

Infusion Pumps

Accurate fluid infusion and drug administration is crucial for the optimum management of a critically ill neonate. Continuous and controlled intravenous delivery of common medications, such as inotropic agents, vasodilators, aminophylline, insulin, heparin etc. via infusion pump is the preferred mode of therapy in acute care. This is especially true for drugs with short half lives, so as to maintain a desirable constant serum concentration and in situations when constant infusion of glucose is needed. Small babies or those with compromised renal, cardiac or pulmonary function have limited fluid tolerance and hence it is essential to use infusion pumps so as to prevent inadvertent volume overload. For intensive care, more than one infusion pump is often required in tiny babies where drug dosage, concentration, interaction and fluid volume require separate infusion rates. The use of infusion pumps has been advocated over manual flow control system on the basis of assuring precise and accurate delivery of prescribed fluid volumes over a specified time and to help in better nursing management.

Desirable specifications

A good infusion device should be:

1. reliable and electrically safe
2. able to deliver the infusion accurately and consistently
3. easy to set up and use
4. portable and robust
5. powered with battery and mains both
6. equipped with override rapid infusion facility
7. capable of alerting line occlusion and need to re-change syringe
8. able to display rate of infusion and volume infused clearly

Gravity controlled	<ul style="list-style-type: none">• Drip rate regulators• Drip rate controllers
Positive displacement pumps	<ul style="list-style-type: none">• Drip rate pumps• Volumetric pumps• Syringe pumps• Multi-channel pumps• Ambulatory pumps

Types of infusion pumps

1. Gravity controlled devices

Drip rate regulators rely solely on gravity to regulate the rate of flow. The simplest and cheapest systems are dial-a-flow/ dosiflow which are supplied with standard intravenous fluid administration sets. Infusion rate is also dependent on pressure difference across the valve i.e. height of fluid or venous pressure/obstruction. In addition, drip rate controller also relies on gravity to provide the infusion pressure. A drop sensor attached to the drip chamber senses the drip rate. This feedback system can adjust the drop rate to a preset value, but, it cannot account for error incurred because of variation in drop size.

2. Positive displacement pumps

Mechanism of action

These provide a positive displacement of fluid with the help of a motor. They are designed so as to prevent infusion of a large volume of air or subcutaneous infiltration. Positive displacement pumps have either a peristaltic or a piston mechanism.

Infusion pumps utilize either linear or rotary mechanisms. Linear peristalsis consists of finger like projections that sequentially compress the intravenous tubing against a stationary back plate, thus moving the fluid in one direction. Rotator peristaltic pumps have rollers on a wheel which compress the tubing and thus move fluid in the tubing towards the patient.

i) Drip rate pumps

These differ from gravity dependent drip rate controllers in providing a pumping mechanism to replace gravity as the motive force. Similar to infusion controllers, these pumps use drip sensor which are attached to administration set to count drops in order to achieve control of infusion rate. The speed of pumping mechanism is under feedback control from a drip sensor/counter. With pumping mechanism, occlusion alarm pressure settings above 100 mm Hg are usual and some are over 200 mm Hg. The high occlusion pressure can distend the administration tubing to the point of bursting it. Hence, if there is extravasation, pump keeps on pumping fluid into the tissues. This is a serious drawback of these pumps. Therefore, because of these problems, volumetric pumps have replaced drip rate pumps.

ii) Volumetric pumps

These pumps overcome limitations associated with variation in drop size. They use either:

- a) piston type action, or
- b) peristaltic pumping action on an accurately made section of tube which forms part of a special administration set.

These special administration sets increase the cost of each infusion. These pumps are calibrated in ml per hour. It is capable of precise regulation of the set flow rates and hence delivers accurate volume infusion.

Volumetric infusion pumps are capable of calculating the volume of fluid with the microprocessor based calculations, taking into account the size of the drop produced and the standardized diameter of the tubing. It has capability of functioning on mains and on rechargeable batteries. If bubbles appear in the tube, the alarm lamp and warning buzzer work simultaneously and the pump stops immediately. It advises the operator when infusion is completed, the battery voltage is low and flow line is occluded apart from the usual audiovisual alarms of malfunctioning and air-bubbles in the system.

Volumetric infusion pumps are the state-of-the-art technology capable of delivering precise quantities of fluids at a very slow to very fast rates. They are more expensive than the drop counters. The running expenses of these pumps are exorbitant because they require special IV infusion sets of a standard size which may be 2-4 times expensive than ordinary sets. However, they are ideal when precise volumes need to be delivered.

(iii) Syringe pumps

The most commonly used pumps for the administration of intravenous drugs are positive displacement syringe pumps that utilize a gear reduction mechanism and lead screw. These pumps are extremely accurate and have the convenience of not requiring specialized tubing. Probably the most significant advance has been the introduction of a calculator mode/feature within the pumps so that clinician can set the weight of patient, the drug concentration and the infusion rate in the mg per kg per minute and the calculator in pump then calculates the infusion in ml per minute.

Specifications of syringe pump include

1. Microprocessor-controlled motor capable of accurate propulsion
2. It should be capable of functioning on mains and rechargeable Ni-Cd batteries; indicators for mains/battery should be in built
3. It should have few controls upon power switch, start switch and reset/stop switch
4. It should have a range of 0.1-99.9 ml/hr with up-to 0.1 ml/hr increments
5. It should have a display for alarm/error messages, infused volume and infusion rate
6. It should give alarms for dis-engagements of syringe clamp, any occlusion, when syringe becomes empty or plunger is out, low battery and mains power failure

The performance of infusion pumps is generally adequate for clinical use, but the volume that may be infused is limited by the syringe capacity. Infusion must be stopped whenever it is necessary to replace or refill the syringe. The largest syringe accepted by these pumps accommodates 100 ml of infusate. The small weight and immunity to the effect of gravity and positioning makes these syringe pumps suitable for transport. These pumps can be mounted on an IV pole or on the operating table. In addition these are small and light weight and have an occlusion alarm pressure of 570 mm Hg.

Recently introduced modern infusion pumps incorporate a soft key interface by which a range of body weight and drug concentrations can be entered. Bolus doses can be easily and rapidly administered at any time during the infusion. They are able to accept all syringe sizes from 10-100 ml and have two independent microprocessors to monitor and control infusion processes for consistent delivery.

Table 15.2: Advantages and disadvantages of syringe pumps
Advantages
<ul style="list-style-type: none"> • Cheaper than drip rate pumps • Precise control of total volume infused • Suited for small volume • Low cost of disposables • Pressure maintains rate inspite of resistance • Delivery of air impossible • Portable
Disadvantages
<ul style="list-style-type: none"> • Unsuitable for large volume • Comprehensive alarm system not usually provided

(iii) Multi-channel pumps

These are now several multi-channel pumps available which permit simultaneous administration of 2 or 3 infusions. However, one potential problem with such a system is the possibility of incompatible mixing.

(iv) Ambulatory pumps

These are pocket size pumps, which use linear peristaltic mechanism and have a fluid container in the form of a small floppy bag or cassette. The pumps are designed for users who need to wear them for long periods and they have good alarm and display systems.

Table 15.3: Common infusion pumps available in the market

S.No	Model	Type	Principals	Dealer	Unit cost (Rs.)
1.	Diginfusa 3000	Drop	Arcomed ag	Instrument & Machine	50,000
2.	JMS SP 500	Syringe	Japan Medical Supply Co. Ltd.	Indian Surgicals	35,000-40,000
	JMS OT-601	Drop	.	Indian Surgicals	50,000
3.	Perfusor compact S	Syringe	B. Braun	B. Braun	40,000-50,000
4.	Terumo TE-311 TE-312	Syringe	Terumo corp.	Regisarsons	40,000-50,000
5.	Terfusion STC-503	Drop	Terumo corp.	Regisarsons	50,000
6.	Atom 1235-N	Syringe	Atom	Vishal Surgicals	50,000
	Atom P-600	Volumetric	Atom	Vishal Surgicals	50,000
7.	Pilot A ₂	Syringe	Fresenius	Rohanika	35,000-50,000
8.	Graseby 3100, 3200	Syringe	SIMS Graseby	Medisphere	55,000-1,00,000
9.	Model ZMP 2003	Syringe	Zeal	Global Medical system	38,000
10.	EMCO	Syringe	EMCO Meditex	International Surgico Industries	36,000
11.	Alaris P1000, 2000, 3000, 7000	Syringe	Alaris, UK	Medex	60,000-95,000
12.	Alaris Model 598	Volumetric	Alaris, UK	Medex	60,000
13.	Jong Sang	Volumetric	Jong Sang, Korea	Medisphere Marketing	65,000

Frequently asked questions (FAQ's)

Q1. How should I select a syringe pump?

A pump which accepts multiple size syringes (20, 50,100 ml) of all makes and has specifications as outlined above.

Q2. If one has a choice, which pump should one buy-drop based or syringe type, and why?

Syringe pump is a better choice, and does not require much maintenance. Drop based (volumetric pump) often requires special infusion sets which are costly and not available in the open market. Often the problem in drop based pump may arise at site of sensor or peristaltic pump.

Q3. Is there any limit to infusion rate for syringe pump?

Ideally the pumps are for small volume continuous administration. It may not be cost effective, if one uses them for higher rates of volume infusion. Say infusing at a rate of 8 ml/hr one will have to keep on filling a syringe of 50 ml every 6 hourly and if the rate is much higher, more frequently. This exposes the baby to risk of nosocomial infections.

Q4. Give some useful tips for using syringe pumps.

- Always run on mains whenever you can.
- Use only damp cloth soaked in soap-water (detergent) for cleansing the panel.
- Always inspect IV site periodically.
- Handle the clamp gently while pulling and snapping the syringe.

Q5. What spares may be required for syringe pump?

Battery may have to be replaced earlier, if not charged periodically or otherwise after 1-3 years of use.

Q6. While using a syringe pump, should I connect special extension tubing or standard IV set tubing to the loaded syringe?

The IV set tubings are not tailored to serve as a connection between the syringe and the intravenous cannula placed in the baby. They are liable to leak at the syringe end due to the pressure generated by the pump. This prompts repeated manual tightening by nurses, increasing chances of infection due to contamination. The extension tubing is specifically meant for this purpose. It has groove system for tight connection with the syringe nozzle. Extension tubing is a more aseptic device and is therefore, the preferred choice.

Q7. How frequently do the syringe and extension tubing need to be changed while using infusion pumps?

The syringe and extension tubing must be changed every 24 hours. One should not compromise with this policy, otherwise nosocomial infection rate may increase necessitating use of expensive antibiotics for the baby.

Q8 Are Indian syringe pumps available in India?

Currently a few Indian manufacturers are importing the kits and assembling them in the country. The final product is priced much the same as the imported but the aesthetics & technological advantages offered are far from satisfactory. Ensure feedback from Indian colleagues using the same product before you invest.