

Intravenous therapy

Intravenous therapy or **IV therapy** is the giving of liquid substances directly into a vein. The word **intravenous** simply means "within a vein". Therapies administered intravenously are often called **specialty pharmaceuticals**. It is commonly referred to as a **drip** because many systems of administration employ a drip chamber, which prevents air entering the blood stream (air embolism) and allows an estimate of flow rate.

Compared with other routes of administration, the intravenous route is the fastest way to deliver fluids and medications throughout the body. Some medications, as well as blood transfusions and lethal injections, can only be given intravenously.

Intravenous access devices

These can all be used to obtain blood (e.g. for testing), also known as phlebotomy as well as for the administration of medication/fluids.

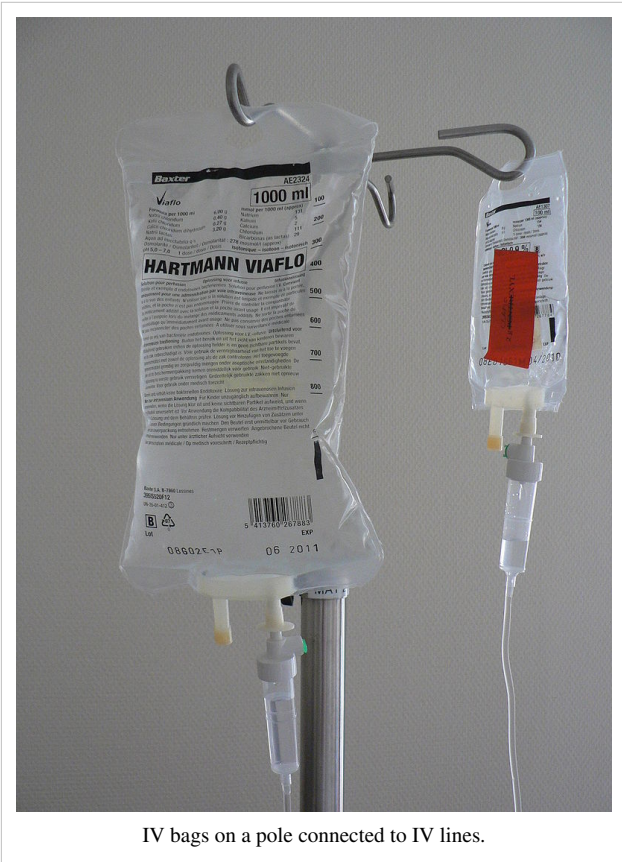
Hypodermic needle

The simplest form of intravenous access is by passing a hollow needle through the skin directly into the vein. This needle can be connected directly to a syringe (used either to withdraw blood or deliver its contents into the bloodstream) or may be connected to a length of tubing and thence whichever collection or infusion system is desired.

The most convenient site is often the arm, especially the veins on the back of the hand, or the median cubital vein at the elbow, but any identifiable vein can be used. Often it is necessary to use a tourniquet which restricts the venous drainage of the limb and makes the vein bulge. Once the needle is in place, it is common to draw back slightly on the syringe to aspirate blood, thus verifying that the needle is really in a vein. The tourniquet should be removed before injecting to prevent extravasation of the medication.

Peripheral Cannula

This is the most common intravenous access method in both hospitals and pre-hospital services. A **peripheral IV line** consists of a short catheter (a few centimeters long) inserted through the skin into a peripheral vein (any vein that is not inside the chest or abdomen). This is usually in the form of a cannula-over-needle device, in which a flexible plastic cannula comes mounted on a metal trocar. Once the tip of the needle and cannula are located in the vein the trocar is withdrawn



IV bags on a pole connected to IV lines.



Peripheral IV in hand

discarded and the cannula advanced inside the vein to the appropriate position and secured. Blood may be drawn at the time of insertion.

Any accessible vein can be used although arm and hand veins are used most commonly, with leg and foot veins used to a much lesser extent. On infants the scalp veins are sometimes used.

The caliber of cannula is commonly indicated in gauge, with 14 being a very large cannula (used in resuscitation settings) and 24-26 the smallest. The most common sizes are 16-gauge (midsize line used for blood donation and transfusion), 18- and 20-gauge (all-purpose line for infusions and blood draws), and 22-gauge (all-purpose pediatric line). 12- and 14-gauge peripheral lines actually deliver equivalent volumes of fluid faster than central lines, accounting for their popularity in emergency medicine. These lines are frequently called "large bores" or "trauma lines".

The larger the cannula the more discomfort there is for the patient and it is sometimes kinder to give a small injection of local anaesthetic into the intended site of insertion of the larger (18G and above) cannula. To make the procedure more tolerable for children topical local anaesthetic (such as EMLA or Ametop) can be applied for about 45 minutes beforehand.

The part of the catheter that remains outside the skin is called the connecting hub; it can be connected to a syringe or an intravenous infusion line, or capped with a bung between treatments. Ported cannulae have an injection port on the top that is often used to administer medicine.

Complications

If the cannula is not sited correctly, or the vein is particularly fragile and ruptures blood may leak into the surrounding tissues, this situation is known as a "tissuing" or a "blown vein". Using this cannula to administer medications causes extravasation of the drug which can lead to edema, causing pain and tissue damage, and even necrosis depending on the medication. The person attempting to obtain the access must find a new access site proximal to the "blown" area to prevent extravasation of medications through the damaged vein. For this reason it is advisable to site the first cannula at the most distal appropriate vein.

If a patient needs frequent venous access, the veins may scar and narrow, making any future access extremely difficult or impossible.

A peripheral IV cannot be left in the vein indefinitely, because of the risk of insertion-site infection leading to phlebitis, cellulitis and sepsis. The US Centers for Disease Control and Prevention updated their guidelines and now advise the cannula need to be replaced every 96 hours.^[1] This was based on studies organised to identify causes of Methicillin-resistant *Staphylococcus aureus* MRSA infection in hospitals. In the United Kingdom, the UK Department of health published their finding about risk factors associated with increased MRSA infection, now include intravenous cannula, central venous catheters and **urinary catheters** as the main factors increasing the risk of spreading antibiotic resistant strain bacteria.



A nurse attempting an insertion of an IV line

Central IV lines

Central IV lines flow through a catheter with its tip within a large vein, usually the superior vena cava or inferior vena cava, or within the right atrium of the heart. This has several advantages over a peripheral IV:

- It can deliver fluids and medications that would be overly irritating to peripheral veins because of their concentration or chemical composition. These include some chemotherapy drugs and total parenteral nutrition.
- Medications reach the heart immediately, and are quickly distributed to the rest of the body.
- There is room for multiple parallel compartments (lumen) within the catheter, so that multiple medications can be delivered at once even if they would not be chemically compatible within a single tube.
- Caregivers can measure central venous pressure and other physiological variables through the line.

Central IV lines carry risks of bleeding, infection, gangrene, thromboembolism and gas embolism (see Risks below). They are often more difficult to insert correctly as the veins are not usually palpable and rely on an experienced clinician knowing the appropriate landmarks and/or using an ultrasound probe to safely locate and enter the vein. Surrounding structures, such as the pleura and carotid artery are also at risk of damage with the potential for pneumothorax or even cannulation of the artery.

There are several types of central IVs, depending on the route that the catheter takes from the outside of the body to the vein.

Peripherally inserted central catheter

PICC lines are used when intravenous access is required over a prolonged period of time or when the material to be infused would cause quick damage and early failure of a peripheral IV and when a conventional central line may be too dangerous to attempt. Typical uses for a PICC include: long chemotherapy regimens, extended antibiotic therapy, or total parenteral nutrition.

The PICC line is inserted through a sheath into a peripheral vein sometimes using the Seldinger technique under ultrasound guidance, usually in the arm, and then carefully advanced upward until the catheter is in the superior vena cava or the right atrium. This is usually done by measuring the distance to an external landmark, such as the suprasternal notch, to estimate the optimal length. An X-ray can be used to verify that the tip is in the right place.

A PICC may have a single (single-lumen) tube and connector, two(double-lumen) or three (triple-lumen) compartments, each with its own external connector. Power-injectable PICCs are now available as well. From the outside, a single-lumen PICC resembles a peripheral IV, except that the tubing is slightly wider.

The insertion site needs to be better protected, than what is required for a peripheral IV, due to the higher risk of serious infection if bacteria travel up the catheter. However, a PICC poses less of a systemic infection risk than other central IVs, because the insertion site is usually cooler and dryer than the sites typically used for other central lines. This helps to slow the growth of bacteria which could reach the bloodstream by traveling under the skin along the outside of the catheter.

The chief advantage of a PICC over other types of central lines is that it is safer to insert with a relatively low risk of uncontrollable bleeding and essentially no risks of damage to the lungs or major blood vessels. Although special training is required, a PICC does not require the skill level of a physician or surgeon. It is also externally unobtrusive, and with proper hygiene, care, and some good luck, can be left in place for months to years if needed for patients who require extended treatment.

The chief disadvantage is that it must be inserted and then travel through a relatively small peripheral vein which can take a less predictable course on the way to the superior vena cava and is therefore somewhat more time consuming and more technically difficult to place in some patients. Also, as a PICC travels through the axilla, it can become kinked causing poor function.

Central venous lines

There are several types of catheters that take a more direct route into central veins. These are collectively called *central venous lines*.

In the simplest type of central venous access, a catheter is inserted into a subclavian, internal jugular, or (less commonly) a femoral vein and advanced toward the heart until it reaches the superior vena cava or right atrium.

Because all of these veins are larger than peripheral veins there is greater blood flow past the tip of the catheter meaning irritant drugs are more rapidly diluted with less chance of extravasation. It is commonly believed that fluid can be pushed faster through a central venous catheter but as they are often divided into multiple lumens then the internal diameter is less than that of a large-bore peripheral cannula. They are also longer, which as reflected in Poiseuille's law, requires higher pressure to achieve the same flow, all other variables being equal.

Tunnelled Lines

Another type of central line, called a Hickman line or Broviac catheter, is inserted into the target vein and then "tunneled" under the skin to emerge a short distance away. This reduces the risk of infection, since bacteria from the skin surface are not able to travel directly into the vein; these catheters are also made of materials that resist infection and clotting.

Implantable ports

A port (often referred to by brand names such as *Port-a-Cath* or *MediPort*) is a central venous line that does not have an external connector; instead, it has a small reservoir that is covered with silicone rubber and is implanted under the skin. Medication is administered intermittently by placing a small needle through the skin, piercing the silicone, into the reservoir. When the needle is withdrawn the reservoir cover reseals itself. The cover can accept hundreds of needle sticks during its lifetime. It is possible to leave the ports in the patient's body for years; if this is done however, the port must be accessed monthly and flushed with an anti-coagulant, or the patient risks it getting plugged up. If it is plugged it becomes a hazard as a thrombus will eventually form with an accompanying risk of embolisation. Removal of a port is usually a simple outpatient procedure; however, installation is more complex and a good implant is fairly dependent on the skill of the radiologist. Ports cause less inconvenience and have a lower risk of infection than PICCs, and are therefore commonly used for patients on long-term intermittent treatment.

Forms of intravenous therapy

Intravenous drip

An **intravenous drip** is the continuous infusion of fluids, with or without medications, through an IV access device. This may be to correct dehydration or an electrolyte imbalance, to deliver medications, or for blood transfusion.

IV fluids

There are two types of fluids that are used for intravenous drips; crystalloids and colloids. Crystalloids are aqueous solutions of mineral salts or other water-soluble molecules. Colloids contain larger insoluble molecules, such as gelatin; blood itself is a colloid.

Colloids preserve a high colloid osmotic pressure in the blood, while, on the other hand, this parameter is decreased by crystalloids due to hemodilution.^[2] However, there is still controversy to the actual difference in efficacy by this difference.^[2] Another difference is that crystalloids generally are much cheaper than colloids.^[2]

The most commonly used crystalloid fluid is *normal saline*, a solution of sodium chloride at 0.9% concentration, which is close to the concentration in the blood (isotonic). *Ringer's lactate* or *Ringer's acetate* is another isotonic solution often used for large-volume fluid replacement. A solution of 5% dextrose in water, sometimes called D5W, is often used instead if the patient is at risk for having low blood sugar or high sodium. The choice of fluids may also depend on the chemical properties of the medications being given.

Intravenous fluids must always be sterile.



Saline solution for IV

Composition of common crystalloid solutions

Solution	Other Name	[Na ⁺](mmol/L)	[Cl ⁻](mmol/L)	[Glucose](mmol/L)	[Glucose](mg/dl)
D5W	5% Dextrose	0	0	278	5000
2/3D & 1/3S	3.3% Dextrose / 0.3% saline	51	51	185	3333
Half-normal saline	0.45% NaCl	77	77	0	0
Normal saline	0.9% NaCl	154	154	0	0
Ringer's lactate	Lactated Ringer	130	109	0	0
D5NS	5% Dextrose, Normal Saline	154	154	278	5000

Ringer's lactate also has 28 mmol/L lactate, 4 mmol/L K⁺ and 3 mmol/L Ca²⁺. Ringer's acetate also has 28 mmol/L acetate, 4 mmol/L K⁺ and 3 mmol/L Ca²⁺.

Effect of adding one litre

Solution	Change in ECF	Change in ICF
D5W	333 mL	667 mL
2/3D & 1/3S	556 mL	444 mL
Half-normal saline	667 mL	333 mL
Normal saline	1000 mL	0 mL
Ringer's lactate	900 mL	100 mL

Infusion equipment

A standard IV infusion set consists of a pre-filled, sterile container (glass bottle, plastic bottle or plastic bag) of fluids with an attachment that allows the fluid to flow one drop at a time, making it easy to see the flow rate (and also reducing air bubbles); a long sterile tube with a clamp to regulate or stop the flow; a connector to attach to the access device; and connectors to allow "piggybacking" of another infusion set onto the same line, e.g., adding a dose of antibiotics to a continuous fluid drip.

An *infusion pump* allows precise control over the flow rate and total amount delivered, but in cases where a change in the flow rate would not have serious consequences, or if pumps are not available, the drip is often left to flow simply by placing the bag above the level of the patient and using the clamp to regulate the rate; this is a *gravity drip*.

A rapid infuser can be used if the patient requires a high flow rate and the IV access device is of a large enough diameter to accommodate it. This is either an inflatable cuff placed around the fluid bag to force the fluid into the patient or a similar electrical device that may also heat the fluid being infused.

Intermittent infusion

Intermittent infusion is used when a patient requires medications only at certain times, and does not require additional fluid. It can use the same techniques as an intravenous drip (pump or gravity drip), but after the complete dose of medication has been given, the tubing is disconnected from the IV access device. Some medications are also given by **IV push** or **bolus**, meaning that a syringe is connected to the IV access device and the medication is injected directly (slowly, if it might irritate the vein or cause a too-rapid effect). Once a medicine has been injected into the fluid stream of the IV tubing there must be some means of ensuring that it gets from the tubing to the patient. Usually this is accomplished by allowing the fluid stream to flow normally and thereby carry the medicine into the bloodstream; however, a second fluid injection is sometimes used, a "flush", following the injection to push the medicine into the bloodstream more quickly.



An infusion pump suitable for a single IV line

Risks of intravenous therapy

Infection

Any break in the skin carries a risk of infection. Although IV insertion is an aseptic procedure, skin-dwelling organisms such as *Coagulase-negative staphylococcus* or *Candida albicans* may enter through the insertion site around the catheter, or bacteria may be accidentally introduced inside the catheter from contaminated equipment. Moisture introduced to unprotected IV sites through washing or bathing substantially increases the infection risks.

Infection of IV sites is usually local, causing easily visible swelling, redness, and fever. If bacteria do not remain in one area but spread through the bloodstream, the infection is called septicemia and can be rapid and life-threatening. An infected central IV poses a higher risk of septicemia, as it can deliver bacteria directly into the central circulation.

Phlebitis

Phlebitis is inflammation of a vein that may be caused by infection, the mere presence of a foreign body (the IV catheter) or the fluids or medication being given. Symptoms are warmth, swelling, pain, and redness around the vein. The IV device must be removed and if necessary re-inserted into another extremity.

Due to frequent injections and recurring phlebitis, scar tissue can build up along the vein. The peripheral veins of intravenous drug addicts, and of cancer patients undergoing chemotherapy, become sclerotic and difficult to access over time, sometimes forming a hard "venous cord".

Infiltration

Infiltration occurs when an IV fluid accidentally enters the surrounding tissue rather than the vein. It is characterized by coolness and pallor to the skin as well as localized swelling or edema. It is usually not painful. It is treated by removing the intravenous access device and elevating the affected limb so that the collected fluids can drain away. Infiltration is one of the most common adverse effects of IV therapy and is usually not serious unless the infiltrated fluid is a medication damaging to the surrounding tissue, in which case the incident is known as extravasation.

Fluid overload

This occurs when fluids are given at a higher rate or in a larger volume than the system can absorb or excrete. Possible consequences include hypertension, heart failure, and pulmonary edema.

Electrolyte imbalance

Administering a too-dilute or too-concentrated solution can disrupt the patient's balance of sodium, potassium, magnesium, and other electrolytes. Hospital patients usually receive blood tests to monitor these levels.

Embolism

A blood clot or other solid mass, as well as an air bubble, can be delivered into the circulation through an IV and end up blocking a vessel; this is called embolism. Peripheral IVs have a low risk of embolism, since large solid masses cannot travel through a narrow catheter, and it is nearly impossible to inject air through a peripheral IV at a dangerous rate. The risk is greater with a central IV.

Air bubbles of less than 30 milliliters are thought to dissolve into the circulation harmlessly. Small volumes do not result in readily detectable symptoms, but ongoing studies hypothesize that these "micro-bubbles" may have some adverse effects. A larger amount of air, if delivered all at once, can cause life-threatening damage to pulmonary circulation, or, if extremely large (3-8 milliliters per kilogram of body weight), can stop the heart.

One reason veins are preferred over arteries for intravascular administration is because the flow will pass through the lungs before passing through the body. Air bubbles can leave the blood through the lungs. A patient with a heart

defect causing a right-to-left shunt is vulnerable to embolism from smaller amounts of air. Fatality by air embolism is vanishingly rare, in part because it is also difficult to diagnose.

Extravasation

Extravasation is the accidental administration of IV infused medicinal drugs into the surrounding tissue which are caustic to these tissues, either by leakage (e.g. because of brittle veins in very elderly patients), or directly (e.g. because the needle has punctured the vein and the infusion goes directly into the arm tissue). This occurs more frequently with chemotherapeutic agents and people who have tuberculosis.

See also

- Life support
- Blood transfusion
- Blood substitutes
- Oral rehydration therapy
- Bolus (medicine)
- Dialysis
- Saline flush
- Hypodermic needle

External links

- Wyeth v. Levine, 06-1249 ^[3] opinion of US supreme Court - No limit in lawsuits as the result of an injury by IV-push injection resulting in gangrene and consequent amputation. Gangrene is likely if the injection accidentally hits an artery — precisely what happened to Levine.
- IVTEAM.com ^[4]
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- IV-Therapy.net ^[6]
- UWash ^[7]
- Venous Air Embolism by Dr. Andrew G Wittenberg, MD, MPH ^[8]
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