Session 6

INFUSION & SYRINGE PUMPS

COVID-19 Preparation for Biomedical Professionals
ECHO Etiquette

• Foundation of love and respect - respond kindly rather than react if you disagree
• It is everybody’s responsibility to keep ECHO a safe space
• Test your equipment ahead of time
• **Mute your microphone** when not speaking
  • Bottom left corner of your screen
• Remember to **unmute before speaking**
• Introduce yourself before speaking
• Speak clearly, and stay close to your microphone
• IT issues? Send a message through chat/email.
  • AssistHTM@assistinternational.org
<table>
<thead>
<tr>
<th>Time Allotted</th>
<th>Topic</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 minutes</td>
<td>Didactic – Infusion &amp; Syringe Pumps</td>
<td>Dr. Masreshaw/Guna</td>
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<tr>
<td>15 minutes</td>
<td>Preventive Maintenance</td>
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<td>10 minutes</td>
<td>Discussion</td>
<td>All</td>
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</table>
What’s so dangerous about COVID-19?

The virus is stable for long periods of time on surfaces and in aerosols. According to a study from experts at the National Institute of Health, the Center for Disease Control, UCLA, and Princeton University the virus is detectable:

- In aerosols for up to **3 Hours**
- On copper for up to **4 Hours**
- On cardboard for up to **24 Hours**
- On plastic and stainless steel for up to **3 Days**

Session 1 Summary

How do we keep our hospitals and equipment virus-free?

PPEs needed include:
- Single use gloves
- Disposable or washable gowns
- Single use caps/hats
- Single use shoe covers
- N95 Respirators
- Eye goggles/face shields

High level disinfectants use products that include one of the following:
- 2% glutaraldehyde
- 6% hydrogen peroxide
- 0.2% peracetic acid
- 7% accelerated hydrogen peroxide
- 0.55% ortho-phthalaldehyde (OPA)

GLOVES AND PPEs DO NOT REPLACE HAND HYGEINE

1. **EVERYONE** should practice basic hygiene and social distancing.

2. In hospital settings, **CLINICIANS and BIOMEDICAL PROFESSIONALS** should adopt the following, in addition to standard procedures:
   - Increased frequency of basic hygiene like handwashing
   - Increased use of personal protective equipment to protect against droplet and airborne infections, such as respirators and face masks
   - Increased frequency of equipment disinfection

3. The virus can last up to three days on some surfaces, so be sure to use proper disinfectants (as recommended by the CDC or WHO) and to autoclave materials at high enough temperatures/for long enough.
Resources

• For more information about the specifications for equipment/PPE needed to manage cases of COVID 19, see the WHO Operational Support & Logistics Disease Commodity Packages, COVID-19 v4, Updated March 6, 2020

• On ventilators –
  • If you need guides or service manuals on ventilators, try visiting the Ventilator Training Alliance webpage.
Objectives

By the end of this refresher module, the participants will recollect:

• Fundamental background such as main parts/function and working principles
• How to perform preventive maintenance
• Basic troubleshooting and corrective maintenance

Clinical attachment yields better experience for trainees to train other BMETs in the future.
Infusion & Syringe

MAIN PARTS & THEIR FUNCTION
Types of Infusion Devices

Infusion devices can be defined by classification. There are two classes:
- Gravity controlled
- Infusion pumps
Types of Infusion Devices

Gravity Controlled
- Most suited to low risk applications
- Simple control system that controls for flow rate, usually in drops-per-minute
- Relies solely on gravity for infusion pressure
- Accurate drop counter
- Volume accuracy depends on conversion drops/ml. Error factors include fluid composition, temperature, surface tension, etc.

Infusion Pump
- Active method to overcome infusion pressure
- Include volumetric, syringe, elastomeric and pneumatic pumps
- Deliver small, medium and high volume and flow rates
- Alarms, flow and pressure sensors included
- Very accurate devices if properly used and maintained
Types of Infusion Pumps

Syringe Pump

PCA Pump

Volumetric Pump
Patient Controlled Analgesia (PCA)

- Patients have the ability to deliver a drug themselves as needed (up to safe limit).
- Used to relieve post operative pain by inducing analgesia.
- Similar to a syringe pump, but requires free flow intravenously.
- Delivers a bolus dose when patient activates the control (via a push button/membrane key)
- Control key mostly with remote cable
- Dosage and intervals are locked to ensure safe usage
Syringe & Infusion

WORKING PRINCIPLES
We will now cover the following:

- Peristaltic Mechanisms
  - Linear
  - Rotary
- Syringe Mechanisms
- Operation
Peristaltic Mechanisms

Linear Peristaltic Mechanisms

Rotary Peristaltic Mechanisms
Linear Peristaltic Mechanism

• The majority of volumetric infusion pumps have a drop sensor, occlusion pressure sensor, and an air sensor in the line.

• The linear mechanism is the most common type and it is composed of several independent fingers that press a silicon tube sinusoidally. These fingers carry out a peristaltic movement, forcing the passage of the flow by pressing the infusion line against the floor of the equipment.
Rotary Peristaltic Mechanism

- The rotary mechanism is made of a main rotor and several rollers that press a tube systematically.
Syringe Mechanism

• The syringe pump has an endless screw that adjusts automatically to the syringe coupled to the instrument.

• Syringe pumps can be used individually or in a multichannel system, where two or more units are linked.
Operation

- **Power ON** – Connect AC powers cable and press main ON / OFF switch.
- **Syringe Check** – Select syringe according to manufacturer specification.
- Fill it with required amount of IV fluid (Total volume plus priming Volume). Remove the air bubble from syringe.
- Attach syringe and insert syringe barrel in to groove.
- Lock the syringe barrel clamp and snug it. Display should show the “Syringe size”. Check syringe size is correct and no audible or visual alarm.
• **Infusion Setting** – After ensuring syringe is secured, press “Set Key” & infusion rate. (Setting may allow minimum of 0.1mL/Hr onwards.)

• **Priming** – Press “*continuous priming*” key to let IV fluid reach the end of cannula.
  - After priming press, “CLEAR KEY” to stop priming operation.

• **Connect Patient** - Introduce the IV set in to patient’s veins.

• **Start Infusion** - Press “START/ STOP key” to start the infusion to patient.
  - Infusion rate set can be changed during infusion. Press START/STOP key to stop infusion.
Volumetric Pump Block Diagram

- Infusion line
- Infusion mechanism
- Driving force
- Control circuit
- Display
- Key board
- Alarms
- Power supply
- Air sensor
- Other sensors
- Drops sensor
• **ALARM**: The alarms indicate adverse situations, for example, air bubbles or system occlusion, free flow, end of infusion, low battery, amongst others.

• **CONTROL CIRCUIT**: Allows the interpretation of the information introduced into the device, control the infusion mechanism, interpret the sensors signals and activate the alarms when needed; It can store the programmed information and data about the alarms, calculate doses, carry out variations in the infusion flow, amongst others; It can be either analogic or digital.

• **DISPLAY AND CONTROL PANEL**: Alphanumeric displays or LCD (liquid crystal display). They give information about the undergoing infusion: the total volume which will be administered, the flow (ml/h or drops /min), the total time and the remaining time of infusion as well as information about the alarms, etc.
**KEYBOARD:** Used to register the data that refers to the flow, the volume and the time of infusion.

**INFUSION MECHANISMS:** This component allows for infusion pressure generation that is responsible for the fluid flow. It can be peristaltic or rotor.

**MOTOR/DRIVING FORCE:** In general, stepper motors are used to activate the infusion mechanisms.

**DROP SENSOR IN PERISTALIC OR ROTOR PUMP:** Used to refeed the electronic circuit of infusion control; It enables information regarding occlusion of the line (by filling the drip chamber), infusion without solution and free infusion (badly positioned system, which leads to an uncontrolled infusion); The drop sensor is placed near the drip chamber of the system.
• **AIR SENSOR IN THE PERISTALIC OR ROTOR PUMP**: Indicates the presence of air in the system; It is placed near the line, after the infusion mechanism.

• **OCCLUSION PRESSURE SENSOR [SHOWN AS OTHER SENSORS]**: Used to control the infusion pressure, by making it possible to quickly and reliably detect an occlusion in the line.

• **INFUSION LINE AND ACCESSORIES**: A set of disposable accessories that ensure the transportation of the fluid from the reservoir to the patient.
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Syringe Pump Block Diagram

• The **Detector Circuit** has a circuitry that analyzes outputs from sensors, including: **syringe sensor**, **occlusion sensor**, **plunger/clutch detector** and **low power detector**.

• Once the syringe barrel clamp is lifted, the sensor (potentiometer) will rotate. The resistor value changes according to rotation angle.

• The **syringe plunger clamp** moves along the drive shaft of the motor. When the occlusion occurs, it obstructs the movement of the plunger. The **occlusion sensor** is equipped with a strain gauge, which changes the resistor value by load and forwards the information signal to CPU.
Syringe Pump Block Diagram

• The syringe plunger clamp operates the syringe plunger sensor (micro switch). If the syringe is clamped and sensor is ON, the respective information is sent to CPU.

• If the instrument is using the external power or internal power, the controller recognizes immediately and checks the required voltage and current. It monitors and sends the information to CPU.
Syringe Pump Block Diagram

- **Controller Board** – the main board of the syringe pump has a motor controller, detector circuitry, power supply and battery charging monitoring, key pad and display controller circuitry. It has a micro-controller CPU with ROM, RAM and data converter. It is interconnected to all PCB’s to control and monitor the proper functioning of infusion pump.

- The **Motor Controller** detects the rotation of motor and controls the actual speed according to program set up. The motor rotation pulses are given by the main CPU to drive the motor. Simultaneously, an input pulse from motor is sent to CPU to calculate and control the drive. It also generates a error code for any malfunctioning of motor.
Motor - In earlier infusion system, a DC motor was utilized to drive the piston pump at rate set by the unit. Now, a stepper motor is used and angular velocity is controlled by digital electronics.

The internal diameter of syringe is stored in ROM. Also the applicable internal diameter of syringe can be loaded as per the setting of syringe size and brand selected. With reference to this information CPU reads the available set up and generates the motor drive signal for infusing rate.
Syringe Pump Block Diagram

- **Power Supply module** – The power supply has AC line input and transformer. It generates the DC voltage of +/- 5VDC, +/- 12 VDC, +/- 15VDC, 7.5VDC after step down transformer and bridge rectifier. The power is given to each PCB and battery charging circuitry.

- **Battery Operation** – The fully charged battery gives a constant power supply to the unit, while remaining power is monitored by the CPU. It monitors the charging current, discharge current and time. If the minimum requirement of voltage is not reached, a battery alarm is activated.
Syringe Pump Block Diagram

- **Pump Unit** – The pump is driven by stepper motor. Motor controller board drives the motor by applying number of pulses. Infusion pump motor has two slots, which is detected by sensor. This is monitors the direction of rotation and speed of pump.

- **Front Panel** – The Front panel of pump consists of LCD display and keypad control. The LCD display shows in a plain text, green background and shows the status of Unit. It displays whether the the unit is connected on AC mains or Battery operation, Alarm status, History of Drug infused, time interval, bolus doses and quantity delivered to patient. While keypad controls the data feeding for the patient’s drug delivery and setup.
Applications

Infusion Pumps:
• Used to administer IV fluids

Syringe Pumps:
• Regional anesthetics
• Anti-arrhythmic medication
• Chemotherapeutic agents
• Diabetic management (Insulin)
• Anticoagulant (Heparin)
Common Problems

Infusion Pumps
• Faulty drip sensor
• Battery fails due to lack of charging, or improper charging
• Damaged pump & housing from dropping, clinical user error
• Weakened pump housing
  • Do not use alcohol-based cleaning solutions on plastic housing

Syringe Pumps
• Slipping of plunger may break glass syringes
• Damaged pump & housing from dropping, clinical user error
• Battery fails due to lack of charging, or improper charging
• Weakened of pump housing
  • Do not use alcohol-based cleaning solutions on plastic housing
• Using the incorrect syringe size causes incorrect volume and rate infusion.
How to Avoid Common Clinical User Errors
Train Your Clinical Users

When using Syringe Pumps:

• Use only manufacturer recommended syringes.
• Pay attention to whether the manufacturer gives accuracy in terms of mechanical accuracy of pump rather than the volume accuracy
• Remove the clamp of infusion set from machine side before attempting to clear the blockage, when an occlusion occurs
Train Your Clinical Users

Make sure clinical users know to:

• Avoid using the pump on patients when alarms are sounding. Do not just mute the alarm; it’s important to eliminate the cause of the alarm.

• Avoid reusing disposable syringes. Dispose of the syringes properly after use.

• Always monitor the system to check the volume remaining in the syringe and replace at 70 – 80% full.
  • Do not depend solely on the alarm feature of the system during infusion.

• A patient may require continuous infusion of multiple drips simultaneously hence clinical operator must put a label on each pump/tube.
Power & Batteries

Infusion & Syringe Pump Batteries:
• The battery should be kept charging before and after use.
• Check the battery status regularly or as per the manufacturer recommendation.
• Always install the battery when the pump is used on AC power.
• Do not short the battery across the plus (+) terminal and minus (-) terminal.
• If the battery is damaged, disassembled, or leaking, replace immediately.
Syringe & Infusion

PREVENTIVE MAINTENANCE
Preventive Maintenance

Preventive maintenance is necessary in order to:

1. Reduce the risk of injury (to patient, staff or visitors) and the risk of significant adverse impact on patient care.
2. Decrease equipment life-cycle costs.
3. Avoid operational difficulties.
4. Comply with codes, standards and regulations.
Preventive Maintenance

The PPM (planned preventive maintenance) procedure can be divided into the following tasks:

• **Qualitative Task/Physical Inspection**
  • Visible test and Cleaning

• **Electrical Safety Test**
  • Verify the electrical safety of the system

• **Performance Verification Test**
  • Verify that it performs as per its design parameters.
Test Tools & Cleaning Materials

You always need:
- Electrical safety analyzer
- Multimeter

If you have an infusion analyser:
- Infusion analyzer

If you don’t have an infusion analyzer:
- Digital pressure meter or pressure gauge
- Mounting glass burette
Qualitative Tests/Physical Inspection

Cleaning for both Infusion & Syringe Pumps:

• Avoid moisture or contact with water, excessive humidity and temperature. Pumps should be kept clean and dry whenever not in use.

• Keep the pump away from any x-rays, ultrasounds or other electronic instruments.

• Clean all accessories, such as catheters and patient remote switches, then store properly.
  • Most accessories such as syringe, catheters, and tubing are single use, and should be replaced.
Qualitative Tests/Physical Inspection

- Chassis - verify physical integrity, cleanliness
- Mount - verify physical integrity of mounts
- Casters/Brakes - if mounted on IV pole, verify physical integrity
- AC Plug - verify integrity
- Line Cord - verify proper insulation and integrity
- Strain Reliefs - verify physical integrity at both ends of line cord
- Circuit Breaker/Fuse - verify integrity of external circuit breaker and/or value of external fuse
- Cables - inspect drop sensors and external air-in-line detectors as appropriate
- Connectors examine all cable connectors (drop sensor, nurse call, etc.)
- Controls/Switches - verify proper operation; inspect membrane switches
- Indicators/Displays - verify proper illumination and
Qualitative Tests/Physical Inspection

- Alarms - verify proper operation. Specifically verify (as appropriate) alarms for air-in-line, empty container, infusion complete, open door/misloaded set, nurse call
- Audible Signal - confirm appropriate volume and operation of volume controls
- Labeling - verify presence and placement of all labels, placards, instruction cards, etc.
- Accessories - verify physical integrity, connection, and proper operation of drop sensors and external air-in-line detectors
- Flow-Stop Mechanisms - verify operation and integrity
Electrical Safety Test

- For protection against shock hazards, connect the monitor only to a three wire, grounded hospital grade receptacle. If the power cord or plug is cracked, frayed, broken or damaged, it must be replaced.
- Always use a 3 pin power cable.
- Always replace fuse with of one the same type and rating for protection.
- Connect only equipment that complies with local standards & regulations to power.
Electrical safety test for suction pumps:
Some suction devices are Class I device some are class II. This depends on the manufacture’s design.

Grounding resistance between chassis and ground pin should not exceed 0.3 ohms.
Maximum chassis leakage current with ground wire disconnected should not exceed 300 microamps.
# EST Checklist

<table>
<thead>
<tr>
<th>Description</th>
<th>UOM</th>
<th>Set values</th>
<th>Measured values</th>
<th>Limit/Tolerance</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Voltage L-N</td>
<td>Vac</td>
<td>-</td>
<td>-</td>
<td>10%</td>
<td>(    ) (    ) (    ) (    )</td>
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<tr>
<td>Device Current</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>(                ) (    ) (    ) (    )</td>
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<tr>
<td>Earth/Ground wire resistance</td>
<td>Ω</td>
<td>-</td>
<td>-</td>
<td>&lt;0.3Ω</td>
<td>(    ) (    ) (    ) (    )</td>
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<tr>
<td>Insulation test (optional) 500V/250VDC</td>
<td>MΩ</td>
<td>-</td>
<td>&gt;2MΩ</td>
<td>(                ) (    ) (    ) (    )</td>
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<tr>
<td><strong>Earth Leakage Current</strong></td>
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<tr>
<td>1. Normal Condition</td>
<td>uA</td>
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<td>&lt;500 uA</td>
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<tr>
<td>2. Open Neutral</td>
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<td>&lt;1000 uA</td>
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<tr>
<td>3. Open Neutral- Reversed Mains</td>
<td>uA</td>
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<td>&lt;1000 uA</td>
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<td>4. Normal Condition- Reversed Mains</td>
<td>uA</td>
<td></td>
<td>&lt;500 uA</td>
<td>(                ) (    ) (    ) (    )</td>
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<td></td>
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<tr>
<td><strong>Enclosure Leakage Current</strong></td>
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<tr>
<td>1. Normal Condition</td>
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<td></td>
<td>&lt;100 uA</td>
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<tr>
<td>2. Open Earth</td>
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<td>&lt;500 uA</td>
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<td>3. Open Neutral</td>
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<td>4. Open Neutral- Reversed Mains</td>
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<td>&lt;500 uA</td>
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<tr>
<td>5. Normal Condition- Reversed Mains</td>
<td>uA</td>
<td></td>
<td>&lt;100 uA</td>
<td>(                ) (    ) (    ) (    )</td>
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<tr>
<td>6. Open Earth- Reversed Mains</td>
<td>uA</td>
<td></td>
<td>&lt;500 uA</td>
<td>(                ) (    ) (    ) (    )</td>
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</tbody>
</table>
FLOW RATE & VOLUME CHECK

Required Materials:

• Syringe and extension set - always use a new set
• Graduated and calibrated cylinder with a volumetric capacity of 25 to 100 ml
• Distilled water
• Calibrated stop watch

*Important: Do not plunge the tip of the tube into the water, as this may falsify the result of the measurements.*
Mount the syringe and extension set on the pump according to instructions contained in the User Manual and fill with distilled water.

Program the syringe pump for a 5 ml/h flow rate and a volume (for instance) of 20 ml. The EN 60601-2-24 standard recommends that measurement tests should be carried out at a rate of 5 ml/h.

Place the extension set outlet so that the water drips inside the cylinder. Make sure that the tube outlet does no touch of the collected water, in order to avoid falsifying the result measured.
PVT – Without Infusion Analyzer

• Start the infusion into the graduated cylinder and simultaneously start the stop

• At the end of the infusion, stop the watch and check for the final volume infused into the graduated burette;

Calculate the flow rate using the following formula:

\[
\text{Flow Rate (ml/h)} = \frac{\text{Final graduated burette volume (ml)}}{\text{Time of infusion (h)}}
\]

• Check that the degree of uncertainty of the calculated flow rate falls within the range of syringe pump tolerance of ± 5% (including the syringe uncertainty)

• Should the obtained values meet the acceptance criterion, the equipment will be ready for use.
Occlusion Pressure Level Check:

- Fill the 50 ml syringe with 20-30 ml of distilled water and connect it to the pressure meter using the extension set. Switch on the pressure meter and take the reading of max/min pressure.

- Set pump occlusion alarm level according to manufacturer recommendation and launch infusion at 5 ml/hr rate. For pump operation details, refer to the Operator’s Manual.

- When the pump stops, read the maximum pressure recorded by the pressure meter. Readings will be within the 200 -800 mmHg range; exact numbers will depend on the brand. Please refer to the user manual or service manuals for further details.

- If recorded value is outside this range, re-calibrate the force sensor.

Required Material:
- Syringe and extension set
- 3-port valve connector
- Digital pressure meter, (0-1500mmHg)
Occlusion Connection Settings

- EUT = Equipment under test
- DUT = Device under test
Occlusion Connection Settings

- The occlusion test simulates an obstruction in the infusion process and monitors the variation in pressure due to the blockage. Most infusion devices have the ability to detect this obstruction and provide an occlusion alarm. The occlusion test is able to test this alarm feature in infusion devices.
**Force Gauge To Test Occlusion**

A force gauge can be used where the occlusion pressure is measured in kgF and for a set occlusion pressure ‘level’ defined by the manufacturer.

The pump should alarm when a certain amount of force in KgF is applied to the plunger, with stated limits.
## PVT - Syringe Pump Checklist

### Quantitative Tasks

<table>
<thead>
<tr>
<th>Description</th>
<th>UOM</th>
<th>Set rate</th>
<th>(t) Measured values</th>
<th>From glass burette</th>
<th>Limit/Tolerance</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flow Rate Accuracy @Duration depend on setting</td>
<td>ml/hr</td>
<td>5 ml/hr</td>
<td>( ) ( ) ( )</td>
<td>( ) ( ) ( )</td>
<td>±5%</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ml/hr</td>
<td>10 ml/hr</td>
<td>( ) ( ) ( )</td>
<td>( ) ( ) ( )</td>
<td>±5%</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
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<tr>
<td></td>
<td></td>
<td>20 ml/hr</td>
<td>( ) ( ) ( )</td>
<td>( ) ( ) ( )</td>
<td>±5%</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>2. Occlusion and alarm</td>
<td>mmHg/psi</td>
<td>LOW</td>
<td>( ) ( ) ( )</td>
<td>( ) ( ) ( )</td>
<td>±51.71mmHg/1psi</td>
<td>( )</td>
<td>( )</td>
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<tr>
<td>Pressure 20 to 30 mL</td>
<td></td>
<td>MEDIUM</td>
<td>( ) ( ) ( )</td>
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<tr>
<td>Set pressure on syringe pump L/M/H</td>
<td></td>
<td>HIGH</td>
<td>( ) ( ) ( )</td>
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<td>( ) ( ) ( )</td>
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</tr>
<tr>
<td>3. Volume</td>
<td>ml</td>
<td></td>
<td>( ) ( ) ( )</td>
<td>( ) ( ) ( )</td>
<td>±5%</td>
<td>( )</td>
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<tr>
<td>4. KVO (Keep the vein open)</td>
<td></td>
<td></td>
<td>( ) ( ) ( )</td>
<td>( ) ( ) ( )</td>
<td>Alarm</td>
<td>( )</td>
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</tr>
</tbody>
</table>

Flow Rate (ml/h) = Final graduated burette volume (ml)/ Time of infusion (h)
Refer to 1 for flow.
PVT – With Infusion Analyzer
In this case the comparative method with an Infusion Pump Analyzer is applied. This calibration procedure consists of comparing the flow indicated in the infusion system with the value given in the Infusion analyzer.

The connection between the two instruments is ensured by the adequate lines in which a purge is carried out, so as to eliminate all the air bubbles from the system. In order to ensure the flow stabilization between the syringe and the infusion analyzer, there should be a waiting time of at least 10 minutes before beginning to collect the data.

The data should be collected in conditions that will allow feasible results and according to the manufacturer’s specifications. It is essential to ensure the monitoring and record of the temperature of the fluid to be administered and the environmental conditions, which should be in accordance with the manufacturer’s specifications. In addition, it is very important that the humidity values be higher than 50% in order to prevent evaporation. All of the necessary corrections should be considered in order to obtain precise and accurate result.
PVT – With Infusion Analyzer

Setup Diagram 1

Infusion/Syringe Pump Analyzer

- Collection vessel
- Inlet
- Outlet
- Syringe Driver

300mm 1/4" OD 1/8" ID Tygon tubing or similar
1000mm 1/4" OD 1/8" ID Tygon tubing or similar

NB: Tubing should not drop below level of work surface
PVT – With Infusion Analyzer

- Manufacturer height requirements:
  - Carefusion 8100: 19-21 in. (48-53 cm)
  - Baxter/Spectrum: 24 in. (61 cm)
  - Hospira Plum XL, A+: 18-24 in. (46-61 cm)

- Primed IV Set

- Container: 0-18 in. (45.7 cm) max. height from base of FT-2

- Output Hose
## PVT - Syringe Pump Checklist

<table>
<thead>
<tr>
<th>Quantitative Tasks</th>
<th>UOM</th>
<th>Set rate</th>
<th>(t) Measured values</th>
<th>From glass burette</th>
<th>Limit/Tolerance</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Flow Rate Accuracy @ Duration depend on setting</td>
<td>ml/hr</td>
<td>5 ml/hr</td>
<td></td>
<td></td>
<td>±5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ml/hr</td>
<td>10 ml/hr</td>
<td></td>
<td></td>
<td>±5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ml/hr</td>
<td>20 ml/hr</td>
<td></td>
<td></td>
<td>±5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Occlusion and alarm</td>
<td>mmHg/psi</td>
<td>LOW</td>
<td></td>
<td></td>
<td>±1.71mmHg/1psi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure 20 to 30 mL</td>
<td></td>
<td>MEDIUM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set pressure on syringe pump L/M/H</td>
<td></td>
<td>HIGH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Volume</td>
<td>ml</td>
<td></td>
<td></td>
<td></td>
<td>±5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. KVO (Keep the vein open)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alarm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow Rate (ml/h) = Final graduated burette volume (ml)/ Time of infusion (h) Refer to 1 for flow.
# PVT – Infusion Pump Checklist

<table>
<thead>
<tr>
<th>Description</th>
<th>UOM</th>
<th>Set rate</th>
<th>Measured values</th>
<th>Limit/Tolerance</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Flow Rate Accuracy @Duration of 5 mins</td>
<td>ml/hr</td>
<td>60 ml/hr</td>
<td>±10%</td>
<td>( ) ( ) ( ) ( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ml/hr</td>
<td>120 ml/hr</td>
<td>±10%</td>
<td>( ) ( ) ( ) ( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ml/hr</td>
<td>240 ml/hr</td>
<td>±10%</td>
<td>( ) ( ) ( ) ( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Occlusion and alarm pressure</td>
<td>mmHg/psi</td>
<td>±51.71 mmHg/1 psi</td>
<td>( ) ( ) ( ) ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Volume</td>
<td>ml</td>
<td>±10%</td>
<td>( ) ( ) ( ) ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. KVO</td>
<td>Test</td>
<td></td>
<td>( ) ( ) ( ) ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TROUBLESHOOTING & CORRECTIVE MAINTENANCE
Internal View of Syringe Pump
Syringe Driver

• The driver rotates a threaded metal rod, so the rod slowly advances inwards, and this pushes in the syringe-end, which dispenses the medicine.
Syringe Switch

- There is a switch at the end of the rod, near where the syringe end is, which is used to reset where the motor mechanism attaches to the rod, so that the system can be reset and the pump can be used to dispense the next dose.
Common Problems

Additional issues include:
- Wrong syringe size
- Wrong syringe type
Infusion Pump Troubleshooting Guide
CASE STUDY
The causes of these performance failures include, but are not limited to:

**We’ll talk about:**
- Damaged mechanical parts (e.g., doors, latches and syringe lock)
- Battery failures - fire, sparks, charring, or shocks
- Damaged pump casing, housing
- Alarm errors
- Broken components
  - Spindles

**Other issues:**
- Software defects
- Inadequate user interface design ("human factors" issues)
**Damaged Pumps**

**Problems:**

- The pump may have been dropped or damaged during use, which may result in an over-infusion or an under-infusion if the pump continues to be used without being repaired.

- The plastic casing of an pump, although promoted as waterproof, is prone to cracking. This allows water to enter the case and can cause the pump to malfunction.

- Slight misalignment of the syringe places stress on the pump plunger, resulting in eventual cracking of pump case. This may cause stepper motor and mechanism failure.
Damaged Pumps

Solutions:

• For misalignment – adjust syringe mechanism, or replace damaged parts
• For damaged casing – replace or seal with waterproof & bacteria-proof silicone

Cracks can cause insufficient waterproofing in the green case.

Insufficient waterproofing can affect the plunger switch as well.

Misalignment occurs here.
Issues with Settings

Problems:
• The wrong syringe size
• The wrong brand of syringe
  • Always use what the manufacturer recommends
• Reusing the same syringe on a new patient
• Incorrect settings, such as volume setting

Solutions:
• Only purchase syringes per manufacturer recommendation
• Train clinical users to check settings between patients and to never reuse syringes
Broken Spindles

**Problems:**
- Spindles can be damaged if dropped or mishandled
- If mechanism is not maintained and frequently lubricated, spindle may be scratched or damaged

**Solutions:**
- Maintain according to manufacture recommendation (typically every 6 months)
- Train clinical users to handle carefully
Broken Spindles

(a) Undamaged engaging piece between driving tube and drive spindle

(b) Broken engaging piece between driving tube and drive spindle

Drive spindle
Battery Failures

Problems:

- If battery overheats –
  - Can lead to premature battery failure
  - Casing can melt
  - Battery can expand and crack the casing
- A patient leaves his bed/walks around, then forgets to plug in the infusion pump when he returns.
  - If no alarm or speaker volume is set too low, the alarm goes unnoticed. The infusion pump powers off after the battery is depleted.

Solutions:

- Check battery every six months and replace as needed
  - Maximum lifespan is about two years
- Make sure that volume is loud enough to alert the clinicians to an issue
Feel free to speak up or use the chat function so that our moderators can speak for you!