This book has been issued to………………………………………………………………………………………………………..

Date………………………………

Ward………………………………………………………………………………………………………………………………………………

Name(s) of assessor(s) – (please print).

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For audit and verification purposes, please complete the above section. You are reminded that only senior staff that have completed the RUH Bath NHS Foundation Trust’s Intravenous and Subcutaneous Therapy Assessors Workshop Course should assess you.
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contents</td>
<td></td>
<td>.3</td>
</tr>
<tr>
<td>Introduction</td>
<td></td>
<td>.4</td>
</tr>
<tr>
<td>Section 1</td>
<td>Intravenous Therapy</td>
<td>6</td>
</tr>
<tr>
<td>Section 2</td>
<td>Pharmaceutical Aspects of Intravenous Therapy</td>
<td>12</td>
</tr>
<tr>
<td>Section 3</td>
<td>Infection Control Issues</td>
<td>20</td>
</tr>
<tr>
<td>Section 4</td>
<td>Intravenous Calculations and Assessment Questions</td>
<td>25</td>
</tr>
<tr>
<td>Section 5</td>
<td>Anaphylaxis</td>
<td>32</td>
</tr>
<tr>
<td>Section 6</td>
<td>Infusion Systems</td>
<td>33</td>
</tr>
<tr>
<td>Section 7</td>
<td>Assessment Questions</td>
<td>41</td>
</tr>
<tr>
<td>Section 8</td>
<td>Competencies</td>
<td>44</td>
</tr>
<tr>
<td>Section 9</td>
<td>Additional Modules</td>
<td>49</td>
</tr>
</tbody>
</table>
Introduction

This workbook has been developed as a basic guide to safe, competent intravenous therapy. Many aspects of therapy are covered. However, this book has not been designed as a definitive text and should be read in conjunction with other published material, for which some references are provided.

Additional information and competencies are available on the Royal United Hospital’s intranet site parenteral nutrition, subcutaneous infusion, central venous catheters and paediatrics/NICU. Staff should complete the additional competencies relevant to their clinical practice after having been signed off as competent in intravenous therapy by their assessor.

You are reminded that issues relating to accountability and competence encompass all aspects of health care, not just intravenous therapy. You are strongly advised to read your own professional body’s Code of Professional Conduct, such as the Nursing and Midwifery Council code of professional conduct. Furthermore, it is essential that you refer to the RUH Bath NHS Trust Medicines Code: Administration of intravenous Drugs and Medusa – the National Injectable Medicines Guide, which has been customized for use in the RUH. If you have any doubts as to the correct procedure for the administration of a given medicine, seek senior help.

The Assessment Strategy for IV Therapy

This section should be read in conjunction with the assessment strategy flow chart, a copy of which can be found overleaf.

Your assessor must have completed a teaching and assessing course, and have both current IV drug administration competency AND have completed the RUH IV and SC Therapy: Assessor Workshop course. You MUST NOT be assessed by anyone who has not undertaken this training.

This workbook is designed as a self-study document for practitioners to work through at their own pace. It is expected, however, that completion of the book will take a maximum of three months. If you are having difficulty in completing the book within this time period, you should discuss this with your assessor or ward/unit manager at the earliest opportunity.

Near the end of the book is a section of questions which must be completed. These will be marked by your assessor. All questions must be answered correctly.

If you have answered any questions incorrectly, the book will be returned to you so that you can attempt to provide the correct answer(s). In addition, your assessor will question you verbally to assess your knowledge and competence.

At the end of this document is a competency section which you will complete with your assessor after a period of supervised practice, when you are both agreed that you are competent in the practice of IV medicine administration. However, it is your professional responsibility to ensure that you continue to work with your assessor after this point to complete any additional competencies relevant to your clinical practice (e.g. blood transfusion). If you have any queries regarding the assessment process, you should contact your assessor for advice.
Intravenous Therapy - Competence Strategy for Registered Staff

- These competencies apply to all registered staff employed at the Royal United Hospital NHS Trust
- For newly registered nurses access to this program is at your manager’s discretion, this is normally undertaken 6 months after qualifying
- Competency documents should be available for audit or investigation purposes

Candidate and assessor agree timing for completing the work book

Candidate completes workbook and accesses medical equipment training as required

Assessor signs off completed work book and negotiates a period of supervised practice with candidate

With a patient, the candidate demonstrates competence to the assessor using skills and knowledge from the program

Assessed as competent

Assessor addresses learning needs and offers a further period of supervised practice

Assessor must manage, as appropriate, on going issues with a candidate unable to demonstrate competence.

No

Yes

Assessor and candidate sign off competencies - to be kept by candidate but a copy given toward or department manager

Candidate is now competent to practice I.V. therapy.

*Annual re-assessment required.*
Candidate and assessor identify a time frame for completion of any additional competencies & follow same procedure.
Section 1  Intravenous Therapy

Authors: The Resuscitation and Clinical Skills Team

This section gives an overview of the administration of intravenous (IV) drug therapy. Good practice, complications and accountability issues are discussed.

Learning outcomes

After studying this section the practitioner will be able to:

- Describe the correct procedure for giving an IV bolus and commencing an infusion.
- Explain some of the complications of IV therapy, their prevention and treatment.

Prior to studying this section, please ensure that you have read and understood the latest version of the Trust’s Medicines Code: Administration of intravenous Drugs. This is available on the Royal United Hospital’s intranet site.

Intravenous Therapy

Intravenous therapy is now a very common place procedure with the majority of inpatients now requiring a vascular access device at some point during their admission (Gabriel 2008). This is not a procedure without risk and it is the nurse’s responsibility to ensure they are remain up to date with best evidence based practice and are assessed as competent to use such devices.

Why IV Therapy?
The reasons for IV therapy are explained in detail in the section ‘Pharmaceutical Aspects of Intravenous Therapy’. In summary these are:-

- Transfusion of blood and blood products.
- Replacement and/or maintenance of fluids and electrolytes.
- Where the oral route is unsuitable.
- Where the intramuscular route is inappropriate.
- Where a rapid response is required.
- To achieve high, predictable levels of medication.
- Where there is a need to give medication as an infusion.

Intravenous fluids
These come from the manufacturer in a vacuum packed presentation. Before using a particular fluid you should check the following:

- That you have taken the correct prescribed fluid from the appropriate storage area. This sounds obvious however stray bags are associated with administration errors. Also fluid is wasted if the wrong infusion bag is removed from the storage area and un-wrapped it before checking it.
• If the bag is vacuum packed the plastic wrapping on the infusion bag should form a tight covering. If not, the bag may have been tampered with or it may not have been sterilised properly. If in any doubt, the bag should be returned to pharmacy with an accompanying note and your ward pharmacist informed.

• The infusion bag should not feel wet. If so this may be due to incorrect sterilisation of the infusion bag during manufacture or it may have a leak (this can be checked for by gently squeezing the bag). If the infusion bag is wet or leaks it should be returned to pharmacy with an accompanying note and your ward pharmacist informed.

• The infusion bag should be shaken gently to dislodge any particles that may be within it and then held up to the light at a slight angle to check for them as this will magnify any particles or crystals present. If the fluid is not clear or any particles are observed then the fluid should be rejected, returned to pharmacy with an accompanying note and your ward pharmacist informed.

If a medicine is added to an infusion bag or a syringe for infusion then a label must be completed immediately and the following information written on the label:

• The patient’s name and hospital number.
• The medicine name, dose, manufacturer’s batch number, expiry date and expiry time.
• Name and final volume of the diluent used (expiry date & batch number).
• Signature of administering practitioner and checker (if a checker has been used).
• Route of Administration.

Manufacturer’s batch numbers:
These are important as they can identify not only where and when a particular medicine vial/fluid bag was packed, but also by whom. This could be important if the patient experiences a reaction to the substance being given.

Additives:
Medicines should never be added to the following:
• Blood, plasma and blood products
• Parenteral nutrition (PN)
• Mannitol
• Sodium Bicarbonate

Intravenous giving sets
On all giving sets there is a drip chamber, this forms the drips and allows you to calculate the rate (in drops per minute). The presence of drips indicates that the infusion is continuing satisfactorily i.e. no occlusions.¹

¹ Some pump specific sets (such as the Graseby 500) actually fill the drip chamber so that drops cannot be seen.
ALWAYS use the correct giving set for the correct application. Some infusion pump giving sets have a side arm injection port (epidural lines do not have injection ports and have a yellow stripe for identification) which allows for the injection of bolus medicines etc. Gravity giving sets are not routinely supplied with such a port.

More information on giving sets is found in **Section 6** of this workbook.

The presence of air in the infusion line is potentially very dangerous for the patient and must be avoided.

Partly used bags of intravenous fluids should NEVER be reconnected to administration sets as there is a risk of air embolism and microbial contamination.

The expiry date of the giving set must be checked prior to use and the packaging examined for any tears or breaks. On removal from the packaging, the giving set should be clean and dry and any clamps should be in the fully open position. If not, it is probable that the set has not been sterilised properly, has been tampered with, or has become contaminated.

**In-line infusion filters**
These are only used routinely in the Neonatal Intensive Care Unit. However there are certain medicines which require additional filtration so it is vital that the up to date Medusa monograph is checked prior to administration and discussed with pharmacy if needed.

The filters are often designed to be used in the drawing up and NOT the administration of infusions. Using the wrong filter or using a filter inappropriately is likely to cause infusion pump rate and occlusion problems.

**Roller clamps**
When using these it is advisable to position them high up the giving set away from the patient to avoid tampering, especially if giving IV fluids to a child or to a confused patient.

**Roller clamp creep**
Giving sets are made from plasticised PVC. They tend to ‘creep’ which means that with time the line shape will be kinked allowing the clamp will gradually move usually opening the line. So for example a simple bag infusion controlled by a roller clamp might change rate over time as the tube deforms and the wheel moves therefore the number of drops per minute will change resulting in over infusion or rarely under infusion. Rates should be checked hourly as a minimum when fluids are being administered by gravity.

**Changing IV lines**
Each line should be labelled with date and time of setting up (in order to facilitate line changing). According to the RUH Trust’s Medicines Code: Administration of intravenous Drugs, changing of IV infusion lines must be carried out every 72 hours unless the following applies:

- If a medicine is being administered via an intermittent infusion the line must be changed at every dose.
• For blood administration the line must be changed at least every 12 hours.

• When giving a lipid infusion (e.g. Propofol, Total Parenteral Nutrition (TPN)) the line must only be used for 24 hours and must be discarded at the end of the infusion.

**Procedure for giving an IV bolus or commencing an infusion**

Please ensure that you have read the relevant sections and appendices in the Medicines Code: Administration of intravenous Drugs, and understand the care for peripheral venous catheters, both available on the Royal United Hospital's intranet site. In particular you must know:

What to do prior to drug administration

The Trust’s position on checking and double checking of intravenous drugs

Principles of administration including Aseptic Non-Touch Technique (ANTT)

Procedure for flushing peripheral intravenous cannula

Procedure for assessment and documentation of intravenous drugs and peripheral venous cannula

**Complications of IV therapy**

There are many complications of IV therapy but those given below are the most common.

**Phlebitis**

This has been defined as…


**Causes and Prevention**

There are 4 main types:

1) Chemical or infusion - caused by an irritant such as a medicine or infusion fluid.

2) Physical or mechanical - Caused by contact with an object such as a cannula. This may be due to improper choice of size of cannula or lack of skill in inserting it.

3) Infective or septic phlebitis - occurs due to an infection.

4) Thrombophlebitis - Inflammation of the vein caused by thrombus formation.
Clinical Signs:
- Pain
- Erythema (Redness)
- Swelling
- Infection

There are many contributing factors to phlebitis developing so there are a number of steps that should be taken to prevent it as described by Dougherty, L. & Lamb, J. (2008). All sites must be regularly observed care given as per the RUH care plans which can be found in the intranet and include VIP scoring.

Infiltration

Infiltration is the inadvertent administration of a non-vesicant medication or solution into the tissue surrounding avascular access device (RCN 2010).

Causes and Prevention
Causes can be divided into mechanical and inflammatory as described by Dougherty, L. & Lamb, J. (2008) and to prevent infiltration the key step is observation and monitoring of the site. If infiltration is observed the infusion should be stopped and the RUH care plans followed.

Extravasation
This has been defined as “…the unintentional infusion of a vesicant solution into the tissues surrounding a vein.” (INS 2006) A vesicant solution is one that will cause the formation of blisters with subsequent sloughing of tissue due to tissue necrosis, and certain patient groups are at increased risk (Dougherty, L. & Lamb, J. 2008).

Clinical signs:
- Burning sensation
- Pain
- Some resistance to giving of a bolus injection or slowing of an infusion.
- Tissue sloughing but this often takes a few days or a few weeks to become apparent.
- Necrosis

Prevention
Treatment of extravasation is difficult so it is essential that every measure is taken to ensure its prevention. Good and frequent observation of the site is the best weapon available to the practitioner when combating this problem. The Trust has a care plan for peripheral venous cannula and IV infusions to help with this.

Extravasation can be reduced by taking the following precautions:-

- Ensure that the cannula position is optimal and has been sited correctly using the smallest gauge possible.
• If the cannula has been in situ for more than 72 hours make sure that it is replaced and preferably on a different limb remove once the new one has been tested.
• Administer vesicant medicines first, after testing for placement by flushing.
• If in doubt stop and resite cannula.
• Where possible, involve the patient in the care of their cannula by asking them to report any sensations of burning, pain or stinging
• For high risk and slow infusions consider central venous cannulation (Dougherty, L. & Lamb, J. 2008)

Inform medical staff as soon as possible if extravasation is suspected. Complete nursing documentation and refer to the RUH NHS Trust Care Plan for the use of intravenous cannulae and intravenous infusions.
http://webserver/clinical_directory/care_plans/documents/intravenous_therapy/Care_plan_Peripheral_Venous_Cannula.pdf
http://webserver/clinical_directory/care_plans/documents/intravenous_therapy/Care_plan_Intravenous_infusion.pdf

If extravasation of vesicant medicines occurs, refer immediately to the Trust Policy on Extravasation and instigate treatment urgently in accordance with this.

References & Further Reading:

British National Formulary (BNF) Available at: http://www.bnf.org/bnf/terms.htm
Operated by the Royal Pharmaceutical Society of Great Britain, of 1 Lambeth High Street, London, SE1 7JN

Dougherty L. (2008) Obtaining peripheral venous access


Medicines and Healthcare Regulatory Agency (MHRA) 2007
Medical Device Alert MDA/2007/051


Royal Marsden NHS foundation Trust, (2001) *The Royal Marsden Manuel of clinical nursing procedures* [online] 8th Ed Available at: www.rmmonline.co.uk accessed on 30/06/2014
Section 2  Pharmaceutical Aspects of Intravenous Therapy.

Amanda Skirrow – Aseptic and Clinical Services Pharmacist

This section gives an overview of the pharmaceutical issues concerned with intravenous administration of medicines. The reasons for using the intravenous route, the potential hazards of intravenous therapy, stability and compatibility issues and common problems associated with intravenous medicines are discussed.

Learning outcomes

After studying this section the nurse will be able to:

• Describe why intravenous therapy is used.
• Describe the advantages of using the intravenous route.
• Describe the different formulations of intravenous medicines.
• Describe the pharmacological hazards of intravenous therapy.
• Know which medicines are potentially problematic, and the difficulties associated with their use.

Prior to reading this section, please ensure that you are familiar the Medusa Injectable Medicines Guide available on the Trust’s intranet site.

Pharmaceutical aspects of intravenous therapy

All practitioners administering intravenous medications must familiarise themselves with the Medicines Code. This is a set of local policies providing an effective system for the safe and secure handling of medicines in line with the Duthie Report and Standards for Better Health. The Administration of Medicines section of the Medicines Code covers the safe and effective preparation and administration of all medicines and has a specific section on Infusions. There is also a separate Medicines Code policy on the administration of Potassium containing infusions.

Why use the intravenous route?

• The oral route is unsuitable, because the patient is unconscious, unable to swallow, nil by mouth, pre or post operation, has an obstruction, has bowel damage, is severely ill, or needs a high dose of medicine rapidly.

• The medicine is destroyed by the stomach acid for example, Insulin, Heparin or Benzylpenicillin.
• The medicine is not absorbed orally for example, Gentamicin, Vancomycin and Amphotericin.

• The intramuscular route is inappropriate, such as in patients who are Haemophiliacs and HIV positive, because of the risk if bleeding occurs. The intramuscular route may also be inappropriate for elderly and malnourished patients due to both groups having less muscle bulk to inject into, which can lead to painful injections.

• A rapid response is required, as in an emergency situation when Adrenaline (Epinephrine); Lidocaine and Adenosine need to be administered quickly.

• To achieve high, predictable levels of a medication in the patients circulation, such as in severe sepsis when it is important to know that the patient is receiving a therapeutic dose of the medicine.

• There is a need to give a medication as an infusion, which will allow the dose to be titrated to the responses of individual patients e.g., Isoket™ and Heparin, or when there is a need to administer large volumes of fluid.

### Intravenous versus oral route

**Advantages**

**Oral:**
- Non-invasive.
- Less severe adverse medicine reactions (i.e. side effects).
- Patient is in control.
- Less practitioner time needed for administration.

**IV:**
- Can achieve a rapid response.
- High blood levels can be achieved and quickly.
- Rapid dose alterations are possible.
- Continuous response.
- Can give large volumes.

**Disadvantages**

**Oral:**
- There is frequently unpredictable absorption, for example in elderly patients who can have slower stomach emptying rates which can lead to a slower response to the medicine. Also, every patient is an individual, and will therefore respond differently when a medicine is administered.

**IV:**
- Invasive.
- Reversal of dose is difficult even impossible in some cases, whereas the reversal of an oral medication is easier by using charcoal or gastric lavage.
- Increased adverse medicine reactions.
- Increased risk of error due to the need for reconstitution and then the correct rate of administration.
- Risk of embolism, phlebitis and extravasation.

**Preparations available**

Intravenous medications are manufactured in several different formulations, usually dependent on their stability in solution. The four available formulations are:

- **Aqueous solutions** – these are medicines which are stable and ready to use e.g. Heparin.
- **Powders for reconstitution** – These are less stable and require addition of a diluent before using e.g. Flucloxacillin, Benzylpenicillin.
- **Powders with diluent provided** – these are fairly insoluble and require a specific diluent to reconstitute, which is provided by the manufacturer and must be used e.g. Rifampicin.
- **Non-aqueous solutions** – these are medicines which cannot form an aqueous solution e.g. Diazemuls™.

**Pharmacokinetics of parenteral medicines**

Pharmacokinetics is the study of the way in which the body processes a medicine. It can be used to predict dosing frequency by assessing the way in which the body distributes and metabolises the medicine.

**Administration**

Is the medicine being given by bolus injection, intermittent infusion or continuous infusion? The method can alter how quickly the body responds, for example if a medicine is being infused over an hour, the body will respond more slowly than if the medicine was administered by a bolus injection.

**Distribution**

Medicines given by the IV route bypass the GI tract and go straight into the systemic circulation where it exerts its effect at the target site.

**Metabolism**

This primarily occurs in the liver. Various reactions occur to make the medicine suitable for excretion. If the liver is damaged in any way, this will affect the metabolism of many medicines.

**Excretion**

This primarily occurs in the kidneys.

If we understand the pharmacokinetics of a medicine it can tell us if a dose change is needed, for example, as a person gets older their renal function deteriorates. If a medicine they are taking is renally excreted the dose or frequency of dosing may need to be changed so that the patient does not receive an excessive dose. This is especially important for medicines with a small therapeutic window (as discussed later).
Pharmacological hazards

These can depend on factors such as:

- Rate of administration
- Side effects
- Stability
- Compatibility
- Mixing

Rate of administration

This is important for both bolus injections and infusions. Adverse effects of medicines can often be related to the rate of administration, and often the severity of a reaction can be decreased by slowing down the rate. There can be a wide variety of problems e.g. fluid overload if an infusion is given too quickly. Excessive pharmacological effects can also occur for example:

Furosemide – Risk of hearing impairment if given too quickly
Vancomycin – Risk of ‘Red man syndrome’ (upper body flushes) if given too quickly
Theophylline – Increased rates can cause arrhythmias, nausea, vomiting and tachycardia.
Phenytoin – causes arrhythmias and cardiac arrest if given too quickly.

A big culprit of rate related side effects is Potassium. The recommended rate is 10-20 mmol of potassium per hour and if given more quickly it can cause arrhythmias and cardiac arrest. There is also the risk of layering if potassium is added to an infusion bag. Layering occurs when potassium chloride is added to the infusion fluid, but the bag is not then mixed, so a layer of potassium can be left on the bottom of the bag and there is then the risk of the patient receiving a bolus dose of potassium. This can be avoided if the bag is inverted several times before administration to ensure mixing. Due to this risk it is recommended that the ready mixed infusion bags are always used. Please also refer to the relevant Trust Policy.

Due to the potential fatal errors that can occur with Potassium Injections and Infusions the National Patient Safety Agency issued an alert on 23rd July 2002. This alert related to the control of potassium chloride concentrate solutions and restricted the storage, use and transfer of these injections and solutions. What this means in practice is that the concentrated solutions of potassium chloride are restricted to use in critical care areas only (e.g. ITU, CCU, NICU etc.), and have been removed from routine ward stock. All concentrated solutions are ordered and stored as a controlled medicine. The full alert can be accessed at www.npsa.nhs.uk (go into Health Professionals section and then into Alerts and Advice).

Side effects (adverse medicine reactions)

Severe reactions, including anaphylaxis, are more likely and more severe after IV administration as it bypasses the normal gastrointestinal defences.

It is very important to document any allergies that a patient may have in as many places as possible so that the patient is not exposed to the medicine again. Side
effects are treated according to the reaction seen, for example if a patient develops a rash an antihistamine may be prescribed.

Stability
It is important for the medicine to be in its intended form and ensure that the product is stable before it is administered. Instability can lead to the formation of an inactive or a toxic chemical and therefore the product will not give the expected results.
A product can become unstable for a number of reasons:

a) PH: reactions can occur when two compounds have a different pH, so if an acidic medicine is mixed with an alkaline (base) medicine a salt is formed which can be seen as a precipitate. This is particulate contamination.
An example of one medicine which can be affected by pH is amphotericin. This is added to Glucose prior to infusion, and the glucose cannot be below a pH of 4.2, otherwise the amphotericin will precipitate out of solution. Therefore it may be necessary to add a buffer solution to the Glucose to increase the pH.

b) Light: some medicines can be degraded by light, which can lead to a loss of potency, or can increase toxicity e.g., Nitroprusside (a vasodilator) degrades to cyanide if exposed to light.
Therefore there is a need to protect the solution from light by:
• Using amber coloured ampoules (manufacturer does this)
• Using over bags
• Using opaque giving sets.
It is always important to check the storage instructions.

c) Temperature: many medicines can be affected by high temperatures and this can cause degradation. Some products are affected by low temperatures e.g., Phenytoin and Ciprofloxacin can precipitate out of solution.
If a product should be kept in the refrigerator (2-8°C) then it is vitally important that the cold chain is maintained, because we need to prove that the medicine has been kept at the required temperature throughout transportation to guarantee its integrity.

d) Co-solvents: a solvent increases the ability of a medicine to dissolve in solution. Poorly soluble medicines can require a co-solvent included in the formulation by the manufacturer to improve the solubility and stability e.g. Phenytoin and Amiodarone. Diluting injections can change the pH and make the co-solvent less effective and therefore the product is less stable. This can lead to precipitation.

e) Time: It is always very important to observe expiry dates as manufacturers carry out tests so that within a medicine's shelf life there is more than 90% of the original concentration remaining. After this time the product may lose potency or degrade to a toxic compound. Therefore expiry dates cannot be
extended. All injections and infusions which are made on the ward should be administered immediately and not stored, due to the risk of infection.

Compatibility and Mixing
When a medicine is in contact with another chemical compound and remains unchanged it is said to be compatible. The compound the medicine is in contact with can be another medicine, an infusion bag, a giving set etc. If they are incompatible the medicine may be altered or a precipitate may form, and in some cases the incompatibility may not be seen. This is why it is very important to check before and during administration. Incompatibilities can be seen in the form of haziness, colour change, viscosity change, effervescence or separation. Information is limited on the compatibility of mixing two medicines and it is best to avoid this wherever possible. However, if a patient has very poor access and mixing is necessary, it is vital in this situation to look at the likelihood of a reaction occurring. When administering two or more different medicines it is important to flush the line between each medicine. It is also worth checking with pharmacy before administering the medicines, as there may be information on compatibility.

Sorption:
This is another compatibility problem and is a reaction between the medicine and the container it is in.

Adsorption is when the medicine sticks to the container e.g., insulin and heparin are adsorbed by glass/PVC/rubber.

Absorption is when a medicine is taken up into the container e.g., diazepam absorbed by PVC.

Permeation is when a medicine passes through the container into the surrounding environment e.g. Isoket.

Leaching is when the medicine draws chemicals out of the container e.g. Taxol.

This shows that always very important to follow the manufacturer’s instructions.

Problematic medicines
Some intravenous medicines have further difficulties associated with them. There is a need to be aware when administering them because they often have a very narrow therapeutic window. This means that there is a very small difference between a therapeutic dose and a toxic dose.

With these medicines there may be a need to carry out therapeutic drug monitoring (TDM). This usually involves taking blood levels and determining the levels of the medicine in the patients system. Monitoring plans should be established when starting treatment; this must be recorded in the patient’s notes along with any results thereafter. Examples of medicines requiring TDM are:

- Digoxin
- Phenytoin
- Gentamicin

These all require TDM.
Theophylline
Vancomycin

Cytotoxics – benefits outweigh the risks

Any deviations from expected monitoring results must be communicated with team members as soon as possible so that appropriate action can be taken.

Errors

Intravenous medicines pose a high risk of errors and the majority of administration errors are in this area. Examples of published errors are:

- Potassium chloride being used as a flush in place of sodium chloride. This has also been used to reconstitute IV antibiotics. The side effects of giving potassium too rapidly have been discussed (arrhythmias/cardiac arrest)

- Oral/IV syringe mix-up: oral Phenytoin suspension has been given intravenously in error, as has Paracetamol suspension.

To avoid this kind of wrong route error, purple barrelled oral syringes only must be used for administering medicines orally or via any other enteral route e.g. nasogastrically/via a PEG. An oral syringe will not fit an intravenous cannula.

Due to the risk of errors with preparation and administration of intravenous medications, and those associated with the use of IV syringes for administration of oral medications the NPSA issued two alerts in April 2007.

The first one covers injectable medications, and requires hospitals to carry out risk assessments on all injectable medications made in a ward environment along with an assessment of the way in which injectables are prepared. The NPSA receives 800 reports a month relating to injectable medicine incidents. The NPSA is therefore recommending that all hospitals undertake a risk assessment of injectable medicine procedures and products in all clinical areas to identify high risks and develop an action plan to minimise them. All protocols and procedures involving injectable medicines must be up to date.

The second alert covers the use of oral syringes and requires hospitals to use specific syringes for oral or enteral use. Incorrect administration of oral liquid by the intravenous route has resulted in 3 reported deaths to the NPSA. The recommendation in this alert is that syringes being used for oral/Enteral use are clearly labelled as such and cannot be connected to IV ports. It also covers the equipment used for Enteral feeding, requiring that these ports cannot be connected to IV syringes. This will mean a review of all feeding tubes used (Nasogastric (NG), Nasojejunal (NJ), Percutaneous Endoscopic Gastrostomy (PEG), Radiologically Inserted Gastrostomy (RIG) Jejunostomy tube (JEJ) etc.) to ensure compliance with the alert.
Summary
When administering any intravenous medication the following points should be considered:

1. Is the medicine suitable for the patient (consider any allergies, liver/kidney impairment)?
2. Is the medicine in the correct form, correct concentration and has it been reconstituted correctly?
3. Is it stable and compatible? Has the expiry date been checked, has it been stored correctly, has it been mixed adequately, is it in a suitable container?
4. Is the rate of administration correct?
5. Is any therapeutic drug monitoring necessary?
6. Are there any likely side effects?

IF IN ANY DOUBT CONSULT MANUFACTURER’S INFORMATION, BNF, PHARMACIST, MEDICINES INFORMATION.

References & Further Reading

Medusa Injectable Medicines Guide (Follow the links via the intra-net – Recap, Clinic Systems)


Therapeutic Drugs, Volumes One and Two; Edited by Colin Dollery; 1999

UCL Hospitals Injectable Drug Administration Guide; Edited by Shulman et al; 1998
Section 3  

Infection Control Issues.

Infection Control Team

Peripheral intravenous cannula insertion is a commonly performed procedure and has an associated risk of infection because of the potential for direct microbial entry to the bloodstream. Intravenous cannula may be contaminated by the patient’s skin flora at the insertion site or by the introduction of other organisms via the cannula hub or injection port.

Learning outcomes

After studying this section the nurse will be able to:

- Identify local infection control policies/procedures relevant to IV administration.
- Describe the prevention and management of IV related infection.
- State the infection-related implications of IV site patency and suitability.
- State how to manage IV administration sites in relation to:
  - handling technique.
  - appropriate dressing.
  - patient observation.

Before reading this section, please ensure that you are familiar with policies and procedure relating to infection prevention and control, available on the Trusts intranet site. The learner is directed to the epic3 guidelines (2014).

Infection Control Issues

a) The risk of infection increases with time and activity. The IV catheter related infection complications include entry-site infection, tunnel infection, blood stream infections and endocarditis.

b) Around 44% of bloodstream infections are associated with invasive devices, with two thirds of these due to intravenous access devices such as peripheral and central line catheters. (NAO 2009)

Microorganisms that cause IV catheter related infections

a) The organisms that cause IV catheter related infections might be commensals on the patient's skin, to which the patient has some resistance so are a low-level threat. Alternatively the organisms may originate from the hospital environment. Patients will not have resistance to these organisms so they pose a serious threat to the patient.

b) The microorganisms found to be the major cause of catheter-related blood stream infections are:

  *E.coli* and other gram negative bacteria
Staphylococcus aureus around 13% are sensitive S.aureus, 4% MRSA

Detection of IV catheter related infection
a) Early detection of any potential localised infection is essential in order to prevent systemic infection. All IV catheter insertion sites must be inspected prior to access and at least once per shift. This must be documented in the patient’s care recode.

b) When checking IV catheter sites:
   - Ensure that the device has not become dislodged
   - Check for erythema, tracking, and swelling or localised oedema, heat, pain/tenderness and any discharge from the site.
   - Take a swab from the site if there is sign of infection and send to Microbiology, remembering to complete the necessary clinical details on the request form.

Contamination of equipment
Sterile equipment must be stored in a clean dry area above floor height. Check all equipment prior to ensure that materials are sterile. Do not use material or equipment if outer packaging is damaged. Check expiry dates and do not use if the product is out of date.

Single use items must never be reused.

Skin disinfection
a) Skin disinfection prior to insertion is an important measure for preventing IV catheter related infections.

b) The antiseptics used for skin disinfection are:
   - Alcoholic chlorhexidine Gluconate 2% (ChloraPrep) (Central Venous Catheter)
   - Alcoholic chlorhexidine gluconate 2% (ChloraPrep®Sepp®) for peripheral cannula insertion.

IV dressings
a) The purpose of the IV dressing is to:
   - Prevent contamination of the site
   - Secure the catheter
   - Prevent trauma to the wound and the cannulated vessel

b) The dressing should be:
   - Transparent to allow continuous visual inspection of the catheter and site
   - Self-adhesive to ensure stability, reduce the risk of trauma, mechanical phlebitis and contamination
   - Semi-permeable to protect from bacteria and liquids whilst allowing the site to ‘breathe’
   - Sterile to prevent contamination of the site
   - Compatible with the patient’s skin. Check for allergies
Central venous access devices must be changed every 7 days or sooner if no longer intact or moisture collects under the dressing (Loveday et al 2014).

c) Central venous access devices must be changed every 7 days or sooner if no longer intact or moisture collects under the dressing (Loveday et al 2014).

Peripheral catheter site dressings must be changed if:
   a. Soiled
   b. Loose
   c. Moist
   d. You are unable to observe the site

**Policies and procedures to reduce the risk of IV site infection**
a) Several policies identify measures that will help reduce the risk of IV site infection, including Care of Central Venous Access Devices, Peripheral Venous Cannulation and the Venepuncture Policy and Procedure and Aseptic Non Touch Technique Policy.

**Reducing the risk of IV site infection**
a) You can reduce the risk of IV site infection by:
   • Decontaminating hands with soap and water and/or alcohol hand gel.
   • Wear gloves if indicated
   • Use Aseptic Non Touch Technique.
   • Inspect the insertion site for signs of infection.
   • Clean the site using alcoholic chlorhexidine 2%.
   • Reapply sterile dressing when the site is dry.
   • Replace caps with new sterile ones if they have been removed from the circuit.
   • Replace caps if contaminated with blood products, liquid emulsions or medicines.
   • Use needle free access ports, e.g. Vadsite
   • Peripheral cannulas should be removed within 72 hours or earlier if no longer in use

**Protecting yourself from infection**
There are several policies that discuss how you may protect yourself from infection, these are:

   • Protection Against Infection with Blood Borne Viruses
   • Hand Decontamination
   • Standard/Universal Infection Control Precautions
   • Sharps Safety
   • Management and Disposal of Waste
   • Central venous access
   • ANTT

The procedures you need to undertake to protect yourself and your colleagues are:
• Wear gloves if body fluid or medicine contact (e.g. cytotoxic) anticipated.
• Take the sharps bin to the patient to reduce handling of sharps (Free trays that hold 2.5 l sharps bins are available from Infection Control).
• Wash hands following handling of IV sites and removal of gloves
• Cover cuts with a waterproof dressing.
• Know the procedure to take following needle stick injury / contamination.

Documentation issues

i. Accurate records of IV access and management need to be maintained for each patient to promote high standards of care and ensure accountability. Good record keeping helps protect patient welfare in many ways, including the ability to detect problems such as the early signs of infection promptly.

The following should always be recorded:

• Date and time of insertion
• Reason for insertion
• Insertion site
• Name of person inserting cannula
• Date and time of removal
• Reason for removal

The site should be checked at least three times a day (once per shift) and care plan completed. The following should be recorded:

• Whether the cannula is still required
• VIP score

Patient participation

Your patient may also be able to help reduce the risk of IV catheter related infections. When a patient has a cannula inserted it is always helpful if you can inform them when they can expect the cannula to be removed. You should also ask them to report the following to you:

• Any pain, inflammation or discomfort at the IV site.
• If the IV dressing becomes wet...
• If the IV dressing becomes loose or soiled.

It is important for staff to understand the guidance set out in the epic3: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England (Loveday et al 2014). Section 4 is of particular note in relation to preventing infections associated with intravascular devices and can be accessed:

http://www.his.org.uk/files/3113/8693/4808/epic3_National_Evidence-Based_Guidelines_for_Preventing_HCAI_in_NHSE.pdf
References and Further Reading


Contact the Infection Prevention and Control Team if you have any questions on RUH ext. 5450 or via email.
Section 4  Intravenous Calculations and Assessment Questions

Resuscitation and Clinical Skills Team

This section aims to provide a thorough introduction and understanding to the sometimes complex field of IV calculations. Example calculations of varying complexity are provided.

Learning outcomes

After studying this section the nurse will be able to:

• Understand the methods used to calculate IV doses.
• Demonstrate accurate results in example calculations

Staff working with children should also complete the paediatric / NICU drugs calculations booklet and competencies available separately on the Royal United Hospital's intranet site, in addition to any local training determined by ward / department managers.

Introduction

The Nursing & Midwifery Council (NMC) states in its Standards for Medicine’s Management (2010), that…

“Some drug administrations can require complex calculations to ensure that the correct volume or quantity of medication is administered. In these situations, it is good practice for a second practitioner (a registered professional) to check the calculation independently in order to minimise the risk of error. The use of calculators to determine the volume or quantity of medication should not act as a substitute for arithmetical knowledge and skill.”

NMC (2010) pp26

On the following pages you are required to attempt to answer some questions of varying difficulty. The list of examples below is provided to help you but is there as a guide only. If you have your own way of arriving at an answer this is fine but it is important that you understand how you arrived at it. These calculations are designed to build on existing knowledge from previous medicines management assessments.

Clearly whilst these questions are designed to be as realistic as possible they are designed to test your ability to calculate and are NOT a guide to medicine administration. The Intravenous Policy and Procedure manual MUST be adhered to at all times.
Intravenous Calculation Example Sheet

Units used.
Mcg  = micrograms
Mg   = milligrams
Hr   = hour
Min  = minutes

1. To calculate infusion rate per minute in drops:

\[
\text{Drops per minute} = \frac{\text{Drops per ml of the giving set} \times \text{volume of infusion in ml}}{\text{Time in hours} \times 60}
\]

Example:

1000 ml of Sodium Chloride 0.9% is prescribed to be administered over 8 hours. The administration set delivers at 20 drops per ml. Calculate the drip rate in drops per minute.

Answer:
20 (drops/ml) x 1000(volume of infusion in ml) = 20000 drops
8(time in hours) x 60 = 480 min
Therefore 20000 drops to be given over 480 minutes

\[\frac{20000}{480} = 41.67\text{ drops/min}\]
Rounded up to whole number as you cannot give part of a drop = 42 drops per minute.

2. To calculate time fluid will last when infused at a specific drop rate:

\[
\text{Time fluid will last in hours} = \frac{\text{Volume in ml}}{\text{Rate of drops per minute}} \times \frac{\text{Drops per ml}}{60}
\]

Example:

500 ml of whole blood transfused at 25 drops per minute. The administration set delivers at 15 drops per ml. How long will the blood last?
Answer:

Time Blood will last in hours = \[ \frac{500 \text{ (ml)}}{25 \text{ (drops/min)}} \times \frac{15 \text{ (drops/ml)}}{60} \]

= \[ 20 \times 0.25 = 5 \text{ hours} \] – this would be too long for a transfusion so you would have to increase the drops per minute to ensure it is given in an appropriate time.

3. To calculate the amount of fluid given in 1 hour

\[
\text{Amount of fluid in one hour} = \frac{\text{Rate of drops per minute}}{\text{Drops per ml}} \times 60
\]

Example:

1000 ml of Dextrose 5% is given at 30 drops per minute. The administration set delivers at 20 drops per ml. How much fluid is given in one hour?

Answer:

\[
\text{Amount of fluid in one hour} = \frac{30}{20} \times 60 = 90 \text{ ml per hour.}
\]

N.B. Remember the drops per ml will vary with the type of intravenous administration set.

\[\text{e.g.} \]

<table>
<thead>
<tr>
<th>Type</th>
<th>Drops per ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood set</td>
<td>15</td>
</tr>
<tr>
<td>Fluid set</td>
<td>20</td>
</tr>
<tr>
<td>Paediatric set</td>
<td>60</td>
</tr>
</tbody>
</table>

4. How to calculate volumes of dosages for injection.

It is vital staff are able to calculate the correct amount of drug that needs to be given and what volume this is. It is also important that staff have a feel for if the answer they get is correct to ensure errors are identified.

Example:

Your patient needs furosemide and has been prescribed 60mg IV. The stock ampules are 80mg in 2ml.

\[
\text{Volume required} = \frac{\text{strength required}}{\text{Stock strength}} \times \text{volume of stock solution}
\]
60mg x 2ml = 1.5ml
80mg

5. Medicine addition to IV fluids.

In a number of circumstances medicines will be added to IV fluids.

If the patient is to have the total dose of fluid over a set time then the only calculation involved is the drip rate as set out in example 1 e.g. Erythromycin 500mg in 250mls dextrose 5% over 30 minutes - is the same as calculating the rate for 250mls dextrose 5% over 30 minutes.

However, for some medicines, particularly those used in a critical care situation, the administration of medicine will be at a variable rate. Medicines will be added to IV fluid to make a standard solution and then will be prescribed in milligrams (mg) (or units) per minute or, or more potent/toxic medicines in micrograms (mcg) per kg per minute (e.g. dopamine, dobutamine).

Because these medicines are usually very potent it is of the utmost importance that they are given at the prescribed rate. Nomograms are commonly produced by the medicine manufacturer and are very useful for those familiar with them but they must be used carefully as their layout is variable. There are example tables within Medusa on the RUH intranet.

It is also necessary to be able to perform the necessary calculation which, if a step-wise approach is used, is relatively straightforward.

To calculate the infusion rate, for an infusion such as dobutamine, the following equation may be used:

\[
\text{Infusion rate (ml/hour)} = \frac{\text{Dose (mcg/kg/min) \times patient weight (kg) \times 60 (minutes)}}{1000 \times \text{concentration (mg/ml)}}
\]

For example: To administer a dose of 2.5 micrograms/kg/minute of dobutamine to a 70kg patient using a standard solution of 250mg in 50mL (5mg in 1mL), the calculation would look as follows:

\[
\frac{2.5 \text{ (micrograms/kg/minute)} \times 70 \text{ (kg)} \times 60 \text{ (minutes)}}{1,000 \times 5 \text{ (mg/mL)}}
\]

\[= \frac{10500}{5000} = 2.1 \text{ml/hr} \text{ this is what the infusion pump should be set at}
\]

It is also good practice to be able to check what dose an infusion pump is giving and thus convert mL/hr back to the dose mg/min or mcg/min and mg/kg/min or mcg/kg/min.
For example: an infusion pump containing 250mg dobutamine in 50ml running at 3.5mL/hour on a patient who is 70kg.

Step 1
Calculate how many mg per mL the infusion contains = \( \frac{250\text{mg}}{50\text{ml}} = 5\text{mg/ml} \)

Step 2
Calculate how many mg/hour the pump is giving using the rate set and mg/ml you have just worked out = \( 3.5\text{ml/hr} \times 5\text{mg/ml} = 17.5\text{mg/hr} \)

Step 3
Convert mg/hr to mcg/hr multiply mg/hr by 1000 = \( 17.5 \times 1000 = 17500\text{mcg/hr} \)

Step 4
Convert mcg/hour to mcg/minute by dividing mcg/hour by 60 to give minutes = \( \frac{17500}{60} = 291.67\text{mcg/min} \) (round up to 2 decimal places)

Step 5
Work out the rate per kilogram by dividing mcg/min by the patients weight = \( \frac{291.67}{70} = 4.17\text{mcg/kg/min} \) - This can be rounded up to 4 mcg/kg/min

This should then be checked against the prescription to ensure the correct dose is delivered.

If the prescription was as in the previous example of 2.5mcg/kg/min you should recheck your calculation and if the answer is still the same discuss with the doctor, calculate the correct rate and consider what steps need to be taken next (Lapham and Agar 2009).

References and further reading:


Assessment - Intravenous calculations

Please show any working out on the question sheet as, in case of an incorrect answer, your assessor will be able to discuss with you where you made your error. Managers can access the answer sheet by contacting the Resuscitation Team.

1) A patient is prescribed Flucloxacillin 125mg. 500mg vial of the medicine is dissolved in 10mls of sterile water. How many mls of the solution should be given?

2) A patient has a litre of Dextrose-saline prescribed to be administered over 8 hours. The giving set drips at 20 drops/ml. At how many drops/minute should the drip rate be set?

3) A patient has a 1000mls of 0.9% saline prescribed. The Doctor prescribes the first 200mls to be given over 1 hour. The giving set delivers at 20 drops/ml.
   a) At how many drops/minute should the drip rate be set?

   b) The Doctor then prescribes the remaining fluid in question 3a to be given over 6 hours. At how many drops/minute should the drip rate be set?

4) A 250ml bag of Dextrose 5% containing 900mg of Amiodarone is being administered via a volumetric infusion pump at a rate of 12.4mls/hr. How long will the fluid last?
5) A patient is having a unit of blood (in this case 328mls) to be administered over 4 hours. The giving set delivers at 15 drops/ml. At how many drops/minute should the drip rate be set?

6) A patient is having a 500ml bag of Dextrose 5% containing 600mg of Rifampicin. It is being administered via a standard giving set which delivers 20 drops/ml. The drip is currently set at 65 drops/minute.
   a) Given that the fluid must be administered over 3 hours what should the drip rate be?

   b) If the infusion in 6a continues to run at 65 drops/min how long will the fluid last in hours and minutes?

7) A 59Kg patient is prescribed Dobutamine using a standard solution of 250mg in a 50ml it is prescribed to be given at 3mcg/kg/minute
   a) Calculate the concentration in mcgs/ml of Dobutamine

   b) Given that Dobutamine should always be given via an infusion pump, what rate should you set the pump if the correct rate is to be delivered?

   c) You check the pump and the infusion rate is set at 3mls/hr how many mcg/kg/min is the patient receiving?
Section 5  Anaphylaxis

Resuscitation and Clinical Skills Team

This section is available as a workbook and quiz on the Royal United Hospital’s intranet site. Please go to the Resuscitation Department’s intranet page and search for “Anaphylaxis with Algorithm and Quiz” under the Training Documents section.

The workbook explains the concepts of anaphylactic reactions, their cause and treatment. Common symptoms are identified and there is a detailed discussion of the nursing management and treatment of a patient during and following a reaction.

Staff should complete the quiz and return it to the Resuscitation and Clinical Skills Team for marking. You must produce evidence to your assessor of having completed the anaphylaxis workbook and quiz before you can be signed off as competent in the administration of intravenous medications.

All staff who administer drugs should also be aware of the following NICE guideline:
Section 6     Infusion Systems.

Bettina Deacon – Medical Equipment Nurse

This section introduces the user to the different infusion devices available. The differences between devices are discussed allowing the user to match the pump to the needs of the patient and medicine. The importance of regular maintenance and training is described.

Learning outcomes

After studying this section the nurse will be able to:

- Select and use the correct infusion device.
- Obtain help and training for intravenous equipment.
- Avoid risks to the patient during IV therapy.
- Deliver safe intravenous therapy using infusion devices.

All staff must attend medical equipment training before they can be signed off as competent in the administration of intravenous fluids or drugs. This training is included in the Royal United Hospital’s Trust Induction programme. However if a significant period of time has elapsed between attending Trust Induction and competing this workbook, additional medical equipment training must be undertaken.

Medical Equipment competencies are listed against individual staff profiles on Pegasus. Pegasus is the Trust’s Medical Equipment Training and Competency database and the staff profile will show the relevant competencies for infusion pumps and syringe drivers used in their clinical area. Staff must ensure these competencies are completed before they can be considered competent. These competencies are time limited and must be maintained to continue infusion practice.

Please contact the Medical Equipment Management Service (MEMS) or Medical Equipment Nurse for advice.

Introduction

The aim of this section is to introduce the equipment management area of infusion therapy. This will cover the role of MEMS and MEL and how to select the correct pump taking into consideration the patient needs and the particular medicine to be given.

MEMS

MEMS are the Medical Equipment Management Service who provides a complete service for medical equipment. Most staff will already be familiar with the MEMS
Green Label that is attached to a device when something is wrong with it. However, MEMS do a lot more than just repairs!

- They evaluate new pieces of equipment (when old ones are nearing the end of their life)
- They standardise equipment (this means that staff will be familiar with equipment wherever they are in the hospital)
- They perform Planned Maintenance (PMs) to ensure that equipment doesn’t break when you most need it.
- They dispose of equipment when it reaches the end of its life

Medical Equipment Library
MEMS try and standardise equipment which helps to prevent risks both to the patient and the user. One of the ways that this is achieved is to have a Medical Equipment Library (MEL). Most clinical areas do not have their own infusion devices they are accessed via MEL Ext. 6446, who will collect and distributed the stock of devices as clinically needed across the site. More information can be found on the Royal United Hospital’s intranet site.

Training
Before staff uses a piece of Medical Equipment they must be trained. The Trust is required by law to provide this training. NEVER attempt to use medical equipment if appropriate training has not been received. If something goes wrong the user is responsible. The Medical Equipment Nurse can be contacted for advice and training on medical devices.

The Nursing & Midwifery Council (NMC) Code of Professional Conduct\(^2\) states that …

- ‘As a professional, you are personally accountable for actions and omissions in your practice and must always be able to justify your decisions…
- 39. You must recognise and work within the limits of your competence
- 41. You must take part in appropriate learning and practice activities that maintain and develop your competence and performance

There is a range of Medical Equipment Competencies relating to the infusion devices covered in this article which can be found on Pegasus (the Medical Equipment Training and Competency database). Staff will have a personal profile which will indicate the competencies required to be completed for the clinical area and role. Pegasus is accessible from the link on Desktop Dashboard and links on the MEMS Intranet pages.

If ever you’re asked to set-up an infusion pump and you’re not confident, ASK! This will usually be your colleagues first, but if they can’t help, then ring MEMS on ext 4140.

Types of Infusion Devices.

\(^{2}\)Nursing and Midwifery Council The Code: Standards of conduct, performance and ethics for nurses and midwives, 2008
There are several different types of pump available such as volumetric infusion pumps and syringe drivers. It is important that staff complete the medical equipment competencies for the infusion devices used in their clinical area as detailed on their Pegasus profile.

Detailed information on infusion devices can be found on Pegasus under Training Resources and the intranet under Medical Equipment Management Service (MEMS).

**Factors affecting pump performance.**

There are several factors which must be considered before choosing the appropriate pump for the patient’s needs. Some things are obvious such as accuracy, but what about things like pressure alarms or air alarms? Below some of the factors that affect pump performance are discussed.

**Accuracy**

As an example, assume that a prescription has been written to deliver an infusion of 20 ml over 4 hours. This is clearly a rate of 5 ml per hour. Let’s assume that a syringe is loaded with 20ml. Then, on the hour, the plunger is pushed forward to deliver 5ml (so the plunger is pushed from 20ml to 15ml). Then it is left, and in an hour it is pushed forward 5ml again. What’s wrong with this? 5 ml/hour is being delivered as the prescription asks, every hour the plunger is pushed forward to deliver 5ml. The problem is that it is not a constant delivery. What it actually being delivered is a bolus of 5ml every hour, and a constant delivery is not maintained over the hour. As a result, the medicine concentration in the patient’s blood will not be constant over the hour and it needs be as constant as possible.

Some pumps are better than others at achieving this constant delivery profile. That is, they produce a smoother delivery.

**Occlusion Pressure**

How does fluid actually get into the body?

Any infusion uses pressure to overcome resistance to flow.

- Resistance of the giving set – in practice this is very low but some sets include anti-syphon valves and these will increase the resistance considerably.
- Resistance of any filters.
- Resistance of the cannula – the narrower the cannula the more difficult it is to get fluid through.
- The viscosity of the fluid, for example, 50% dextrose is thick and will require a greater pressure to be pushed down the line.
- Intravascular pressure.

The maximum pressure in an adult vein is 30 mmHg, so in order for a medicine to flow into a vein the pressure at the cannula tip must be greater than 30 mmHg, otherwise nothing will flow.

So how is this achieved in a normal infusion without a pump? Well, because the bag is high above the infusion site it has greater pressure due to gravity and so can ‘push’ the fluid into the vein.
An occlusion can be caused by several factors. Let’s assume for example that a cannula becomes blocked. The pump monitors the pressure in the line and when the cannula occludes the pressure gradually builds up along the length of the line. Eventually it will get to a point that causes an alarm.

The faster the rate the quicker the pressure will build up.

How soon the alarm sounds is dependent on the speed of infusion AND the alarm pressure setting. It would make sense to run infusions at a rate that is as fast as is clinically allowable and also to have the alarm limits to be set as low as possible. This will lead to the pump alarming frequently and being perceived as a nuisance.

* There is no such thing as a nuisance alarm. All alarms indicate a problem and should be acted upon.

**What triggers an occlusion alarm?**

- Blockage in the line (often caused by leaving the roller clamp closed)
- Occluded cannula
- Partially occluded cannula.
- Patient bending their arm.
- High flow rate, long narrow cannula, thick fluid.
- ‘Stiction’ in the syringe (i.e. the plunger does not move easily)
- Occlusion alarm limit is set too low.

**1.1.1.1 Hazards caused by occlusions**

- Interruption to therapy
- Bolus delivery to the patient when the occlusion is removed.

This bolus is caused by the expansion of the giving set and maybe the syringe bung. The fluid will not compress but all the lines, syringes etc. will have some ‘give’. The tubing expands under the increasing pressure, so when it is removed the tubing contracts and a sudden bolus is delivered to the patient. It’s a bit like holding a finger over the end of a bicycle pump as its pumped. When the finger is removed high pressure air rushes out!

The latest infusion devices have sophisticated ‘back off’ mechanisms, so that when an occlusion is detected, they reverse and suck some of the bolus back into the syringe thus minimising how much is given to the patient.

**Choosing the right pump**

Before deciding on which pump to use, consider:-

The patient:
- Is the patient a neonate, a child or an adult?
- What sort of infusion is required?
- Is there a critical volume that needs to be delivered to the patient?
- What would happen if the infusion stopped for any reason... would this be dangerous?
- Does the patient have any special needs?
The medicine

- Does the medicine have a short half-life?
- Does it have a narrow therapeutic window?

Short half-life medicines are where their plasma concentration decreases by half very quickly i.e. less than 5 minutes.

Narrow therapeutic window means the difference between an effective dose and a toxic dose is very small. (A very accurate pump is needed to ensure the dose delivered remains within this ‘safe’ window.) An example of such a medicine is Aminophylline, too little and there is no therapeutic effect, too much and there is toxicity.

In order to ensure the correct device is chosen for each medication it is vital that the practitioner checks the infusion medication against Medusa Injectable Medicines Guide. A link to ‘Medusa’ can be found on the Clinical section of the Intranet Desktop Dashboard. The medication listing in Medusa will indicate the type of infusion device that can be used in relation to the medication.

1.1.1.2 Neonatal infusions

Neonates are very small and so need very small volumes and dosages of medicines. Generally these will be delivered at very slow rates. It is very difficult for a pump to deliver accurately at slow rates, so these pumps need to be very accurate. If there is an occlusion in the line, the pump needs to stop pumping very quickly. That means very sensitive pressure sensors to detect the build-up of pressure. Detection of Air in Line needs to be very sensitive.

Keep Vein Open rate (KVO rate) needs to be very small for neonates. Keep Vein Open is the rate that the pump will run at when it finishes the required volume. This ranges from 0 – 3 ml/hour and is configured to the device according to the clinical practice area by MEMS. When all the above points are considered, it will be of no surprise that a pump that offers the required level of accuracy is going to be expensive. Currently the RUH pumps suitable for use with neonates are the Fresenius Kabi Volumat MC Agilia, Alaris Asena GH and the CME McKinley T34 – these have a special configuration when used in neonatal therapy.

Types of giving set

Blood sets

On blood sets, there are often two chambers one above the other. The top one functions as before but the bottom one allows the user to manually pump blood into the patient if no pump is available. (The little floating ball acts as a valve to stop the blood flowing back into the upper chamber. Instead, the blood flows down the line and into the patient). Blood sets usually have an integral 200 micron filter.

Burette Sets

These consist of a large volume container that can be filled intermittently; this allows an infusion to be accurately volume limited. In the RUH, burette sets are only used in the Children's Ward.
**Pump specific giving sets**

These are manufactured specifically for a certain pump and each manufacturer will have their own design. Only the correct set designed for that pump can be used. You cannot use basic giving sets in pumps.

**Epidural lines**

These will look very similar to a normal giving set. In the RUH the CME Bodyguard 545 is used for epidurals, the dedicated epidural line is yellow and for safety reasons will have no injection ports. There have been many deaths due to giving epidural medicines intravenously.

**Light protective giving sets**

These will be the same as the standard pump specific giving set, but will generally be a dark colour to stop sunlight from degrading certain photo-sensitive medicines e.g. Frusemide, Nitroprusside. The infusion bag will need to be covered with a special bag to stop light degeneration (Photolysis).

**Infusion related problems**

**Air**

The presence of air in the infusion line is potentially very dangerous for the patient and must be avoided. With correct set-up and understanding it is easy to minimise the ‘air in line alarms’ commonly associated with infusion devices. Although IV bag manufacturers do their best to minimise air in IV bags, there will always be some air present. This is because air dissolves in fluid and the pumping action of the pump itself will release this air.

**Uncontrolled free flow**

This can occur with any type of infusion device and is extremely dangerous. It will certainly result in an overdose of medicines or over-infusion of fluid.

1.1.1.3 Volumetric infusions

The most obvious example of ‘free flow’ is leaving the roller clamp open when removing the administration set from the device. Modern devices have an anti-free flow device that prevents free flow occurring if the roller clamp is not closed when removing the administration set from the device. (This is the white clamp on the Graseby 500 and dark blue slide clamp on the Fresenius Volumat MC Agilia)

The roller clamp must be closed when opening the door of an infusion device to prevent free flow should the clamp not fully close the line.

1.1.1.4 Syringes

It is also possible to get ‘free flow’ from a syringe. This can occur in two ways:

- If the syringe is higher than the end of the giving set, the hydrostatic pressure in the syringe is much greater than that at the end of the line. This pressure may be sufficient to overcome the friction of the syringe barrel and the resistance of the line and so the plunger will move and the syringe will empty quickly!
Most modern syringe drivers clamp the end of the plunger and so prevent this from happening. However, if the syringe is incorrectly loaded and it is higher than the infusion site, free flow can occur. Be careful when disconnecting/removing a syringe from a pump when changing patients’ clothes etc. It is easy to wave the syringe in the air without realising it which could cause free flow.

- If the syringe is damaged, air can enter around the seal between the plunger and the barrel. If the syringe is higher than the infusion site this can cause the plunger to move causing free flow.

Both of the above risks can be minimised by reducing the height between the syringe and the infusion site.

The risk is minimised by using the clamp on the extension line before removing the syringe from the device and using administration lines that have anti-syphon valves.

Using infusion devices

- All air must be removed from the line before being connected to the patient.
- When using syringe drivers ‘Purge’ the line after the syringe has been inserted in the pump but before it is connected to the patient. This will remove any air in the line and will take up any ‘slack’ in the mechanism. Modern syringe drivers will have a specific purge button.

Conclusion

You have now completed this section of the workbook.

Listed below are some of the key points that should have been learnt from this session:-

- Understand the role of MEMS and MEL as related to Infusion devices.
- Different types of infusion devices and which are used in this hospital.
- Pump performance. Accuracy, occlusion alarms etc.
- How to choose the correct pump for the clinical application.
- Different types of giving set.
- An understanding of the problems that can occur with infusion therapy.

To link to infusion device and medical equipment competencies, please visit the MEMS pages on the Trust’s intranet site or type the following link into the web browser:


Glossary
Air in line
Modern infusion pumps detect air in the giving set. There is debate about the risks associated with air entering the body during an infusion. It is clear though, that too much is dangerous so everything should be done to minimise this risk.
Syringe drivers do not detect air in line.

Backlash
Occurs with syringe drivers. After an infusion is started it may take some time for the pump to take up the ‘slack’ in the system. This will cause a delay (sometimes several hours at slow rates!) before therapy is administered to the patient. Many modern syringe drivers automatically remove backlash. If not, backlash can be eliminated by using the ‘purge’ button on the syringe driver.

Bolus
An extra volume of medicine given in addition to the continuous infusion. It is a standard feature on many syringe drivers. It is generally only used in areas of critical care.

Free Flow.
Free flow is the uncontrolled flow from an IV bag or a syringe. It is often caused by inadvertently opening the roller clamp or by forgetting to close the clamp when removing the set from a pump.
Free flow occurs with syringes when the syringe is higher than the end of the line. The difference in pressure can be sufficient to move the plunger. Also, if air leaks into the syringe then fluid can flow out.

KVO (Keep Vein Open)
When an infusion ends, an infusion pump will run at a very slow rate – the Keep Vein Open rate, this is configured according to the infusion device and clinical area it is allocated to.
It is used to prevent the cannula from becoming blocked from blood clotting.

Purge
‘Purging the line’ involves running the medicine through the line to remove any air before the line is connected to the patient. Many modern pumps have a purge facility to allow this to be performed when the giving set or syringe is already mounted in the pump. In the case of syringe drivers, purging will remove any backlash and so therapy will be delivered to the patient as soon as the infusion is started.

References and further reading:

Pickstone M (1999), A Pocketbook for Safer IV Therapy, Medical Technology and Risk Series, Scitech Educational

MDA (2002) Selecting infusion pumps according to therapy categories, Syringe Pumps, MDA Evaluation 02111
Available online:
http://www.mhra.gov.uk/home/groups/dtsiac/documents/publication/con007322.pdf
Section 7    Assessment Questions

For instructions of how to complete this section please refer to the Introduction section of this workbook. An answer book will be made available for managers.

1) Give 2 reasons for the use of the IV route.
   i.
   ii.

2) When should infusion lines be changed for an intermittent infusion?

3) Which is the minimum size syringe that should be used to flush a peripheral cannula?

4) When a medicine is added to a syringe for infusion or an infusion bag, what must be affixed to the outside?

5) Name 2 intravenous substances that medicines should never be added to.
   i.
   ii.

6) Name 2 clinical signs of phlebitis.
   i.
   ii.

7) Give 2 clinical signs of extravasation.
   i.
   ii.

8) State the action that you would take if a patient had a known or suspected case of phlebitis, extravasation or infection.

9) List 7 reasons why an independent check is required for the administration of intravenous medicines.
   i.
   ii.
   iii.
   iv.
   v.
   vi.
   vii.
10) If two persons check a medicine/infusion who is fully accountable for the administration of that medicine/infusion?

11) If giving a medicine via a syringe driver or volumetric pump, when must that infusion be checked?

12) What are the visual signs of incompatibility when making or mixing a medicine or medicines?

13) Which IV medicines can be destroyed by stomach acid?

14) List three IV medicines and the side effects that can occur if the rate of administration is too quick.

15) Name two medicines that require therapeutic medicine monitoring.

16) Name 4 PVC catheter-related infection complications?
   i.
   ii.
   iii.
   iv.

17) What must you not do following skin preparation?

18) What is the minimum information that should always be recorded when inserting PVC catheters?

19) What does the term ANTT stand for?
20) State 6 practices you will adopt when managing PVCs to reduce the risk of PVC associated infection.
   i.
   ii.
   iii.
   iv.
   v.
   vi.

21) State how you will protect yourself from infection when managing intravascular catheters.

22) What daily record must be completed for all PVCs whilst in situ?

23) Give three possible signs of anaphylaxis.
   i.
   ii.
   iii.

24) How should you clean an infusion pump before sending it to MEMS?

25) Give four situations that would give rise to occlusion alarms.
   i.
   ii.
   iii.
   iv.

26) What action would you take if you found an infusion running at a different rate from that prescribed?
Section 8  Competencies.

Royal United Hospital NHS Trust
Competencies for intravenous medicine and fluid administration

These competencies are to be used in conjunction with:-

- The Administration of Intravenous Medicines Policy and Procedure.
- Intravenous Medicine Monographs on Medusa.

Introduction

Prior to the completion of this document newly qualified or registered practitioners will be expected to undertake the approved Trust training for the administration of intravenous medicines. The education and training will include practical skills and will be followed by a period of supervised practice and assessment of competence.

The training and assessment will normally be undertaken 6 months after qualifying but this is at the discretion of the appropriate Senior Nurse/Ward Manager. An Approved Assessor will carry out the assessment of competence.

An Approved Assessor will be somebody who has completed the relevant Trust training Course for intravenous assessors.

Assessment of competence will take place following successful completion of the Trust intravenous administration workbook and the Trust approved medical device training. Questions and competencies must be signed and dated by the approved assessor on each page.

In order to achieve successful completion, competencies which are relevant to your practice MUST be achieved.

If competency is not achieved at the first assessment then the items in which the assessee has been deemed to be not yet competent may be reassessed within 1 month of the previous assessment.

If reassessment takes place at a time longer than 1 month after the previous assessment then ALL competencies must be reassessed.

Nurse Name................................. Signature........................................
Assessor Name............................ Signature...........................................
Manager Name.............................. Signature...........................................
Date........................................
<table>
<thead>
<tr>
<th>COMPETENCY</th>
<th>Competent</th>
<th>Reassessment of competence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1 Accept own accountability in support of own actions and maintain</td>
<td></td>
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<tr>
<td>competency for Intravenous medicine administration.</td>
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<tr>
<td>Accept own limitations and know when to seek and accept advice.</td>
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<tr>
<td>2 Identify local and national policies/procedures regarding the following:</td>
<td></td>
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<tr>
<td>- Intravenous and central venous medicine administration.</td>
<td></td>
<td></td>
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<tr>
<td>- Infection control matters.</td>
<td></td>
<td></td>
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<tr>
<td>2 State the correct method of client identification and demonstrate this.</td>
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<td></td>
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<tr>
<td>3 Demonstrate knowledge of:</td>
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<tr>
<td>Patient’s medical condition and requirement for IV Therapy.</td>
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<tr>
<td>Patency and suitability of the intravenous injection site, VIP score and</td>
<td></td>
<td></td>
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<tr>
<td>frequency of assessment of the cannula and site.</td>
<td></td>
<td></td>
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<tr>
<td>Correct storage of medicine(s) and intravenous fluid(s).</td>
<td></td>
<td></td>
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<tr>
<td>Compatibility to intravenous fluid(s) and/or other medicines.</td>
<td></td>
<td></td>
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<tr>
<td>Equipment required.</td>
<td></td>
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<tr>
<td>Demonstrate the ability to:</td>
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<tr>
<td>Check medication and/or fluid prescription for error</td>
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<tr>
<td>Clarify any error / misunderstanding with prescriber</td>
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<td></td>
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<tr>
<td>Calculate a medicine dosage correctly.</td>
<td></td>
<td></td>
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<tr>
<td>Calculate an infusion rate correctly.</td>
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</table>
### Professional Competence & Knowledge

<table>
<thead>
<tr>
<th>COMPETENCY</th>
<th>Competent</th>
<th>Reassessment of competence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
<td><strong>Date</strong></td>
</tr>
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</table>

#### 4. Describe the prevention and management of the following potential hazards:

- Air embolism
- Anaphylaxis
- Extravasation
- Fluid Overload
- Incompatible medication
- Infection at cannula site
- Occlusion

#### 5. Recognise and state the appropriate response if equipment becomes:

- Faulty
- Unreliable
<table>
<thead>
<tr>
<th>Skill</th>
<th>COMPETENCY</th>
<th>Competent</th>
<th>Reassessment of competence</th>
</tr>
</thead>
</table>
| 1     | Demonstrate effective hand cleaning and disinfection before and after Intravenous procedures.  
Demonstrate when appropriate use of personal protective clothing to protect the wearer and patient and state when it is required.  
Demonstrate aseptic non-touch technique (ANTT)  
Demonstrate safe Intravenous management to reduce the risk of infection including:  
Minimal line manipulation.  
Appropriate lumen for additives.  
Appropriate connection devices.  
Appropriate duration.  
Demonstrate the giving of patient information & instructions to reduce the risk of IV infection and aid prompt infection detection.  
Demonstrate use of the appropriate dressing and that it is clean, dry, secure, and intact.  
Demonstrate ability to observe for signs of local or systemic infection in relation to IV therapy and calculate VIP score.  
Demonstrate the safe disposal of equipment according to Trust policies.  
Demonstrate appropriate documentation of infection control issues including:  
Device insertion, VIP score and removal date.  
Infection episodes and interventions taken. | Yes | No | Date |
<table>
<thead>
<tr>
<th>Skill</th>
<th>COMPETENCY</th>
<th>Competent</th>
<th>Reassessment of competence</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>2</td>
<td>If the checking of a medicine/infusion is indicated select the appropriate person to do this. Identify who is responsible and accountable for administering IV Therapy.</td>
<td></td>
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<tr>
<td>3</td>
<td>The practitioner will be able to demonstrate the following: Medicine reconstitution and admixture technique. Correctly label a medicine/infusion bag/syringe. Select the correct type of infusion device to be used for an infusion.</td>
<td></td>
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<tr>
<td>4</td>
<td>Administer a bolus injection manually. Correctly prime an ordinary gravity giving set. Correctly set and change the rate of an infusion using a gravity giving set.</td>
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<tr>
<td>5</td>
<td>Report and respond correctly to any medicine reaction recognised and has evidence of completing anaphylaxis workbook on quiz on the Royal United Hospital’s intranet site.</td>
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<tr>
<td>6</td>
<td>Record information correctly on the patient documentation and care plan.</td>
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<tr>
<td>7</td>
<td>Describe action to be taken if a drug dose is omitted.</td>
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<tr>
<td>8</td>
<td>Describe action to be taken in the event of a potential or an actual drug error.</td>
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<tr>
<td>9</td>
<td>Complete the specific competencies listed on the personal profile of Pegasus for infusion pumps and devices used in clinical area. Competencies can also be found on the Royal United Hospital’s intranet site.</td>
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</table>

Keep these competencies in your portfolio when complete. Your manager may require a copy.
Section 9    Additional Modules

Resuscitation and Clinical Skills Team

Additional modules and competencies are available on the Royal United Hospital’s intranet site or via internet links:

**Blood Transfusion**
E-learning, policies and procedures are available on RUH intranet.

**Parenteral Nutrition**
Workbook, competencies, policies and procedures are available on RUH intranet.

**Subcutaneous Infusions**
Workbook, competencies, policies and procedures available on RUH intranet.

**Central Venous Catheters**
Workbook, competencies, policies and procedures available on RUH intranet.

**IV drug administration in NICU**
Workbook and competencies, policies and procedures available on RUH intranet.

**IV drug administration to Children**
Paediatric nurses and other registered practitioners caring for children must read NPSA patient safety alert NPSA/2007/22 - Reducing the risk of hyponatraemia when administering intravenous infusions to children. Go to the following link [www.npsa.nhs.uk/health/alerts](http://www.npsa.nhs.uk/health/alerts) - select alerts and search for the article above.

They must then register for and successfully complete the on-line e-learning test which can be found at: [http://learning.bmj.com/learning/search-result.html?moduleId=5003358](http://learning.bmj.com/learning/search-result.html?moduleId=5003358)

Ward / department managers may require staff working with children to undertake additional numeracy and / or drug calculation tests. Please check with your ward / department manager.

Practitioners should identify with their mentors which of these additional modules are relevant to their area of clinical practice. They should only commence the additional modules once they have completed this IV workbook.

Practitioners and mentors should use the flowchart on page 5 as a model for working through additional modules.

Ward / department managers may require staff working in their clinical areas to undertake additional numeracy and / or drug calculations tests, which are not included in this workbook. Please check with your ward / department manager.