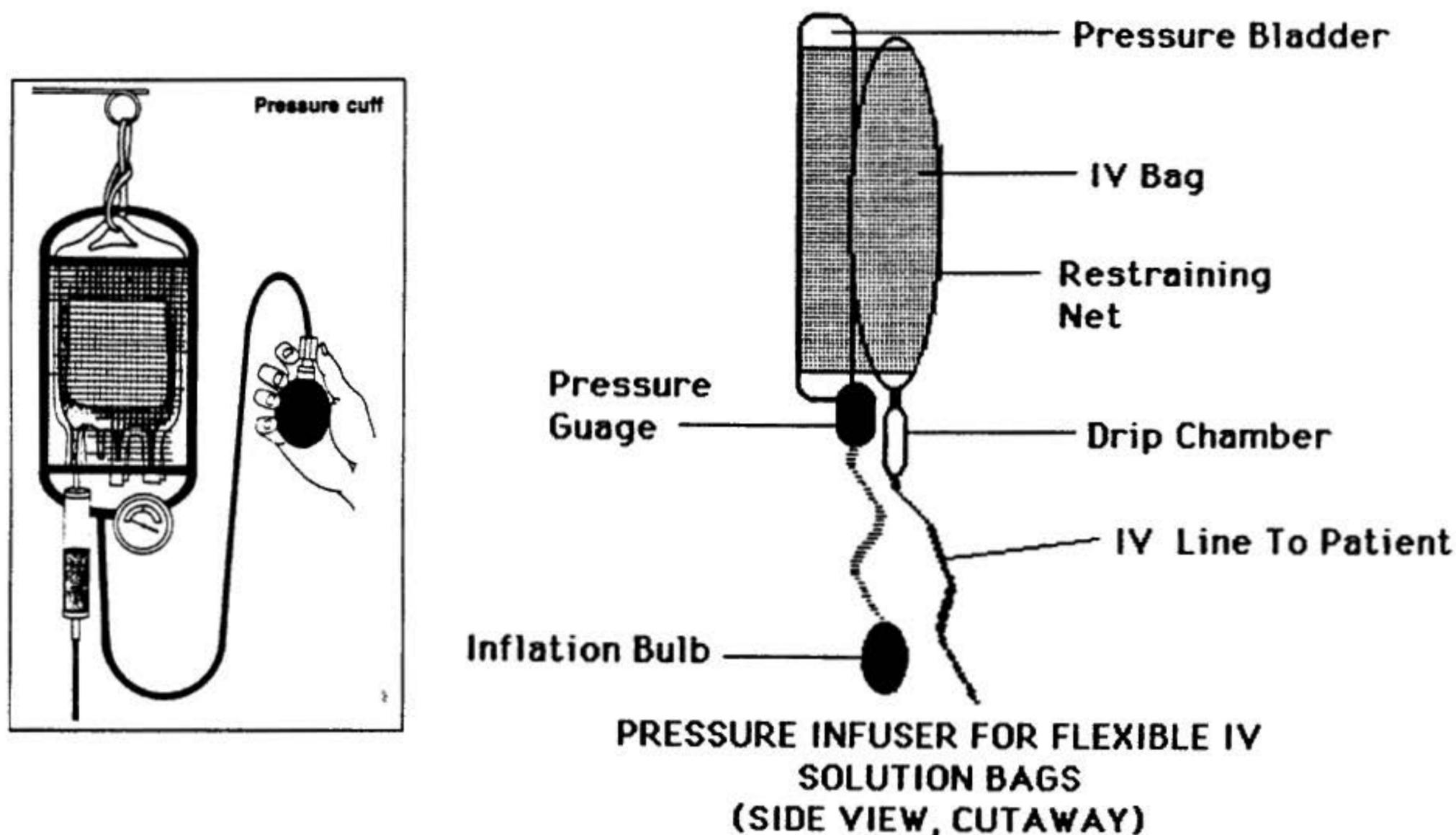


Figure 10-16: Pressure infuser.

Packaging: Specifics

Packaging specifics will vary, but at the time of this writing the IV medications used in transport of cryonic suspension patients are packaged as follows (their pharmacology is discussed in Chapter 11):

- 1) **Potassium chloride**, 2 mEq/cc, supplied as a liquid in 30 cc *rubber-stoppered vial*. Requires 60 cc syringe with an 18 gauge needle to remove contents.
- 2) **Sodium Pentobarbital (Sagatal)**, 60 mg/cc, supplied as a liquid in a 100 cc *rubber-stoppered vial*. Requires 60 cc syringe with an 18 gauge needle to remove contents.
- 3) **Deferoxamine HCl (Desferal)**, 500 mg/vial, supplied as lyophilized powder in *rubber-stoppered vial* to be reconstituted with 2 cc of normal saline. Requires a 10 cc syringe with, as a minimum, a 20 gauge needle to remove contents.

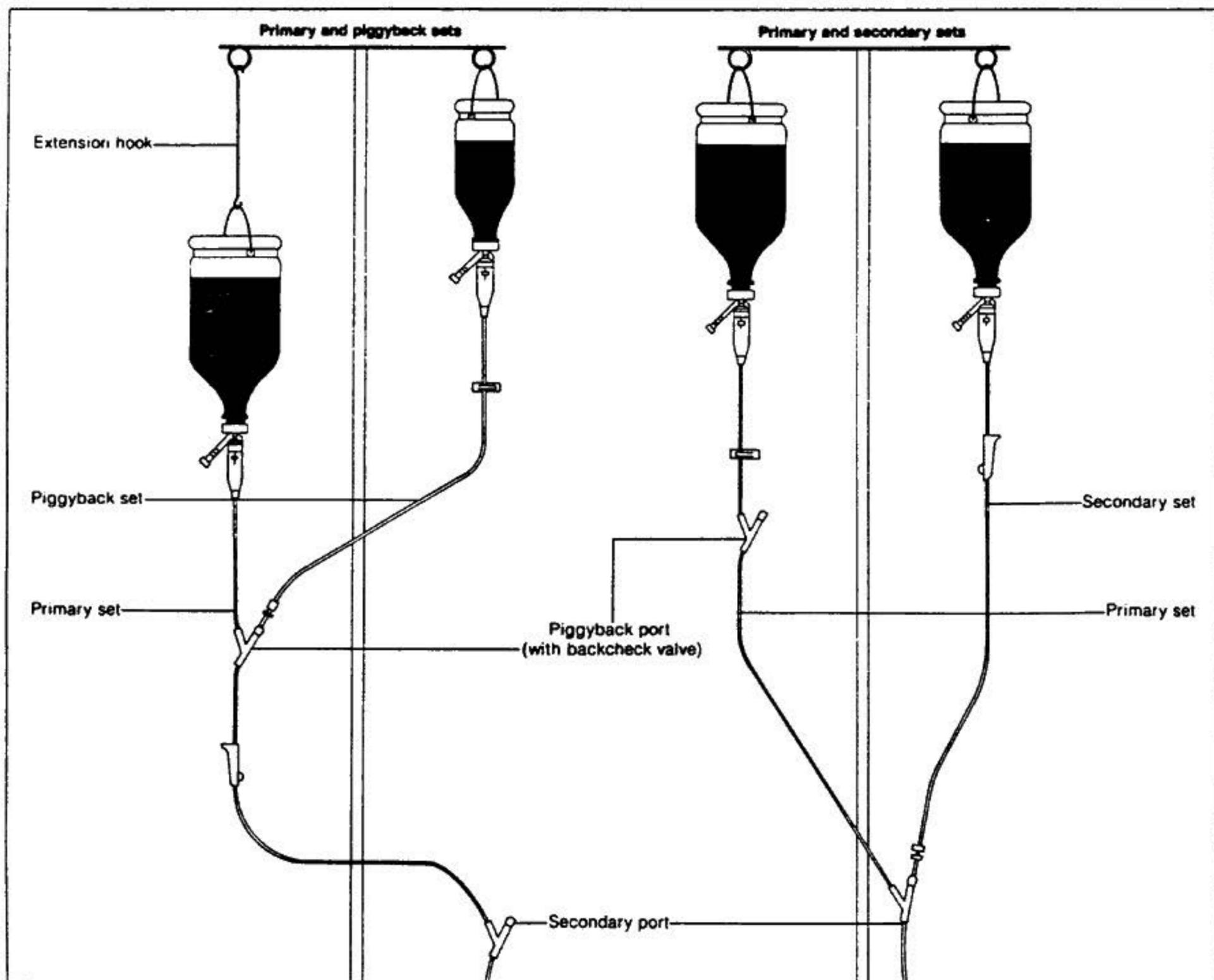
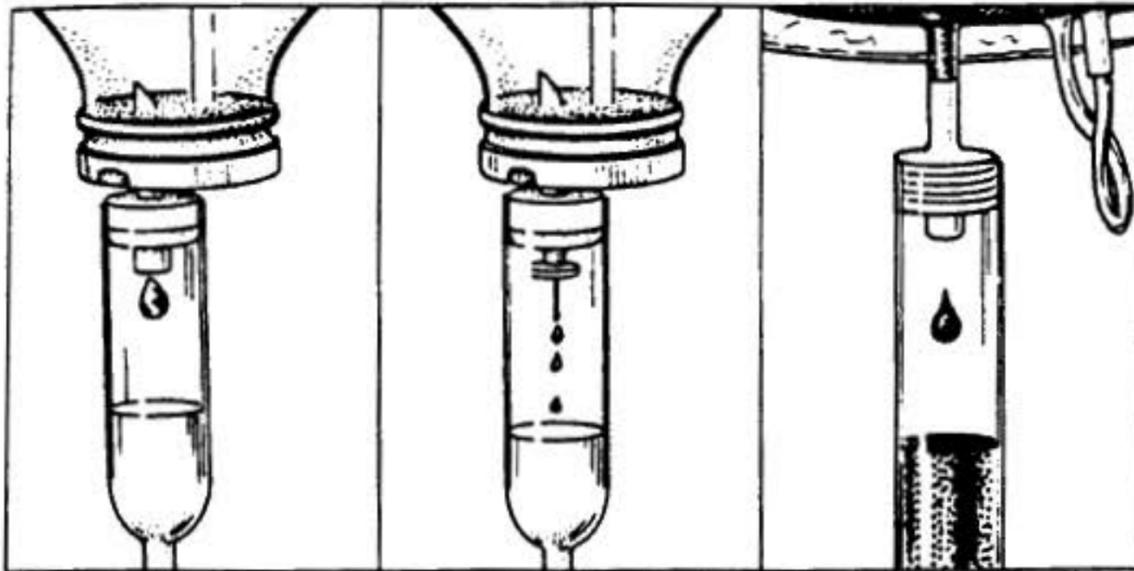


Figure 10-17: IV array.

- 4) **Nimodipine HCl**, 5 mg/5cc ampule. Medication is somewhat *photosensitive*. Bolus administration requires 10 cc syringe with, as a minimum, an 18 gauge 1½" needle for administration. See *Chapter 11* for administration instructions.
- 5) **Diltiazem HCl**, 30 mg/ampule, supplied as a *nonsterile* powder which must be reconstituted with 10 cc of normal saline and then filter-sterilized through a Millex 0.2 μ filter during administration. Requires, as a minimum, a 10 cc syringe with a 20 gauge 1½ in. needle to remove contents.
- 6) **Sodium Citrate** 200 mg/cc supplied as a liquid in 10 cc *glass ampule*. Requires 60 cc syringe with an 18 gauge needle to remove contents.
- 7) **0.3 M THAM** supplied as a solution in water in 500 cc *unvented glass bottle*. Requires a vented IV administration set to withdraw contents (with, as a minimum, an 18 gauge needle if being given via piggyback).
- 8) **Sodium Heparin**, 10,000 units/cc, supplied as a liquid in 5 cc *rubber-stoppered vial*. Requires 5 cc syringe with, as a minimum, a 20 gauge needle to remove contents.

CALCULATING FLOW RATES



When calculating the flow rate of I.V. solutions, remember that the number of drops required to deliver 1 ml varies with the type of administration set used and the manufacturer. The illustration at left shows a standard (macrodrip) set, which delivers from 10 to 20 drops/ml. The illustration in the center shows a pediatric (microdrip)

set, which delivers about 60 drops/ml. The illustration at right shows a blood transfusion set, which delivers about 10 drops/ml.

To calculate the flow rate, it is necessary to know the calibration of the drip rate for each manufacturer's product. As a quick guide, refer to the chart below. Use this formula to calculate specific drip rates.

$$\frac{\text{Volume of infusion (in ml)}}{\text{time of infusion (in minutes)}} \times \text{drop factor in drops/ml} = \text{drops/min}$$

CO. NAME	DROPS/ML	DROPS/MINUTE TO INFUSE					
		500 ml/24 hr 21 ml/hr	1,000 ml/24 hr 42 ml/hr	1,000 ml/20 hr 50 ml/hr	1,000 ml/10 hr 100 ml/hr	1,000 ml/8 hr 125 ml/hr	1,000 ml/6 hr 166 ml/hr
Abbott-Baxter	15	5 gtt	10 gtt	12 gtt	25 gtt	31 gtt	42 gtt
Travenol	10	3 gtt	7 gtt	8 gtt	17 gtt	21 gtt	28 gtt
Cutter	20	7 gtt	14 gtt	17 gtt	34 gtt	42 gtt	56 gtt
IVAC	20	7 gtt	14 gtt	17 gtt	34 gtt	42 gtt	56 gtt
MoGaw	13	4 gtt	9 gtt	11 gtt	22 gtt	27 gtt	36 gtt
Microdrip	60	21 gtt	42 gtt	50 gtt	100 gtt	125 gtt	166 gtt

Figure 10-18: Calculating flow rates.

- 9) **Chlorpromazine (Thorazine, Largactil)**, 25 mg/cc, supplied as a liquid in *glass ampule*. Requires a 10 cc syringe with, as a minimum, a 20 gauge 1½" needle to remove contents.
- 10) **Methylprednisolone (Solu-Medrol)**, 1 gm/vial, supplied as lyophilized powder to be reconstituted with 16 cc of bacteriostatic water. Requires a 20 cc syringe with, as a minimum, an 18 gauge needle to remove contents.
- 11) **20% Mannitol (Osmitol)**, supplied as a hyperosmotic solution in water in 500 cc *flexible plastic container*. Requires an unvented solution administration set to withdraw contents (with, as a minimum, an 18 gauge needle if being given piggyback).
- 12) **Metocurine HCl (Metubine Iodide)**, 2 mg/ml, supplied as liquid in 20 ml multidose

- rubber-stoppered vial.* Requires 3 cc syringe with, as a minimum, a 20 gauge needle to remove contents.
- 13) **Gentamicin Sulfate (Garamicin, Garamicina)**, 40 mg/cc, supplied as a liquid in 1 cc *rubber-stoppered vials or glass ampules.* Requires 3 cc syringe with, as a minimum, a 20 gauge needle to remove contents.
 - 14) **Trimethoprim and Sulfamethoxazole (Bactrim)**, 80 mg trimethoprim and 400 mg sulfamethoxazole per 5 cc, supplied in 5 cc *rubber-stoppered vial.* Requires 5 cc syringe with, as a minimum, a 20 gauge needle to remove contents.
 - 15) **Erythromycin (Erythrocin)**, 500 mg/vial, supplied as powder in *rubber-stoppered vial.* Requires rehydration with 10 cc of sterile water for injection without preservatives or additives. **Do not use normal saline or bacteriostatic water.** Requires 20 cc syringe with, as a minimum, a 20 gauge needle to withdraw contents.
 - 16) **Dextran-1 (Promit)**, 1.5 g/20 cc vial, supplied as an isotonic solution of Dextran-1 in saline. Requires 20 cc syringe with, as a minimum, an 18 gauge needle. *Do not administer with, add to, or dilute with solutions containing Dextran-40.*
 - 17) **6% Dextran-40 (Gentran, Rheomacrodex)**, supplied as a hyperoncotic solution in normal saline. Packaged in 500 cc *flexible plastic container.* Requires *unvented* solution administration sets to withdraw contents (if being administered piggyback, a 16 gauge needle is required).
 - 18) **50% Dextrose (Glucose)**, supplied as a solution in water in a 50 cc multidose rubber stoppered vial. Requires minimum 20 cc syringe with an 18 gauge needle for administration.
 - 19) **5% Dextrose** and other "vehicle" solutions (i.e., solutions used to carry other medications to be given over an extended period) are packaged in flexible plastic containers. Requires unvented solution administration set (for use on vented glass bottles) to withdraw contents.
 - 20) **Streptokinase (Streptase)** 30,000 units rubber-stoppered vial supplied as a lyophilized powder to be reconstituted with normal saline prior to administration.
 - 21) **Neo-Synephrine (phenylephrine HCL)** is supplied in several sizes of bottle or ampule. Requires a minimum of 3 cc syringe.