CHAPTER 2

Supplies and Equipment for Compounding and Administering Sterile Preparations

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Chapter Objectives

1. Review supplies used for compounding sterile preparations.
2. Differentiate open and closed systems.
3. Describe supplies and equipment utilized to administer compounded sterile preparations.
4. Identify factors that influence selection of supplies.
5. Describe important safety considerations with supplies used in preparation and administration of compounded sterile preparations.

Key Terminology

Gauge
Spike
Microns
Solutions
Reconstitute
Leaching

Adsorption
Absorption
Diluent
Admixture
Open system
Closed system
Diaphragm
Piggyback
Coring
Crystalloid solutions

Overview

Certain supplies are essential to conduct the necessary processes and techniques used for compounded sterile preparations (CSPs). This chapter introduces the supplies used in parenteral preparations and provides foundational knowledge that will be referenced in subsequent chapters.

A variety of supplies are used in the preparation process, each with a specific function, and understanding their role is important to be able to effectively prepare CSPs using sterile technique. Moreover, each category of these items often comes in a variety of types. The benefit of such variety is that the operator is able to select the most appropriate supplies during parenteral compounding to best facilitate an accurate preparation and efficient process. If inappropriate supplies or equipment are chosen, this can result in excess time consumption, errors in measurement, loss of product, or inability to effectively and properly prepare the CSP.

Needles and Syringes

Needles and syringes are used during the preparation process to facilitate manipulations. These supplies are fundamental for transferring of medications to and from a variety of containers. Both needles and syringes are manufactured in many different sizes and types, depending on the type of manipulation necessary.

Needles

Needles, made of aluminum or stainless steel, are utilized to transfer solutions and are fundamental in preparing CSPs. They are packaged individually by the manufacturer in a plastic or paper overwrap that guarantees sterility of the needle until the package has been opened or is no longer fully intact.

The parts of a needle are illustrated in **Figure 2-1**. The main parts of a needle are the bevel, hub, heel, shaft, and lumen. The bevel of the needle is the slanted portion of the needle that exposes the opening of the needle. It gives way to the sharp, pointed end of the needle, referred to as the bevel tip, which is intended to enter a vial or container. The heel of the needle is the short end of the bevel and is opposite from the sharp, pointed tip. The lumen, or

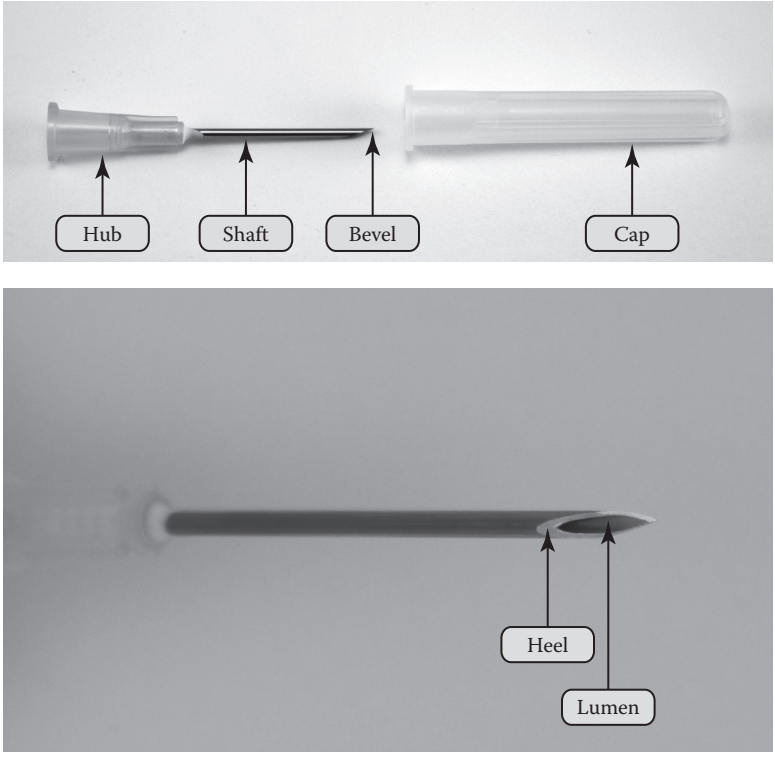

Figure 2-1 Parts of a Needle

bore, of the needle is the inner portion of the needle that allows for the flow of liquid from a syringe into a container or vial. The shaft of the needle is composed of aluminum or stainless steel with an outer surface coated with a silicone lubricant to facilitate smooth penetration through the closures of containers. It is important never to wipe the outer surface of the needle with alcohol, as this action will remove the coating, making entries and exits of the needle through the rubber closures difficult. As the number of manipulations increases, the coating will gradually wear off. This becomes easy to identify during compounding because the entry into closures gradually becomes more difficult as the needle loses its gliding effect from lack of coating. The number of punctures, or entries into closures, per needle should not exceed five.

Needles vary in their length and lumen diameter, and both characteristics should be selected based on the intent of use. The length of the needle is the distance from the hub of the needle to the tip of the needle. The diameter of the lumen is referred to as the needle gauge and comes in different sizes, ranging from 13 to 31. Gauge is a unit of measurement developed early in the 19th century as a way to measure medical equipment and catheters. It was originally developed by the iron wire industry to standardize sizing of wiring, with its use to size needles evolving in the 20th century.[1,2] Besides needle hubs being color coded based on gauge size, needles are also labeled with a number, followed by a G, followed by yet another number. In the example 22 G ½, the "22" references the gauge (G), or outer diameter, of the needle; "G" is an abbreviation for "gauge"; and "½" refers to the length of the needle, in inches. As the number referring to the gauge of the needle increases, the lumen diameter decreases, and vice versa. For example, a 22-G needle will have a smaller lumen diameter than an 18-G needle. Examples of different gauges can be seen in **Figure 2-2**.

TIP: *As the gauge of the needle increases, the diameter of the needle lumen decreases.*

Figure 2-2 Needle Gauges

Selection of the proper gauge depends on the type of solution being transferred. For example, thick or viscous solutions should be transferred using small-gauge needles, such as 19–20, to allow for easier flow of the solution through the needle. Larger-gauge needles can be used for aqueous-based solutions. A needle with a smaller gauge may also serve best when penetrating thick rubber

closures, which will make entries easier. Although use of smaller-gauge needles allows for easier and quicker flow of solutions, the risk of coring increases as the gauge of the needle decreases. Thus smaller-gauge needles should be chosen only when needed and should not be utilized routinely. An 18-gauge needle is most commonly utilized for sterile compounding. Needle gauge is also a factor when administering CSPs. Gauges of 22–25 should be used to deliver IM injections, while gauges 23–25 are best suited for subcutaneous injections.

Needle lengths vary from ⅜ inch to 2 inches. A longer needle should be chosen when working with thick closures or lengthy entry ports on containers. When transferring solutions into a container through the entry port, using a longer needle will allow the contents of the syringe to be transferred directly into the container and prevent accumulation of solution within the entry port. Insulin needles with short needle lengths, for example, will deposit solutions into the entry port of large container bags, requiring subsequent flushing of the port. Needle length also becomes a consideration when administering medications to patients. Longer needles are required for intramuscular injections and shorter needles for subcutaneous and intradermal injections. For example, a needle length of 1–1.5 inches is typically chosen for IM injections in adults, while a needle length of ⅝ inch is typically used for subcutaneous injections in adults.

The gauge and length of the needle selected should also factor into the size of the syringe used. **Table 2-1** offers some guidelines for selecting the type of needle for routine manipulations based on the syringe size or solution type.

Several types of needles are available to facilitate different types of transfers and manipulations, including double-ended needles, filter needles, and vented needles. Also within a similar category, although not necessarily considered needles, are filter straws.

Double-Ended Needles and Transfer Sets

As the name describes, a double-ended, or double-sided, needle has two needles adjoined with a plastic center hub (**Figure 2-3**).

Table 2-1 Selecting Syringe and Needle Sizes[1]

Syringe Size	Needle Gauge	Needle Length
1 mL 3 mL 5 mL	20 gauge	1 inch
10 mL 20 mL 30 mL 60 mL	18 gauge	1½ inch
Large volume Viscous solutions	16 gauge	1½ inch
Ampule	Filter needle	

Source: Adapted from Aseptic technique: using needles, syringes, and filters. In: *Basics of aseptic compounding technique.* Bethesda, MD: American Society of Health-System Pharmacists; 2006:39.

The needle can be handled only from the center hub to avoid touching the metal portion of the needle, which would result in contamination. Double-ended needles are useful when transferring solutions directly from one container to another. When using a double-ended needle, one side of the needle is inserted into one container and the other side of the needle is inserted into a different container. The container into which solution is being transferred should be on the bottom during this process. This allows the content to flow directly from one container into the container on the bottom. Because these types of needles do not attach to a syringe, the volume of the contents cannot be measured. Thus double-ended needles are intended to be used when the entire contents of one container need to be transferred to another container.

Transfer sets are also used to transfer solutions directly from one container to another. Transfer sets consist of plastic tubing with a spike at one end, a syringe connection with a two-way valve at the other end, and a clamp in the middle (**Figure 2-4**). Because a syringe can be connected to one end of the transfer set, the flow

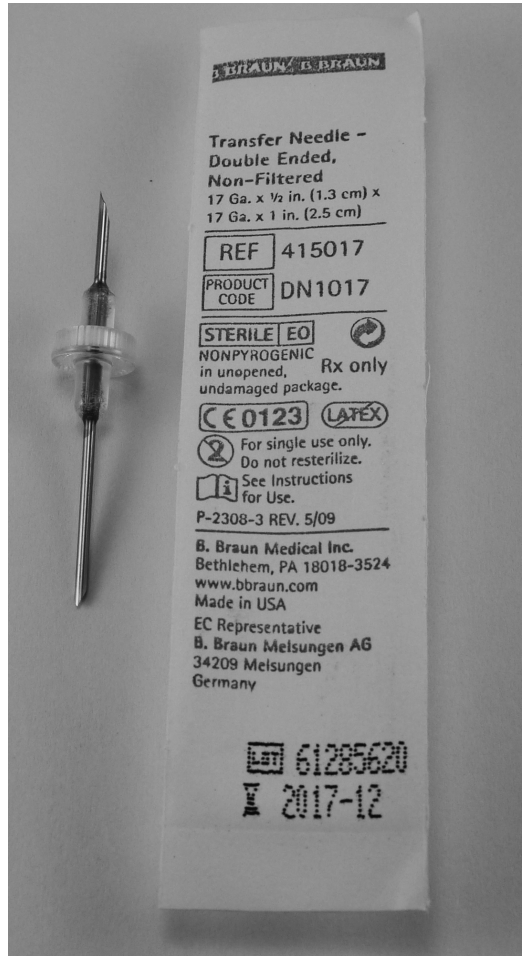

Figure 2-3 Double-Ended Needle

can be controlled and the volume of solution being transferred from one container to another can be measured.

Filter Needles and Filter Straws

Needles are available that contain a filter embedded within the hub of the needle and that attach to the syringe in a typical manner. The filter is typically 5 microns, which is the maximum pore size necessary to prevent particulate matter from passing through the needle. Although the filter cannot be seen, it plays an important role when transferring solutions from ampules. Fragments

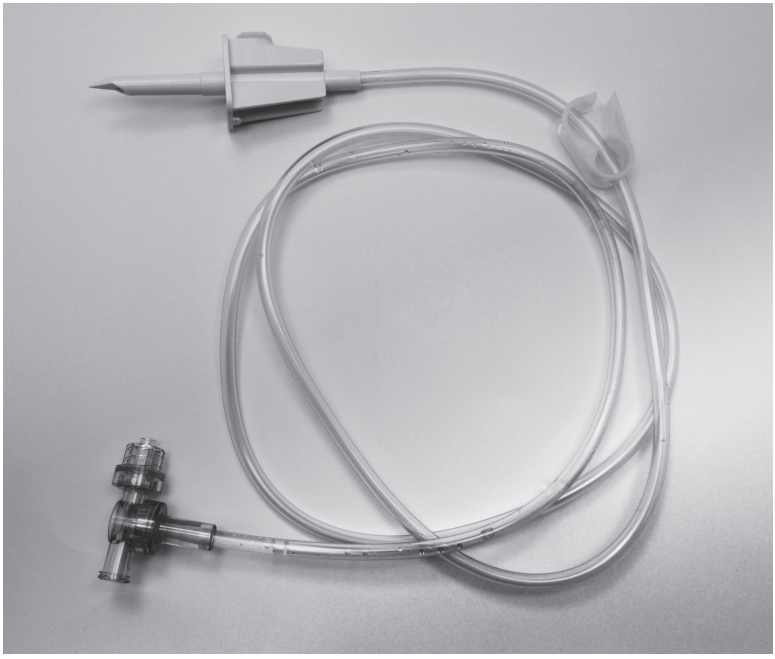

Figure 2-4 Transfer Set

of glass—some microscopic—can result from breaking an ampule and cause serious patient harm or death if infused. To prevent pieces of glass and other unwanted material from being transferred into the final preparation when withdrawing a solution from an ampule, a filter needle must be used every time. When using a filter needle to withdraw solution from an ampule into a syringe, particles are trapped on the underside of the filter. In contrast, solutions expelled from a syringe through a filter needle will result in particles being trapped on the upper side of the filter. Thus it is essential that filter needles be used only one time and used in only one direction. Using a filter needle to both withdraw and expel solution will cause any material trapped in the filter to be expelled into the final preparation.

ALERT: *Always use a filter needle when withdrawing solution from an ampule into a syringe. The needle should then be changed prior to expelling the contents from the syringe.*

If the contents of a syringe will be used for direct patient administration, a filter needle should be used to draw the solution into the syringe, and then the filter needle should be removed and replaced with a regular needle. Filter needles cannot be used with certain medications, such as suspensions and liposomal formulations, as the filter can remove important active ingredients.

Similar to filter needles, filter straws utilize filters within the hub to prevent passage of unwanted material. Filter straws are utilized for purposes similar to those for which filter needles are used. Because a filter straw has plastic tubing in place of the metal needle, it offers the benefit of flexibility and length, which can be useful when drawing up solutions from the bottom of large ampules.

Vented Needles

Vented needles are plastic spikes that are thicker in diameter than the typical needle (**Figure 2-5**). During preparation of CSPs, positive and negative pressure must be accounted for during withdrawal of solutions. Vented needles allow air to pass in and out of a "vent," thereby preventing pressure differences. These types of needles are useful whenever pressure effects are unwanted, but are particularly beneficial for reentering multiple-use vials or when preparing chemotherapy. Attaching a vented needle into a large-volume solution or multidose vial allows reentry multiple times without compromising the integrity of the closure of the container from multiple penetrations. When preparing chemotherapy, positive pressure can result in spraying of vial contents, putting the operator at risk of exposure. Vented needles alleviate the need to account for positive and negative pressures and result in better protection of the operator from spraying of hazardous drugs.

Syringes

Syringes attach to a needle and house solutions that are to be administered to a patient or transferred from one container to another. Traditionally, glass syringes were used, but have been almost completely replaced with plastic syringes. Glass syringes

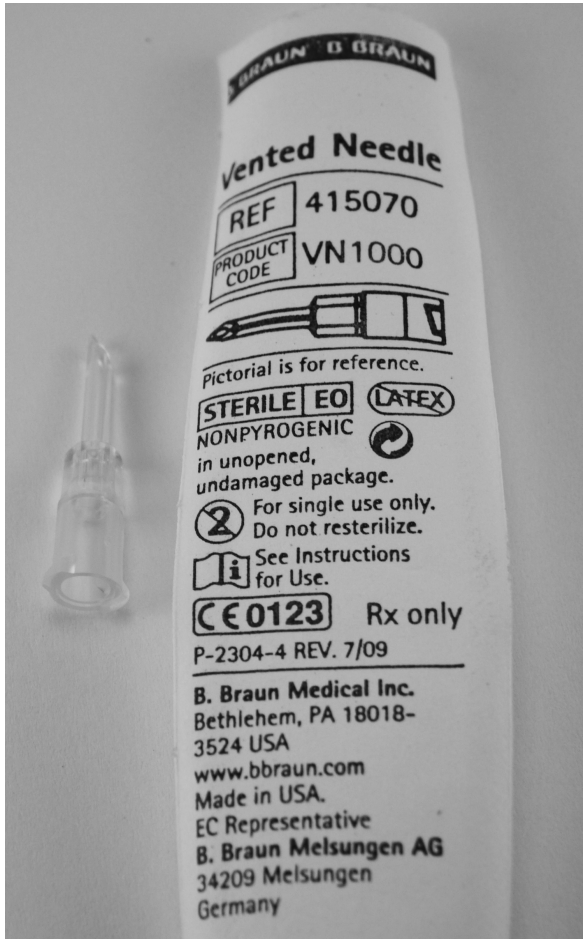

Figure 2-5 Vented Needle

are still used for patients with a plastic allergy and offer the advantage of being able to be sterilized and reused. While plastic syringes offer advantages in terms of less cost, less risk of breaking, and disposability, resulting in decreased risk of contamination, their increased use has also created minor issues with medications that are not compatible with plastic. Because of the short amount of time that the contents remain within the syringe when being transferred, this issue only rarely becomes a problem,

such as with medications in which a direct incompatibility may exist. In these situations, using a glass syringe will circumvent compatibility issues arising from exposure to plastic.

Parts of a Syringe

The parts of a syringe are illustrated in **Figure 2-6**. These parts include the tip, barrel, plunger, top collar, and flange. Syringes are packaged by the manufacturer in an individually sealed paper or plastic overwrap and are intended for a single use. Sterility of the syringe is guaranteed until the package has been opened or has been compromised.

Syringes are available with a Luer Lock tip or a slip-tip (**Figure 2-7**). The tips of Luer Lock syringes contain threads that allow the needle hub to fasten onto the syringe by twisting the

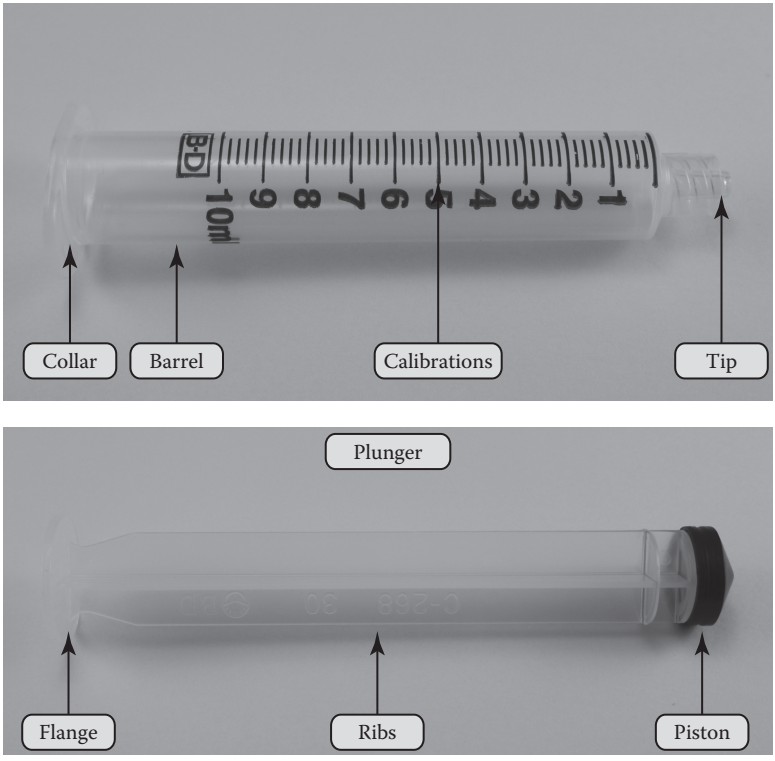

Figure 2-6 Parts of a Syringe

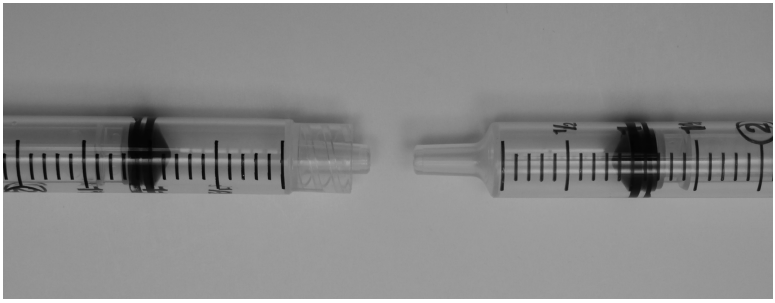

Figure 2-7 Luer Lock (l) and Slip-tip Syringes

hub onto the syringe tip. When using a Luer Lock syringe, the needle should be secured firmly, while taking care not to excessively tighten it. Luer Lock syringes are also available with a needle already attached. When using these types of syringes, the needle should be tightened slightly, prior to its use, by rotating the needle until firmly secured.

Slip-tip syringes do not contain threading; instead, they have a smooth surface upon which tension and friction allow the needle hub to stay attached to the syringe. A disadvantage of slip-tip syringes is the tendency of the needle to disengage from the syringe if not properly attached. When attaching a needle to a slip-tip syringe, the operator should press the hub of the needle firmly on the tip while using a slight twisting motion. Disengagement is most likely to occur when removing the needle cap from a needle attached to a slip-tip syringe. To avoid this problem, the syringe and needle can be slightly bent so as to provide tension at the point where the needle attaches to the syringe. When removing the cap, push the needle cap toward the syringe tip and then quickly pull the cap off while maintaining a slight bend. This should be done in one continuous motion. Because of the potential for needles to disengage from a slip-tip syringe, these types of syringes should not be used to prepare chemotherapy or other hazardous agents.

The barrel of the syringe holds the solution that is to be transferred. Calibration marks are found on the barrel that permit volume measurement. As the size of the syringe increases, the increments of the calibration marks become larger.

The syringe plunger consists of the plunger piston, ribs, and flange. The flange is also referred to as the lip or flat end of the plunger. The ribs of the plunger are located between the flange and the plunger tip. This portion of the plunger comes in contact with the inside of the barrel when the plunger is pushed in fully; thus the inside of the barrel may become contaminated if the ribs are touched. The flange provides a flat surface that facilitates manipulation of the syringe. The tip of the plunger piston is pointed and resembles a triangle. The plunger piston comes in direct contact with the solution being transferred and is used to measure the syringe's contents along the calibration marks. The base, or flat, part of the triangular portion is referred to as the final edge and should be used to align with the calibration marks to measure the desired volume. **Figure 2-8** illustrates the final edge of the piston plunger that is aligned using the calibration marks to ensure accurate measurements; this figure depicts a measurement to 10 mL.

TIP: *The final edge of the plunger piston should be aligned with the calibration marks on a syringe to measure the desired volume.*

Syringe Size

Syringe sizes vary from 0.5 mL to 60 mL, indicating the maximum volume that can be drawn up into the syringe. As the size of the syringe increases, the length and diameter of the syringe also increase. As mentioned previously, calibration marks vary with syringe size. For example, a 1-mL syringe will have calibration marks in increments of 0.01 mL, beginning with 0.01 mL and increasing to 1 mL.

It is important to consider accuracy of measurement when selecting a proper syringe size. A large syringe, for instance, should not be selected to draw up a small volume. Literature substantiates the relationship between syringe size and accuracy. One study found that both accuracy and reproducibility of 0.5 mL of volume decreased as the syringe size increased from 1 mL to 5 mL, with an error toward overdelivery of volume as the

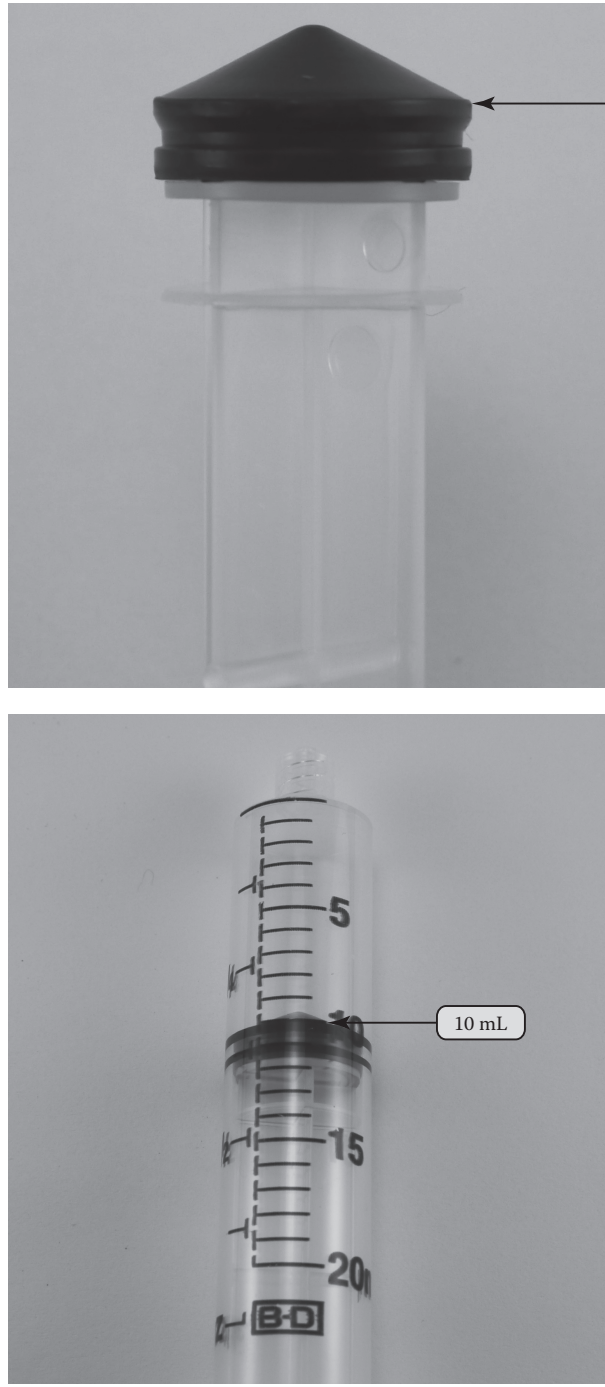

Figure 2-8 Final Edge of Piston Plunger Used for Measuring

syringe size increased.[3] Thus small syringes will have the greatest accuracy compared to other sizes due to the small increments of the calibration marks. As a rule of thumb, the smallest syringe size that can accommodate the desired volume should be chosen.

TIP: *The smallest syringe size that can accommodate the desired volume should be used.*

Accuracy of a syringe can be determined by dividing the smallest increment of the calibration marks in half. For example, a 10-mL syringe with 0.2-mL increments will be accurate up to 0.1 mL. Therefore, measurements of 3.2 mL and 5.1 mL could all be measured with confidence in accuracy. In contrast, measurements of 3.25 mL or 5.09 mL could not be accurately measured in a 10-mL syringe. Calibration increments for common syringe sizes can be found in **Table 2-2**.

Mistakes during measurement may arise secondary to confusion created by the calibration markings of insulin syringes and 1-mL syringes. Calibration marks on an insulin syringe are in units, the standard measurement of insulin. Because most

Table 2-2 Calibration Mark Increments for Common Syringe Sizes

Syringe Size	Calibration Graduations
Insulin syringes:	
Standard U-100 (holds 1 mL or 100 units)	2 units (dual scale with numerical markings for every 10 units—with even 2 unit increments on one side and odd 2 unit increments on the other)
U-50 (holds 0.5 mL or 50 units)	1 unit
U-30 (holds 0.3 mL or 30 units)	1 unit
1 mL (tuberculin syringe)	0.01 mL
3 mL	0.1 mL
5 mL	0.2 mL
10 mL	0.2 mL
20 mL	1 mL
30 mL	1 mL
60 mL	2 mL

manipulations involve measurements with calibration markings in milliliters, switching between insulin syringes and 1-mL syringes commonly results in a mistake in the volume of insulin withdrawn. With insulin being a high-risk medication, this type of error can result in great harm to the patient and even death.

Oral Syringes

Oral syringes allow medications to be administered directly to the patient, but the structure of the syringe tip will not accommodate attachment of a needle. In the inpatient setting, oral syringes can be available, but must be used only for oral administration of medications. Similarly, non-oral syringes should never be used for delivering oral medications. Using non-oral syringes to hold oral medications can result in accidental administration of an oral medication through a parenteral route. To prevent this possibility, oral medications must never be placed in a non-oral syringe. A multitude of incidents involving such accidental administration have been reported, with many resulting in irreversible patient harm and death of adults and children alike.[4] In an effort to increase patient safety, any medication to be administered orally should be prepared only in an oral syringe and should be clearly marked with an auxiliary label, such as "For Oral Use Only."

ALERT: *Oral medications must never be placed in a non-oral syringe.*

Prefilled Syringes

Often, medications may be drawn up into a syringe with the intention of delivering them via direct patient administration through parenteral routes. When preparing a syringe for direct patient administration, the needle can be removed from the syringe and a plastic syringe cap can be easily pushed or twisted onto the tip of a syringe to provide closure and maintain sterility until the contents are ready to be administered (**Figure 2-9**).

Prefilled syringes are also available; these syringes are provided by the manufacturer with a specific volume of medication

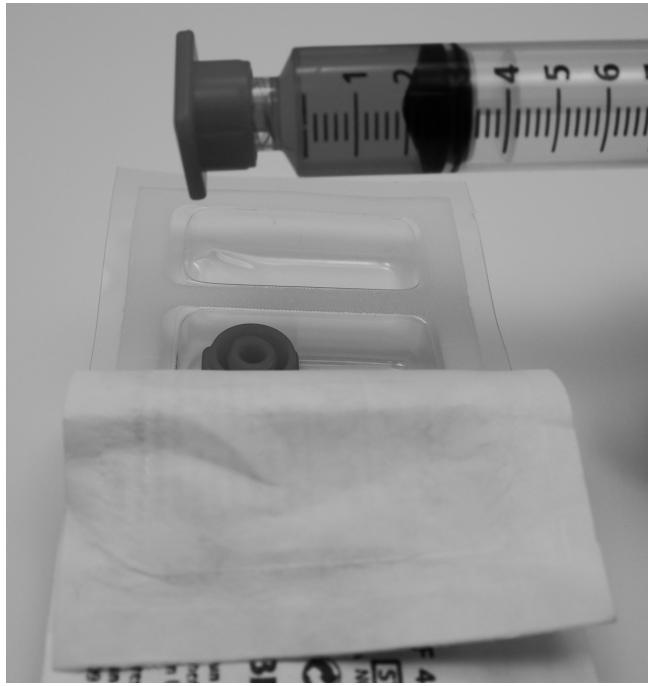

Figure 2-9 Syringe Cap

Figure 2-10 Prefilled Syringe

already present within the syringe and are intended for direct administration to a patient (**Figure 2-10**). These types of syringes are gaining popularity in the healthcare setting and their use is expected to increase over the next few decades. Such single-use syringes are provided by the manufacturer in either glass or plastic and come either as a needleless system that attaches directly

to an access catheter or as a unit with a needle already attached. Glass prefilled syringes can be dual-chambered devices, with one chamber containing medication in a powder formulation and the other a diluent. The syringe can be activated and the contents of both chambers mixed just prior to administration.

Prefilled syringes accommodate volumes that typically range from 0.25 to 5 mL and are most suitable for solutions or medications that will be administered by subcutaneous or intramuscular injection. Antithrombotics, vaccines, and biotechnology-based drugs account for the majority of prefilled syringes currently available.[5] Some interferons, rheumatoid arthritis medications, and blood stimulants are also provided by the manufacturer in prefilled syringes.

Because these syringes are prefilled, and some are needleless units, the operator does not need to withdraw medication from a vial, which in turn minimizes the potential for medication errors, contamination, and needle sticks. Besides improved accuracy and safety, prefilled syringes offer added convenience, efficiency, and ease of use. Disadvantages of these systems include their complexity as well as the potential for needle sticks with those that are not provided by the manufacturer as needleless devices. Additionally, problems with malfunction, breaking, or clogging with certain prefilled glass syringes have been reported in the past. Because of these limitations, in 2011 the FDA recommended the avoidance of needleless glass prefilled syringes in emergency situations.[6]

Safety Needles/Syringes

Needle stick injuries from manipulation of needles introduce occupational hazards to healthcare personnel and introduce the potential for transmission of blood-borne pathogens. At an average-size hospital, approximately 30 needle stick injuries are reported by workers for every 100 beds every year.[7] Thus needle safety is of great concern in the healthcare setting.

To mitigate these risks, a variety of safety syringes are available with different mechanisms to shield the needle following use. One type, for instance, will inactivate the plunger of the syringe once the plunger is fully depressed, preventing reuse of

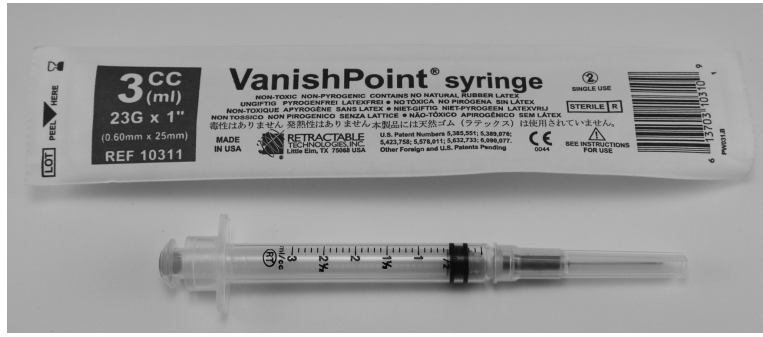

Figure 2-11 Safety Syringe

the syringe altogether. Another type of safety syringe shields the needle, either by retracting the needle into the syringe barrel when the plunger of the needle is pulled back or by deploying a protective shield over the needle. **Figure 2-11** depicts an example of a safety syringe. Safety syringes and needles are more expensive, but are much more effective at protecting the healthcare worker from needle sticks.

Types of Containers

Containers are used throughout the sterile compounding process to house solutions such as diluents and medications, as well as powders for reconstitution. Empty containers into which solutions are transferred or for mixing multiple product preparations are also available. Most solutions placed within containers will chemically interact with the container either minimally or to the point of incompatibility. The type of container used for storing CSPs needs to be considered so as to minimize any potential interaction between the container and the preparation. While the manufacturer provides medications in suitable containers, sometimes the operator must choose the container type when preparing CSPs. Therefore, the operator should be knowledgeable as to the various forms of containers and be able to select the proper container appropriately.

Ampules

Ampules are glass containers that hold sterile injectable solutions (**Figure 2-12**). Ampules may be used to contain hazardous medications, diluents, and medications with volumes that can range from 1 mL to 50 mL. Often, medications that pose risk of chemical incompatibility with plastic are supplied in glass ampules. Ampules, which structurally consist of a neck and a body, must be broken at the neck prior to accessing their contents. Many ampules are scored or have pressure points located on the neck to facilitate breaking them at the desired point. If it proves difficult to break the ampule, it can be turned one-quarter turn, which may help with locating the pressure point. A polyethylene breaker/collar that slips over the neck of the ampule can be used

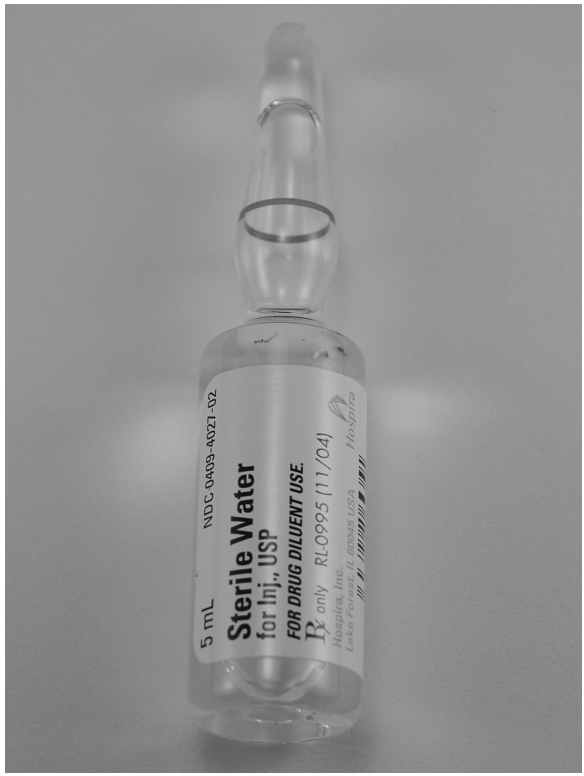

Figure 2-12 Ampule

to improve the operator's grip on the ampule neck, thereby facilitating breaking the ampule in a safe manner. Additionally, the barrel of a 10-mL sterile, clean syringe with the plunger removed can be slipped over the neck of the ampule, providing leverage and improving safety and ease of breaking.

As mentioned previously, because of the potential for glass to enter the solution being withdrawn, a filter needle or filter straw must be used when withdrawing or expelling contents from an ampule. All ampules are intended for single-dose only.

Vials

Vials are made of either plastic or, more commonly, glass. Vials may contain medications in the form of a solution or a freeze-dried sterile powder that requires a diluent be added to form a solution, a process referred to as reconstitution. Because contents of glass vials are packed under a vacuum, some glass vials are equipped with venting tubing—that is, a small air tube located within the vial that facilitates removal of the solution without the need for venting by the operator. Glass vials typically have a rubber closure, also referred to as the rubber stopper or diaphragm, to prevent free passage of air or fluids in or out of the vial. An aluminum sealing ring along the circumference of the rubber closure secures it in place. A flip-top cap or aluminum cover protects the top of the rubber closure; it must be removed to access the contents of the vial. While these covers protect the otherwise exposed rubber closure, they do not guarantee sterility of the closure. Thus it is necessary to disinfect the rubber closure prior to puncturing it.

Plastic vials are available for some medications and are structured similar to the glass vials, with a rubber closure and flip-top cap. Other plastic vials are manufactured with a plastic pull ring that is removed in a circular manner to reveal a rubber plug that can be completely removed. This type of plastic vial is intended to be attached directly to a bag for intravenous infusion, and is commonly referred to as an adaptable system or adaptable container.

Single-Use and Multiple-Use Vials

Medications provided by the manufacturer in vials as solutions can be classified as single-use or multiple-use products, also

referred to as single-dose and multidose vials. The differentiating factor is the addition of a preservative to the solution. When medications are manufactured with small amounts of preservatives, the length of time that the solution can be used is extended. The addition of preservatives impedes the growth of bacteria and other microorganisms within the solution. While the preservatives may retard the growth of bacteria, they will not ensure sterility if contamination occurs. Thus sterile techniques during the preparation process still need to be employed.

Vials that are intended for multiple uses contain preservatives and bear a label that identifies them as such. If the vial labeling does not state that it is a multiple-use product, then it should be considered to be for single use. Preservatives commonly used in multiple-use vials include phenol, benzalkonium chloride, benzyl alcohol, parabens, chlorobutanol, phenylmercuric salts, cresol, and thimerosal. Bacteriostatic water for injection contains preservatives, but addition of bacteriostatic water to reconstitute powders does not make the final solution appropriate for multiple uses. Because the addition of preservatives is in small amounts and safe for administration in normal doses, whenever large doses are used, the total amount of preservatives that will be administered to the patient needs to be considered.

It is imperative that medications containing preservatives never be used for epidural or intrathecal administration. Such administration can cause toxicity to the patient. In neonatal and pediatric patients, a small amount of preservative in medications can be significant relative to their size and, therefore, can also lead to toxicity. Given these considerations, preservative-free formulations should always be chosen, when available. When preparing preservative-free medications with the addition of bacteriostatic water for injection, the final solution will contain preservatives and should not be administered via epidural or intrathecal injection; its use should also be avoided in pediatric and neonatal populations.

ALERT: *Medications that contain preservatives or are prepared with bacteriostatic water for injection must never be used for epidural or intrathecal administration.*

Adaptable Systems

ADD-Vantage, Vial-Mate, add-EASE, and Minibag Plus are all examples of adaptable systems (**Figure 2-13**). These systems facilitate direct attachment of a vial to a bag of diluent and are often referred to as ready-mix systems. Vial-Mate and add-EASE are binary connectors that allow the attachment of a vial and a bag together. ADD-Vantage and Minibag Plus systems utilize a special bag of diluent with three main components:

- Set port: for attaching tubing for administration to the patient
- Vial attachment port: for direct attachment of the vial to the bag
- Seal: to prevent the diluent from entering into the vial until the medication is ready to be administered

The ADD-Vantage system has a round plastic pull ring on the bag that is pulled and removed, allowing a vial to be securely screwed into the port. Plastic vials manufactured specifically for this type of system also have a plastic pull ring that can be removed in a circular fashion and is intended to allow attachment of the vial to the bag. The Vial-Mate system contains a plastic adapter with a spike that is covered for sterility and is directly attached to the bag. Once the spike cover is removed, the adapter can be firmly placed atop a compatible vial with a rubber closure and attached by pressing firmly on the plastic adapter, pushing the spike through the rubber closure of the vial.

When the medication is ready to be administered, tubing should be attached and the seal between the bag and the vial must be broken, which will allow the diluent from the bag to enter into the vial. The seal on the ADD-Vantage system consists of a rubber stopper located on the inner portion of the bag; this rubber stopper is cleaved to remove the seal. The seal on the Vial-Mate is a plastic cylinder between the bag and the vial. It can be "snapped" by applying inward pressure, similar to breaking a pencil. Once the seal is broken, the contents of the bag will move freely in and out of the vial. Slight pressure can then be applied to the bag to facilitate flow of the diluent into the vial. The vial and bag should

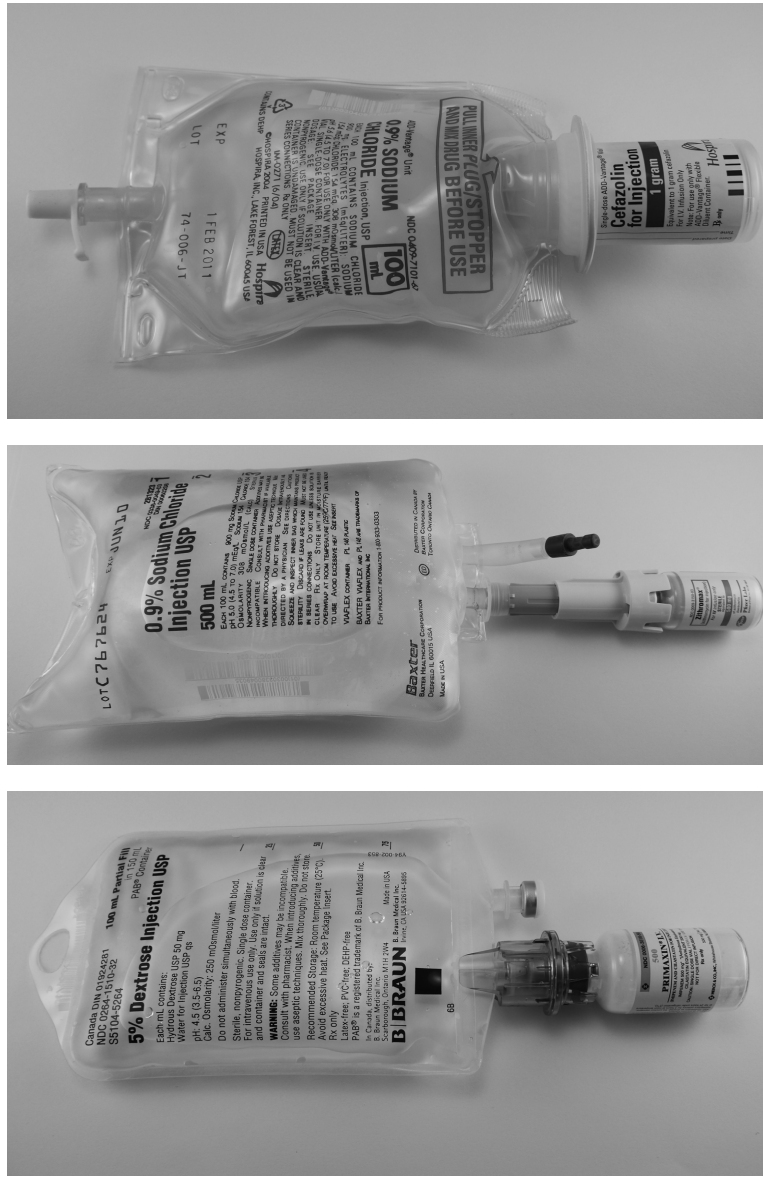

Figure 2-13 Adaptable Systems (ADD-Vantage®, Vial-Mate®, add-EASE®, and Minibag Plus: in order from top to bottom)

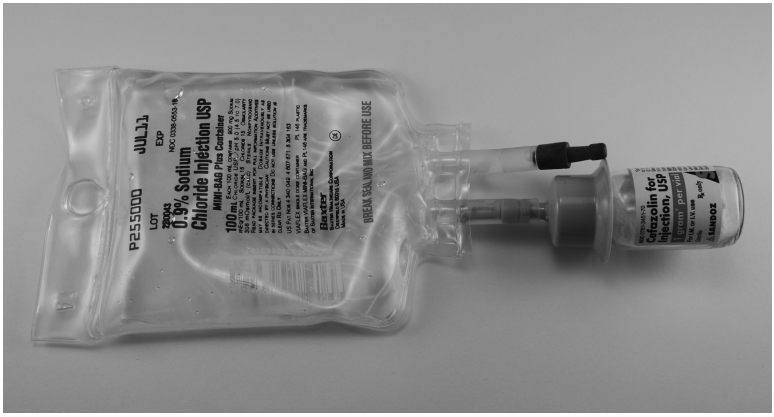

Figure 2-13 (*continued*)

be inverted several times to ensure that the contents of the bag and vial are well mixed prior to administration.

The add-EASE binary connector is plastic and structured similar to a cylinder with two spikes on either end, one for attaching to the vial and the other for attaching to a bag. To use this connector, the spike is centered on the rubber closure of the vial and pushed until the spike penetrates the rubber closure and the connector latches on to the top of the vial. The second spike, on the opposite end, is firmly pushed onto the medication port of the bag. When the medication is ready to be administered, the connector can be activated by folding the bag at the fluid line, which will deploy a plug from the connector into the medication vial. Squeezing the bag will result in flow of solution from the bag into the vial for mixing.

The Minibag Plus is similar to the Vial-Mate except the connector is already attached to the bag. The plastic connector spikes into the vial similarly to the Vial-Mate.

Several advantages and disadvantages are associated with adaptable systems. First, cost should be considered prior to adopting these systems, as the supplies are more costly than traditional supplies. Nevertheless, the faster preparation time, accuracy, reduction in drug wastage, and longer expiration dates help offset this increased cost. For example, adaptable systems facilitate direct attachment of the vial to a bag, while preparing the same

medication without the adaptable system would require a syringe, needle, and personnel time and introduce the potential for errors in the measuring process. Additionally, because the medication in the vial and the solution in the bag remain separate until ready to be administered, the expiration dates are much longer compared to those observed when adding the medication from a vial directly into the bag. Adaptable systems also offer the advantage of convenience and improved efficiency, but come with the disadvantage of needing to store additional inventory, such as vials, that are specific to the system.

Premixed Parenteral Medications

Many IV medications are available in an appropriate type and volume of diluent, ready for patient administration. Using premixed medications can circumvent problems often encountered with prepared admixtures, such as preparation errors and interruptions in pharmacy workflow. Delays in access to medications, resulting in delayed administration, is a consequence of preparing admixtures that can be improved with use of premixed medications. This is particularly beneficial in emergent situations requiring quick administration of medications. Use of premixed medications may be beneficial in preventing accidental misadventures related to standard and maximum allowed concentrations with high-risk medications. Use of premixed medications has also been found to improve time management and efficiency by saving time and labor, reducing turnaround time, eliminating admixture errors, and reducing drug waste.[8] Examples of premixed medications include metronidazole, theophylline, heparin, and amiodarone.

Plastic and Glass Containers

Containers for solutions used in parenteral preparations are made of either glass or plastic. Plastic containers are the most commonly used container for parenteral CSPs, storage of parenteral products, and patient administration. Plastics are mostly made of polymers, including polyethylene polypropylene, polyvinyl chloride (PVC), and polyolefin, some of which are not conducive to certain types of sterilization processes such as autoclaving.[9]

Table 2-3 Advantages and Disadvantages of Plastic and Glass Containers

	Advantages	Disadvantages
Glass	• Decreased chemical interactions between container and contents • Ability to sterilize	• Vacuum (in unvented bottles) • Breakability • Maximum volume of 1 L
Plastic	• Easy storage, including freezing • Flexibility of container • Disposability • Easily hung for IV administration	• Chemical incompatibilities • Easily punctured

Plastic containers offer many advantages over glass containers, as summarized in **Table 2-3**. Plastic containers tend to be less expensive than containers made of other materials and offer the convenience of easy storage and disposal. Despite their many advantages, use of plastic containers presents the most potential for problems with chemical reactions between the container and its contents—for example, leaching, absorption, and adsorption. Both leaching and adsorption are the result of chemical reactions that occur secondary to decreased chemical resistance with changes in pH levels of the contents. Other reactions, such as oxidation, can occur based on changes in temperature and pressure conditions and additives found in the container. Due to the permeable nature of plastic containers, medications that are easily oxidized cannot be stored in plastic containers; such is the case with nitroglycerin. Medications that are incompatible with plastic when in a solution are often stored in a powder formulation in glass containers, with the powder requiring reconstitution before its administration to a patient. Adding a solvent prior to administration minimizes the time that the medication spends as a solution and the contact time with the container. Examples of medications that are stored as powder formulations include vancomycin, penicillin, and ceftazidime.

Glass containers are less commonly used owing to the disadvantages listed in Table 2-3. Glass, which mostly consists of silicone dioxide, is used for ampules, vials, and large empty containers. While one of the most readily apparent disadvantages of

glass is the risk of breaking, these containers offer the advantage of being less permeable and less likely to result in chemical reactions. The most likely reaction to occur with use of glass containers results from leaching of oxides from the glass into the solution, which can induce pH or other changes in the solution and give rise to additional chemical reactions. Different classifications of glass are available based on the chemical resistance of the glass to leaching and other chemical reactions. The United States Pharmacopeia (USP) provides a recommended maximum volume for glass containers and glass ampules, as well as overall requirements for glass containers.

When transferring medications into containers, the selection of glass or plastic should be considered. Manufacturer recommendations for the medication should be referenced to determine its potential incompatibility with plastic or glass.

Solutions or powders stored in plastic and glass containers are subject to light exposure, which can affect the integrity of some medications. Containment in amber glass can decrease the amount of light that enters the container. Certain medications that undergo chemical reactions secondary to light exposure are often provided by manufacturers in amber glass, such as multivitamins that degrade over time with light exposure. For certain CSPs, brown, green, or black plastic sleeves can be placed over the container to decrease light exposure. Some products include light-protective plastic sleeves in their packaging to ensure the preparation is light protected; **Figure 2-14** shows a sodium nitroprusside light-protective sleeve. Further information regarding compatibility and stability with glass and plastic will be discussed in a subsequent chapter of this text.

Diluents

Bags and bottles of solution are available as diluents for administration to patients for purposes of fluid and electrolyte replacement as well as for dilution of medications. An admixture is defined as a final solution resulting from medications, referred to as additives, being added to a bag or bottle of diluent.

The main parts of a plastic bag include an eyehole at the top of the bag for hanging the bag on an IV pole, a medication port, and

Figure 2-14 Light Protective Sleeve

an administration set port (**Figure 2-15**). Bags, which are more commonly used than bottles, are available for a variety of solutions with volumes ranging from 50 mL to 3000 mL. Bottles are available in a maximum size of 1000 mL, per USP requirements.

Most commonly, medications are added to bags or bottles containing either 0.9% sodium chloride, also called normal saline (NS), or 5% dextrose in water (D_5W). Compatibility, isotonicity, and patient-specific needs should all be considered when choosing the type of diluent; **Table 2-4** lists the types of diluents available. Many variations of NS, lactated Ringer's solution, and D_5W are available. While the majority of medications are compatible with NS, which is the most widely used diluent, some medications can be added only to D_5W due to compatibility limitations. For example, and in consideration of patient-specific factors, if a medication can be added to either D_5W or NS and the patient has

diabetes with high blood glucose readings, NS may be the better choice for the patient. This decision is often left to the pharmacist's discretion but should be made in consultation with the prescribing physician.

Concentrated potassium chloride is often added to D_5W, NS, and parenteral nutrition for electrolyte replenishment.

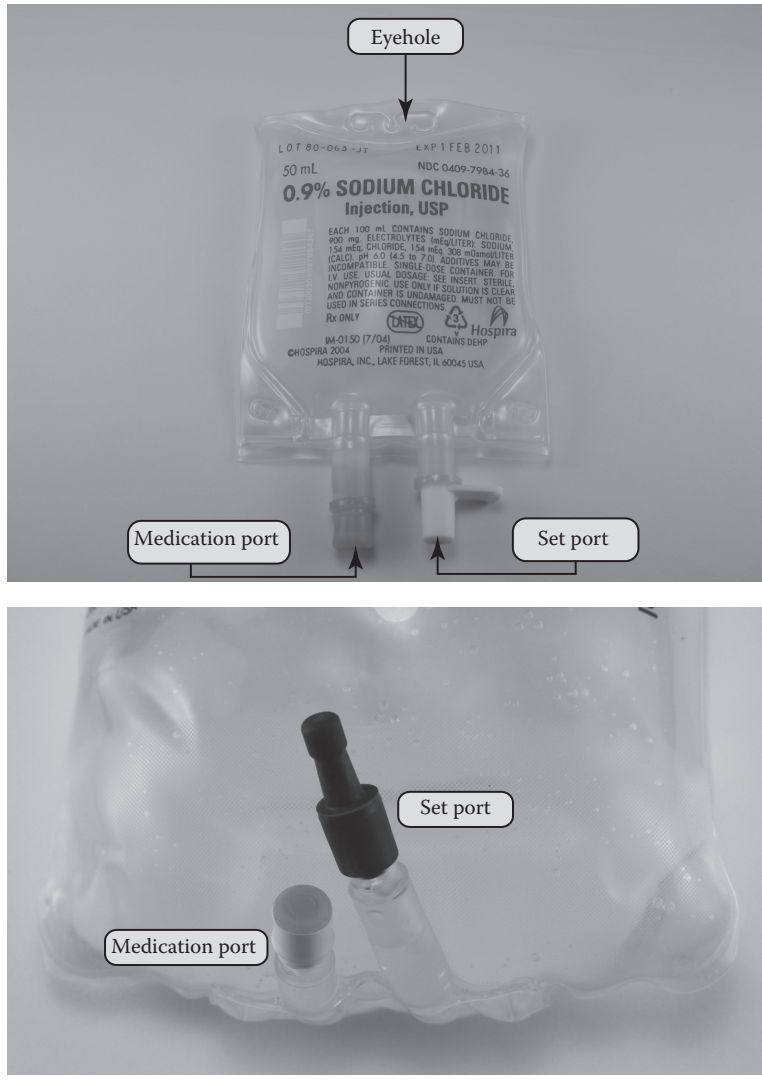

Figure 2-15 Parts of a Bag

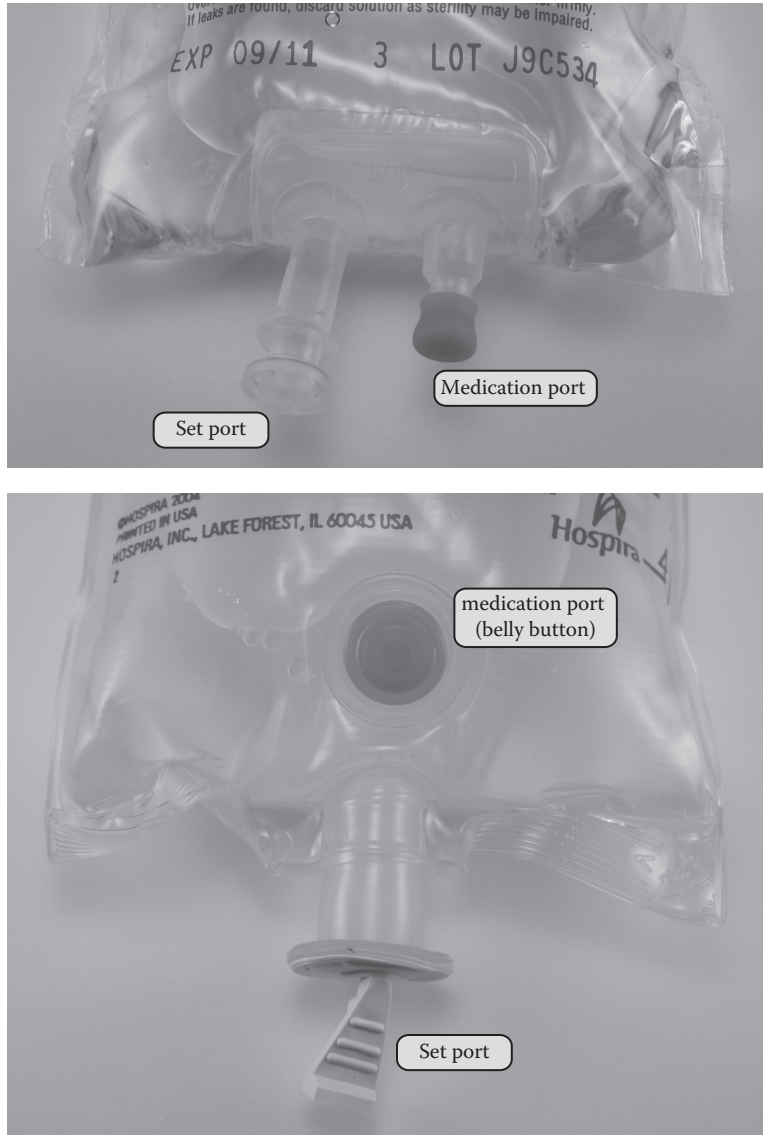

Figure 2-15 (*continued*)

Concentrated potassium chloride should be used only as an additive: It will cause patient death if injected directly or will cause serious patient harm, including cardiac dysfunction, with excessive doses or rates of infusion. Thus concentrated formulations of this high-risk medication should never be stored outside the

Table 2-4 Diluent Types

Diluent Type	Abbreviation	How Supplied	Parenteral Type
Sterile water	W or SWI	Sterile water for injection	LVP and SVP
Dextrose	D_5W	5% dextrose in water	
			LVP and SVP
	D_5NS	5% dextrose with 0.9% sodium chloride	LVP
	$D_{10}W$	10% dextrose in water	LVP
	$D_{10}NS$	10% dextrose with 0.9% sodium chloride	LVP
Saline	NaCl	3% sodium chloride	LVP
		5% sodium chloride	LVP
Normal saline	NS	0.9% sodium chloride	LVP and SVP
			LVP
Half-strength normal saline	½NS	0.45% sodium chloride	LVP
	D_5 ½NS	0.45% sodium chloride with 5% dextrose	
	¼NS	0.2% sodium chloride	LVP
Quarter-strength normal saline	D_{10} ¼NS	0.2% sodium chloride with 5% dextrose	

(*continues*)

Table 2-4 Diluent Types (*continued*)

Diluent Type	Abbreviation	How Supplied	Parenteral Type
Lactated Ringer's (or Ringer's lactate)	LR	Ringer's injection Lactated Ringer's	LVP
	D_5LR	Lactated Ringer's and 5% dextrose	LVP
Potassium chloride	KCl	Potassium chloride (as vial for additive only)	SVP
	NS with 20KCl	20 mEq/L potassium chloride with 0.9% sodium chloride	LVP
	NS with 40KCl	40 mEq/L potassium chloride with 0.9% sodium chloride	LVP
	½NS with 20KCl	20 mEq/L potassium chloride with 0.45% sodium chloride	LVP
	D_5W with 20KCl	20 mEq/L potassium chloride with 5% dextrose in water	LVP
	D_5W with 40KCl	40 mEq/L potassium chloride with 5% dextrose in water	LVP
	D_5 ¼NS with 20KCl	20 mEq/L potassium chloride with 5% dextrose and 0.2% sodium chloride	LVP
	D_5NS with 20KCl	20 mEq/L potassium chloride with 5% dextrose and 0.9% sodium chloride	LVP
	D_5NS with 40KCl	40 mEq/L potassium chloride with 5% dextrose and 0.9% sodium chloride	LVP

pharmacy, care should be taken while mixing preparations, and strict verification procedures should be in place.

ALERT: *Concentrated potassium chloride is considered a high-risk medication and should be used only as an additive. Direct injection of potassium chloride and excessive doses can be fatal.*

Both NS and sterile water for injection (SWI) are considered the best diluents for reconstitution. NS is isotonic and can be used as IV fluid replacement for direct patient administration and as a diluent for medication reconstitution and dilution. SWI, in contrast, is hypotonic and should never be administered directly to a patient through the intravenous route. Such administration can cause hemolysis, resulting in serious patient harm. Confusion regarding the direct infusion of SWI may be influenced by the availability of this solution in a large IV bag that looks similar to IV bags of NS and D_5W. Error reporting programs have received multiple reports of direct IV administration of SWI, some of which resulted in patient death.[10] USP requires that bags of SWI be labeled with cautionary statements that sterile water "is not suitable for intravascular injection without first being having been made approximately isotonic by the addition of a suitable solute."[11] While the bags made available by the manufacturer are appropriately labeled, the text is often overlooked. Thus it is important to place the hospital patient label on the same side as the cautionary text, which may help alert personnel to the restrictions when reading the patient label. Reconstitution of powders for injection requires a relatively small volume of SWI, which should then be added to a larger volume of isotonic D_5W or NS for IV administration.

ALERT: *Patient harm may result from direct injection or infusion of sterile water for injection. This diluent must first be made isotonic prior to intravascular injection.*

USP defines small-volume injections, also referred to as small-volume parenterals (SVPs), as those packaged and labeled with a volume of 100 mL or less.[11] Large-volume intravenous solutions, or large-volume parenterals (LVPs), are those labeled with a volume greater than 100 mL,[11] with typical sizes being 250 mL, 500 mL, and 1000 mL. LVPs are available in glass bottles, both vented and unvented, and in plastic bags. Plastic bags collapse when all air and fluid have been removed from the bag. Large-volume plastic bags are available as in 1 L, 2 L, and 3 L and are used for a variety of solutions, such as parenteral nutrition. Glass bottles are often packaged with a vacuum, requiring air to enter the bottle before the solution will flow out from the bottle. Vented glass bottles contain a small air tube that provides venting. Unvented bottles require administration using a special infusion set that supplies the bottle with air through an airway in the spike. SVPs include minibags, vials, ampules, and prefilled syringes.

Piggyback containers, also known as secondary infusion containers, are used to deliver a second infusion that "piggybacks" onto the primary administration set via a Y-site or medication port. These containers, which usually hold volumes of 50 mL to 250 mL in flexible bags, are manufactured with a base solution to which medications are added. Empty containers are also available for adding customized parenteral preparations.

The volume of diluent selected should be based on medication-specific concentration maximums and any patient-specific factors. For example, fluid-restricted or pediatric patients may require less total volume. In these situations, admixtures may be prepared with the smallest volume of diluent that is necessary to provide adequate stability of the medication in solution. Manufacturer recommendations, as well as compatibility resources, provide information on the maximum concentrations that are appropriate for parenteral medications. Certain medications that have a high likelihood of causing patient harm if infused at high concentrations or at too rapid an infusion rate are considered high-risk IV medications. In an effort to prevent patient harm, these high-risk medications should have standardized

and maximum allowable concentrations and, without deviation, always be prepared at such concentrations that are established by the institution.

Open and Closed Systems

Containers can be classified as open or closed systems based on structural differences of the closure. Open systems refer to closures that expose the medication, solution, or powder to air when the container is opened. An example of an open system is an ampule. Once opened, air and fluid can freely move in and out of the ampule. In contrast, closed systems do not allow passage of air once opened. An example of a closed system is a vial in which, once the vial is opened or accessed, air does not pass in and out of the container. Plastic bags are also considered closed systems. The importance of understanding the distinction between open and closed systems derives from the differences in contamination risk between these two systems. As would be expected, as air exposure increases, the risk of contamination increases as well. Thus open systems have greater risk of contamination.

Supplies for Administration

Once a parenteral CSP is prepared and verified, it is ready to be administered to the patient. The final preparation will typically be in a bag, syringe, or glass container for direct administration. Certain administration supplies are needed to facilitate delivery of the medication from the container or syringe into the patient. A catheter is placed in the patient to whom the medication or solution will be administered. With intravenous administration, for instance, a catheter is placed within the vein and medications or solutions are dripped or pumped into the catheter for infusion into the vein.

Administration Sets

Intravenous administration of solutions or medications from a glass bottle or bag requires the use of an administration set.

Several types of administration sets exist, but most commonly such sets will include the following main parts:

1. Tubing: plastic tubing with two ends, one for attachment to the patient catheter and the other for attachment to the bag or bottle.
2. Needle adapter: located at the end of the tubing and structured to attach directly to the catheter.
3. Clamp: typically a roller or slide clamp. Increasing intensities of pinching will narrow the tubing to regulate the flow of the fluid through the tubing. The clamps can be loosened so that fluid freely moves through the tubing, can be completely clamped off, or can be manipulated for slower or faster flow of fluid.
4. Drip chamber: a plastic cylinder attached to the tubing, directly below the bag, into which the contents of the bag or bottle drip prior to flowing into the tubing. The drip chamber can be used to regulate the rate of infusion in drops per minute (gtt/min) or mL/hr, although regulation "by eye" is infrequently used with the advent of infusion pumps. Some drip chambers have graduated markings to allow for more accurate determination of the infusion rate.
5. Spike: located at the end of the tubing opposite the needle adapter. The spike is used to puncture the set port of the bag or rubber stopper of a bottle.
6. Proximal Y-site: located between the drip chamber and the clamp. This additive, or injection, port is used to attach secondary IV sets and contains a back-check valve that restricts upward flow of fluid from the tubing back into the IV bag.
7. Additive port or distal Y-site: located near the needle adapter. This port provides a site through which medications can be directly infused into the vein. It contains a rubber diaphragm that can be punctured by a needle.

Manual setups of IV fluids using administration sets alone rely on gravity for infusing solutions and medications into the

patient. Rates of infusion can be determined by observing the drip chamber and then adjusting the clamp to increase or decrease the rate. Infusion rate is also a factor of the tubing diameter. Macrodrip sets are wider and deliver 10, 15, or 20 gtt/mL, whereas microdrip sets are narrower and deliver 60 gtt/mL.

Administration sets are prone to contamination, so their intermittent replacement is required to prevent growth of microbes that might otherwise result in catheter-related bloodstream infections (CRBSIs). Data from studies reveal that replacing IV administration sets no more frequently than 72–96 hours following initial use is considered both safe and cost effective.[12] More recent studies suggest that administration sets may not require replacement for as long as 7 days if they are used with antiseptic catheters or if fluids that enhance microbial growth, such as parenteral nutrition or blood, have not been infused through the set.[12] Fluids that potentiate microbial growth, such as fat emulsions and blood, require more frequent changes of administration sets because they have been identified as risk factors for CRBSIs.[12] The Centers for Disease Control and Prevention (CDC) has issued recommendations regarding the frequency of replacing infusion sets, which are summarized in **Table 2-5**.

Secondary Sets

Additional tubing can be attached to a primary infusion set to infuse a secondary IV medication, or an IV piggyback (IVPB). The addition of a secondary set will interrupt the primary infusion to allow for the second medication to be infused. **Figure 2-16** depicts a secondary infusion set attached to a primary infusion set. To piggyback a medication, a secondary set is attached to the proximal Y-site of the primary infusion set. This allows for the primary solution, such as NS for fluid replacement, and another medication, such as an antibiotic, to be infused without the need to remove the primary infusion tubing. A back-check valve located on the primary infusion set prevents backflow of the second medication up through the primary IV tubing. Along with the back-check valve, hanging the secondary medication higher than the primary medication will cause its flow rate to overcome

Table 2-5 CDC Recommendations on Changing Infusion Set Tubing

Type of Product Infused	Frequency of Tubing Change
Any product in which the administration set is continuously used, including secondary sets and add-on devices Exceptions: • Blood • Blood products • Fat emulsions	No more frequently than 96-hour intervals, but at least every 7 days
Tubing used to administer the following products when combined with amino acids and glucose or when infused alone: • Blood • Blood products • Fat emulsions	Within 24 hours of initiating infusion
Propofol infusions	Every 6 or 12 hours, when the vial is changed, per the manufacturer recommendation
Intermittently used administration sets	No recommendation can be made

Source: Adapted from Centers for Disease Control and Prevention. Guidelines for the prevention of intravascular catheter-related infections. 2011. http://www.cdc.gov/hicpac/pdf/guidelines/bsi-guidelines-2011.pdf. Accessed November 25, 2012.

the flow rate of the primary infusion, thereby preventing mixing of the secondary solution into the primary solution.

In-Line Filters

Various studies have demonstrated the presence of particulate matter in solutions infused into patients, such as glass fragments from ampules, rubber pieces from coring, and particulate matter resulting from incompatibilities of parenteral nutrition additives or inherent within drug formulations.[13] Infusion of such particles can cause serious patient harm and potentially death as a result of blocked vessels from occlusive microemboli. Use of in-line filtration has been demonstrated to almost completely prevent

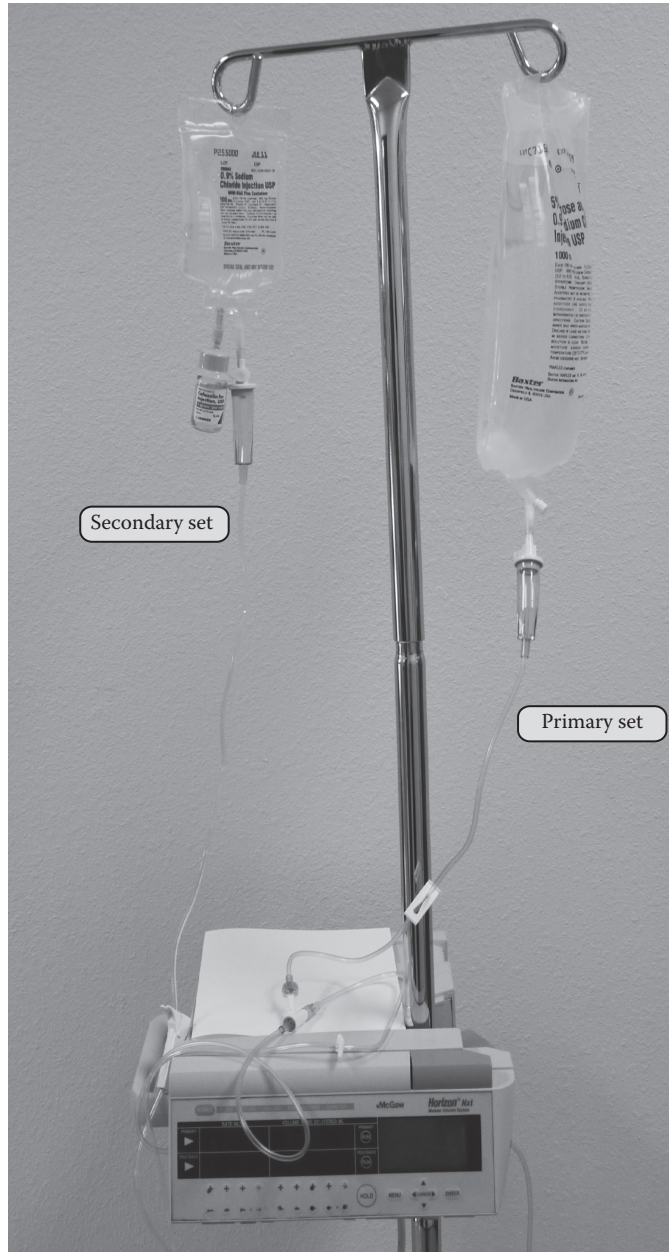

Figure 2-16 Primary and Secondary Infusion Sets

particulate matter from being infused.[13] In-line filters, available as 0.22-micron and 1.2-micron filter sizes, are integrated in the IV tubing of the administration set or as an add-on to existing tubing. The 0.22-micron filters are used for crystalloid solutions and carry a positive charge. Their use has been demonstrated to retain particles, air, microorganisms, and endotoxins.[13] The 1.2-micron filter allows larger particles to be infused and should be used when infusing medications consisting of larger particles, such as lipids. When lipids are added as a secondary infusion, it is important that the lipids be infused downstream from the 0.22-micron filter that is in the primary infusion set. If this setup is not utilized, and the lipids are infused through the 0.22-micron filter, the needed lipids will be filtered out. A 1.2-micron filter should be used with liposomal medications, such as the liposomal formulation of amphotericin B, so as to prevent the medication from being filtered out prior to it reaching the patient. Certain types of medications should always be infused with a filter, such as total parenteral nutrition and mannitol. Mannitol crystallizes readily, even at room temperature, and use of a filter will prevent such crystals from being infused. Total parenteral nutrition has a high propensity for incompatibilities resulting in particulate matter, so a filter should always be used when it is administered. It is important to check the manufacturer's recommendations for specific instructions regarding use of a filter, as several medications require their use.

Add-on filters that remove air are available to attach to IV tubing. Because of the potentially grave consequences of air infusion, as described in literature, in-line air filters should be used in patients at high risk of air embolisms, such as those with right-to-left cardiac shunts and neonates.[14]

Infusion Pumps

External infusion pumps are utilized to safely and accurately deliver fluids and medications to patients in controlled amounts. Infusion sets are used in conjunction with infusion pumps by threading the tubing through the pump so that flow rates can

be regulated electronically. Because of the personnel attention required for manual adjustment of flow rates and decreased accuracy with gravity infusions, electronic infusion pumps have mostly replaced manual setups in healthcare settings. Three types of infusion devices are used: large-volume pumps, syringe pumps, and pumps for patient-controlled analgesia (**Figure 2-17**).

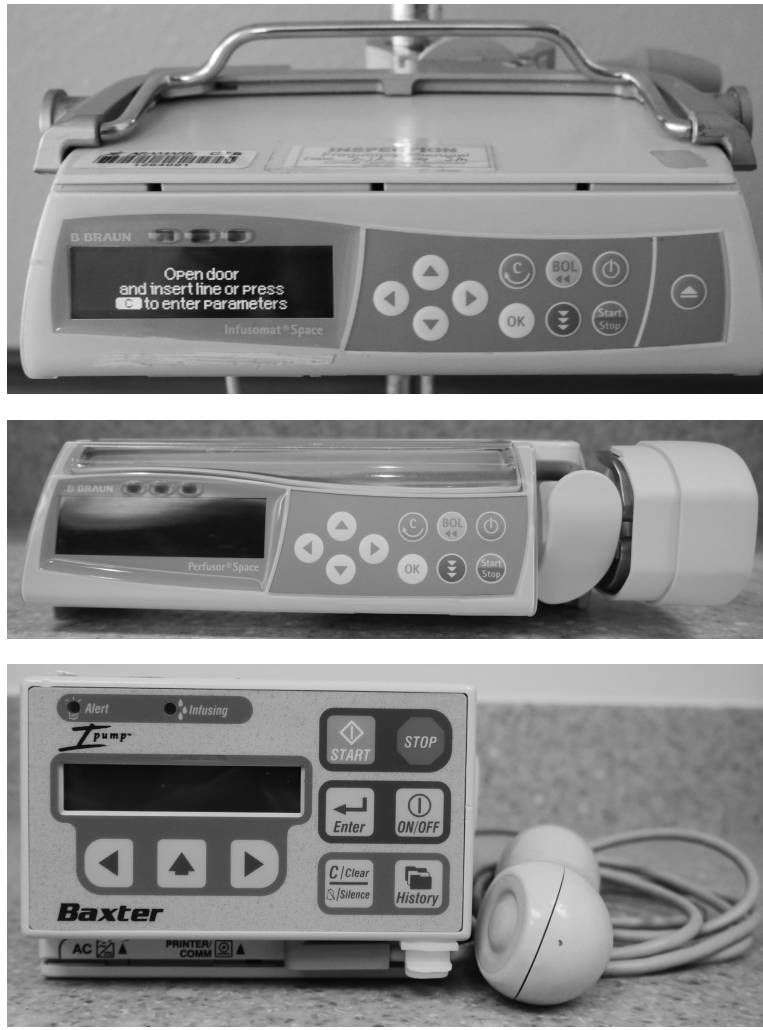

Figure 2-17 Infusion Pumps (Large Volume Pump, Syringe Pump, and Patient Controlled Analgesia Pump: in Order from Top to Bottom)

Large-Volume Pumps

Rather than depending on gravity, large-volume pumps utilize pressure under resistance to force fluid into the vein. Because it is electronic, the nurse can program the pump to specify the rate at which the solution should be infused in milliliters per hour (mL/hr). Multiple solutions can be infused concurrently with infusion pumps, although compatibility between solutions should be ensured prior to infusion.

The most recent advancement in large-volume pumps is the advent of the smart pump. These software-driven pumps can be preprogrammed with drug libraries, which are databases that specify the exact rate that a specific solution should be infused. These sophisticated pumps can accommodate complex infusion regimens, assisting healthcare providers in calculating dose and delivery rates. This is beneficial for tapering or titrating medications or when it is necessary to deliver insulin or nutrition to coincide with meals. The internal alarm system alerts nurses when there is an error in the infusion rate, dose, or route of administration. Smart pump technology can be integrated into barcode scanning systems, computerized order-entry systems, and electronic medication administration records. The literature substantiates that, when used properly, the features available on smart pumps help prevent IV medication errors and reduce patient harm.[15]

Syringe Pumps

Syringe pumps deliver small amounts of fluid at slow rates from medication-filled syringes. The syringe is placed in the pump chamber and the plunger is gradually depressed, delivering medications at a rate that has been programmed into the pump. Because syringe pumps are able to infuse small volumes, they are commonly used in pediatric settings or for fluid-restricted patients in whom small doses or volumes are typically administered. These pumps are also electronic, offering the advantage of programmable rates and alarm sensors.

Pumps for Patient-Controlled Analgesia

These pumps are similar to other electronic infusion pumps and use syringes filled with medications specific for patient-controlled

analgesia (PCA). The technology within PCA pumps enables the patient to self-administer medication by pressing a control button attached to the IV pump. When the button is pressed, the patient will receive a prescribed amount of medication but cannot exceed a "lockout," or maximum allowed dose. For example, PCA pumps can be programmed to deliver loading doses, maximum doses per patient attempt, and maximum doses per hour. The pump can be set to deliver a basal rate of analgesia while allowing the patient to provide the bolus dose when the button is pushed.

Buretrols

Buretrol, also known as Volutrol or burette, systems looks similar to a drip chamber with graduated marks on the outside of the chamber. The chamber sits between the patient's IV catheter and the bag of fluids, with a capacity ranging from 100 to 120 mL. The buretrol can be filled to a specific level based on the prescribed volume of solution or medication. It is used in conjunction with an infusion pump as a safety mechanism. In the event that the infusion pump malfunctions, the pump will administer only the volume that is present in the buretrol. This system is especially useful in pediatric and neonatal patients, although its use is decreasing as the use of syringe pumps and smart pumps increases.

Conclusion

This chapter reviewed fundamental supplies used in the preparation and administration of parenteral CSPs. Subsequent chapters will include additional supplies that are more specific and applicable to the topics covered. Having an overall understanding of available supplies and their role in the preparation and administration processes is essential for compounding sterile preparations in an efficient, effective, and safe manner. Knowledge on the types of supplies available can assist the operator when selecting the best container and diluents based on medication and patient-specific factors. Advancements made in the type and availability of supplies can improve workflow and patient safety, while reducing errors and drug wastage. Understanding administration of

CSPs is an important component in the overall concept of parenteral preparations.

Review Questions

1. Describe the influence of syringe size on accuracy.
2. Differentiate between single-dose and multidose solutions.
3. Describe the influence of open and closed systems on contamination
4. Which types of additives and diluents discussed in this chapter can result in patient death if directly infused?
5. When should products containing preservatives be avoided?
6. Which type of container should never be used in an emergent situation per FDA recommendations?
7. When should an in-line filter be utilized?
8. How often should infusion set tubing be changed when used to administer blood, blood products, or fat emulsions?
9. What are some benefits of smart pumps?

CASE STUDIES *Case 1*

You are a pharmacist working in the sterile compounding room when you are asked to verify a compounded sterile preparation that was prepared for a pediatric patient; the order requires a medication dose of 6.36 mL further diluted in a 50-mL bag. You notice that the technician has the dose drawn up in a 10-mL syringe.

1. Which error has the technician made?
2. How can this error be corrected?

Case 2

An order is received in your hospital for 10 units of insulin in 10 mL 0.9% NaCl. Insulin is provided as 100 units per 1 mL. You will be preparing this admixture for a pediatric patient. Describe the supplies and equipment that will be necessary for this admixture.

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