Infusion Pumps

Accurate fluid infusion and drug administration is crucial for the optimum management of a critically ill neonate. 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. Infusion pumps are also indicated to infuse fluids in small babies with compromised renal, cardiac or pulmonary function in order to prevent fluid overload.. The use of infusion pumps has been advocated over manual flow control system for 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. able to lock the instructions
5. portable and robust
6. powered with both battery and mains
7. equipped with override rapid infusion facility
8. capable of alerting line occlusion and need to re-change syringe
9. able to display rate of infusion and volume infused clearly

Table 1

Types of Pumps	
Gravity controlled	• Drip rate regulators • Drip rate controllers
Positive displacement pumps	• Drip rate pumps • Volumetric pumps • Syringe pumps • Multi-channel pumps • Ambulatory pumps

Types of infusion pumps

1. Gravity controlled devices

The simplest and cheapest systems are dial-a-flow/ dosiflow , which solely rely on gravity to regulate intravenous infusions.. Infusion rate is dependent on pressure difference across the valve i.e. height of fluid or venous pressure/obstruction. 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 variation in drop size. Although cheap and easily available, the disadvantages of gravity controlled devices include difficulty to deliver small volume infusions, frequent cannula blocks and extravasations, difficulty in tight control of infusions such as inotropes and high pressure driven infusions such as arterial lines. These are overcome by positive displacement pumps.

2. Positive displacement pumps

Mechanism of action

These provide a positive displacement of fluid with the help of a motor. Positive displacement pumps have either a peristaltic or a piston mechanism. 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 pumps use drip sensor 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. The high occlusion pressure can distend the administration tubing to the point of bursting it and lead to extravasations.

ii) Volumetric pumps

These pumps overcome limitations associated with variation in drop size. They use either a piston type action or 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. They also need special IV tubing of standard size which is 2-4 times more expensive than normal tubings. However, the pumps are calibrated in ml per hour and are capable of precise regulation of the set flow rates.

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. The pump alarms if bubbles appear in the tube, when infusion is completed, the battery voltage is low and flow line is occluded.

(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. The most significant advance has been the introduction of a calculator mode 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. The main parts of the syringe pump are the control panel, display panel and a driving unit.

Specifications of syringe pump include

1. Microprocessor-controlled motor capable of accurate propulsion
2. It should be capable of functioning on mains and rechargeable batteries
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 can be infused is limited to a maximum of 100 ml. Their light weight and resistance to the effect of gravity and position makes them ideal during transport. These pumps can be mounted on an IV pole or on the operating table. 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 2 :Advantages and disadvantages of syringe pumps
Advantages
• 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
• Unsuitable for large volume • Comprehensive alarm system not usually provided

(iii) Multi-channel pumps

These pumps 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.

(v) 'Smart' Infusion pumps

These are new generation infusion pumps that incorporate a software that includes a "drug library" where in hospital-defined drug infusion parameters, such as acceptable concentrations, infusion rates, dosing units, and maximum and minimum loading and maintenance dose bolus limits, for 60 or more medications can be preprogrammed. Though these are intended to prevent adverse drug events (ADE), clinical studies comparing them with conventional infusion pumps have not demonstrated a distinct advantage of these pump.

However, with rapid advancements in computer technology, these pumps are likely to be used in future along with computerized prescriber order entry (CPOE) and automatic medication dispensing systems.