Acknowledgement of sources of illustrations

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Figure 4 – page 10 Peripherally inserted central catheter. Provided by Vygon (UK) Ltd - © Vygon (UK) Ltd 2012.

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Figure 6 – page 11 Skin Tunnelled central venous access. Provided by Vygon (UK) Ltd - © Vygon (UK) Ltd 2012.

Figure 7 – page 11 Indwelling Central Venous Access Device. Provided by Vygon (UK) Ltd - © Vygon (UK) Ltd 2012.

Figure 10 – page 19 Anaphylaxis algorithm - Reproduced with the kind permission of the Resuscitation Council (UK).
# Contents

Prerequisites for undertaking the IV medicine administration course ................................................................. 2
Aims ........................................................................................................................................................................... 2
Learning Objectives ............................................................................................................................................... 2
Introduction ........................................................................................................................................................... 3
1.0 Legal Aspects .................................................................................................................................................... 4
1.1 Competence ..................................................................................................................................................... 4
1.2 Checking of intravenous medication ........................................................................................................... 5
1.3 Clinical incident reporting ........................................................................................................................... 6
1.4 Adverse medicine reaction reporting .......................................................................................................... 7
2. Advantages and Disadvantages ..................................................................................................................... 8
3. Nursing care ....................................................................................................................................................... 9
4. Vascular Access Devices ................................................................................................................................... 9
   4.1 Peripheral Intravenous Devices ................................................................................................................ 9
   4.2 PICC (peripherally inserted central catheter) .......................................................................................... 10
   4.3 Non-Skin Tunneled Central Venous Access Device .............................................................................. 10
   4.4 Skin tunneled central venous access devices (Hickman Lines) ............................................................ 11
   4.5 Indwelling Central Venous Access Devices ........................................................................................ 11
5. Methods of Administering Intravenous Medications .................................................................................. 12
   5.1 Bolus administration .................................................................................................................................. 12
   5.2 Intermittent intravenous infusion ............................................................................................................ 13
   5.3 Continuous intravenous infusion ............................................................................................................ 13
   5.4 Fluid Balance ............................................................................................................................................... 13
6. Sources of Information ..................................................................................................................................... 14
7. Mechanical Infusion Devices ........................................................................................................................ 14
8. Complications of Intravenous Medicine Administration ........................................................................ 15
   8.1 Infiltration / Extravasation ....................................................................................................................... 15
   8.2 Infection ...................................................................................................................................................... 16
   8.3 Emboli ........................................................................................................................................................ 17
   8.4 Insufficient Mixing ..................................................................................................................................... 17
   8.5 Anaphylaxis ............................................................................................................................................... 18
9. Stability of Medicines in Solution .................................................................................................................... 20
10. Interaction of medicines with the syringe / bag ........................................................................................... 20
SELF EVALUATION............................................................................................................................................. 22
The Basic Calculations - A Quick Reference Guide ............................................................................................ 23
SECTION 1: UNITS AND EQUIVALENCES ........................................................................................................... 24
SECTION 2: CALCULATING DOSE AS VOLUME ............................................................................................... 27
SECTION 3: MEDICINE STRENGTHS AND STATED CONCENTRATIONS ...................................................... 30
SECTION 4: DURATION OF INFUSION ............................................................................................................... 32
SECTION 5: INFUSION RATE CALCULATIONS ................................................................................................. 34
Practice Questions ............................................................................................................................................... 36
Mock Test ............................................................................................................................................................. 37
Answers to Practice Questions .......................................................................................................................... 39
REFERENCES ......................................................................................................................................................... 40
Other Useful Resources ...................................................................................................................................... 41

Practice Development Department. Adult Intravenous Medicine Administration Workbook
For the purposes of this document the term “nurses” will be taken to mean registered nurses (adult), registered nurses (children), registered nurses (mental health), registered midwives, medical technical officers (MTO) and operating department practitioners (ODP).

Pre-requisites for undertaking the IV medicine administration course:
1. All candidates must be registered general nurses, registered midwives, MTOs or ODPs currently working in a clinical area. They should also have at least 6 months post qualification experience and be nominated by their clinical manager.
2. Prior to attending the study day, candidates must have appropriate support available for assessment and completion of 3 month period of supervised practice.
3. Each candidate must work in an area where there is a clinical need for this skill, and it is integral to their role.
4. This self directed learning package must be completed as the candidate will be tested on its contents during the study day.

Criteria for competence in this skill
1. Attendance at a recognised NHS study day in the United Kingdom or completion of an E-Learning package which involves:
   • Successfully demonstrating numeracy skills by achieving 100% pass in a medicine calculation test
   • Undertaking a period of supervised practice leading to verification of competency by Senior Charge Nurse/ Midwife, team leader or agreed deputy
   • Receipt of a certificate of competence by Corporate Practice Development Department NHSGG&C
2. Thereafter the nurse will be responsible for maintaining, updating and reviewing his/her intravenous medicine administration skills (NMC The Code 2008. HPC Standards of conduct, performance and ethics 2012).

It is imperative that candidates complete the pre-course workbook prior to attending the study day.

Course Aims
• To prepare individual practitioners to competently administer medication via the intravenous route.
• To ensure the application of evidence-based practice in developing the individual practitioners role in the administration of intravenous therapy.

Learning Objectives
Following attendance at a NHS GG&C IV medicine administration study day and a period of supervised practice, the practitioner will be able to:
1. Demonstrate awareness of the resources available to increase knowledge of intravenous (IV) therapies (medusa, BNFC, BNF, IV medicine monographs, medicine compendium).
2. Define the registered practitioner’s legal and professional responsibilities in the checking, preparation and administration of IV therapies.
3. Identify national and local policies in relation to IV therapy.
4. Demonstrate the ability to accurately complete necessary mathematical calculations prior to preparation of IV therapy.
5. Identify the advantages and disadvantages of choosing the IV route of administration.
6. Identify the advantages and disadvantages of peripheral and central IV access devices.
7. Define the steps required to check, prepare and administer medications for IV administration including equipment required.
8. Critically analyse the potential complications associated with IV therapy and discuss appropriate actions to prevent and/or treat these complications.
9. Identify issues surrounding stability and compatibility of IV therapies.
10. Demonstrate the safe handling of equipment used in IV therapy, e.g. needles, syringes, ampoules, vials, administration sets and infusion devices.
11. Describe the procedure for reporting incidents and accidents involving self, patient and others
12. Describe the essential maintenance of equipment used in IV therapy.
Introduction
Intravenous medicine administration is the administration of sterile preparations of medicines directly into a vein, via a peripheral or central line, for therapeutic reasons (medicinenet.com 2007). Historically this was a role undertaken by medical practitioners, however the nurses’ role has evolved significantly and the NMC / HPC are supportive of practitioners who seek to expand their scope of practice. The conditions for expanding the scope of professional practice include adequate training and supervision to ensure competence in practice (NMC 2009).

Before carrying out an expanded role the practitioner should always ask:

• Will patient care be improved?
• Are the essential values of nursing and midwifery protected?
• Are you competent to fulfil the role?
• Do you have managerial support?

If you answer ‘No’ to any of these questions, there may be a risk to patient care and to your professional credibility.
1. Legal Aspects

1.1 Competence
At present the administration of intravenous medication is considered an extended role of the nurse. Competence in this skill is achieved by attending a study day, successfully passing a calculations test and completing a period of supervised competency development.

Activity 1
In your place of work what systems are in place to ensure the competence of practitioners with administration of intravenous medicines?

List the main areas of the health care professional’s accountability in relation to the administration of IV medicines.
1.2 Checking of intravenous medication
At present in NHS Greater Glasgow and Clyde all intravenous medications are required to be checked by 2 registered practitioners prior to administration. Ideally both practitioners would be competent in intravenous medicine administration; however, in practice, this is often not possible. Both individuals checking the medication should be aware of its use, side effects, recommended route and method of administration prior to the administration of the medicine.

They must be either:
Two registered nurses band 5 or above and one must be competent in performing such a skill

OR
One registered nurse/ band 5 or above competent in performing such a task to administer and a doctor or pharmacist to check

OR
One doctor to administer and a registered nurse band 5 or above / pharmacist to check.

 Interruptions and distractions are a major cause of error. In the event of an interruption to the checking or administration process the medicine should be discarded and the process recommenced. No unlabelled medicine should ever be left unattended.

Scenario 1
You have been qualified for 2 years; you have undertaken your IV medicine administration study day in another hospital and have partly completed your supervised practice in this ward. Due to a staffing crisis you are the most senior nurse on duty. You notice that a patient is due important IV medicines, what do you do?

What are the implications of your decision for:

1. The patient?
2. You?

Justify your decisions with reference to the NMC The Code and discuss them with your assessor.

Scenario 2
You have partly made up IV clarythromicin, you have reconstituted it but not yet added it to a bag of diluent. You are called to the ‘phone urgently. What should you do?
1.3 Clinical incident reporting

You are professionally bound by the NMC Standards for Medicine Management (2010) to report clinical incidents. Medication incidents and ‘near-misses’ are described in the NHS GG&C Safe and Secure Handling on Medicines Policy (2008) as being clinical (e.g. administration of the wrong medicine to a patient) or non-clinical (e.g. medicine refrigerator turned off in error) in nature. The reporting of clinical incidents in intravenous therapy is important to enable learning to be shared and raises awareness of the hazards involved, thereby minimizing the possibility of recurrence.

Activity 2. Datix reporting

What is a “medication incident”?

To whom and how would you report an incident?

Do you know how to use the Datix reporting system?

Where can you find copies of all Nursing and Midwifery policies?
1.4 Adverse medicine reaction reporting

All staff involved in the administration of intravenous medications have a responsibility to inform the Medicines and Healthcare products Regulatory Agency (MHRA) of any suspected adverse medicine reactions. This is done by completing the yellow suspected adverse medicine reaction form at the back of the BNF or BNFC. This form can be accessed and completed online.

Figure 1

<table>
<thead>
<tr>
<th>YellowCard</th>
<th>It's easy to report online: <a href="http://www.mhra.gov.uk/yellowcard">www.mhra.gov.uk/yellowcard</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>MHRA</td>
<td></td>
</tr>
</tbody>
</table>

**SUSPECTED ADVERSE DRUG REACTIONS**

If you suspect an adverse reaction may be related to one or more drugs/vaccines/complementary remedies, please complete this Yellow Card. See ‘Adverse reactions to drugs’ section in BNF or [www.mhra.gov.uk/yellowcard](http://www.mhra.gov.uk/yellowcard) for guidance. Do not be put off reporting because some details are not known.

**PATIENT DETAILS**
- Patient Initials: __________
- Sex: M / F
- Ethnicity: __________
- Weight if known (kg): __________
- Age (at time of reaction): __________
- Identification number (e.g. Your Practice or Hospital Ref): __________

**SUSPECTED DRUG(S)/VACCINE(S)**
- Drug/Vaccine (Brand if known): ______
- Batch: ______
- Route: ______
- Dosage: ______
- Date started: ______
- Date stopped: ______
- Prescribed for: ______

**SUSPECTED REACTION(S)**
- Please describe the reaction(s) and any treatment given:
- Outcome:Recovered [ ]
- Recovering [ ]
- Continuing [ ]
- Other [ ]
- Date reaction(s) started: __________
- Date reaction(s) stopped: __________

Do you consider the reactions to be serious? Yes / No
- If yes, please indicate why the reaction is considered to be serious (please tick all that apply):
  - Patient died due to reaction [ ]
  - Life threatening [ ]
  - Congenital abnormality [ ]
- Involved or prolonged inpatient hospitalisation [ ]
- Involved persistent or significant disability or incapacity [ ]
- Medically significant; please give details: ______

**OTHER DRUG(S) (including self-medication and complementary remedies)**

Did the patient take any other medicines/vaccines/complementary remedies in the last 3 months prior to the reaction? Yes / No
- If yes, please give the following information if known:
  - Drug/Vaccine (Brand if known): ______
  - Batch: ______
  - Route: ______
  - Dosage: ______
  - Date started: ______
  - Date stopped: ______
  - Prescribed for: ______

Additional relevant information e.g. medical history, test results, known allergies, rechallenge (if performed), suspect drug interactions. For congenital abnormalities please state all other drugs taken during pregnancy and the last menstrual period.

Please list any medicines obtained from the internet:

**REPORTER DETAILS**
- Name and Professional Address: __________________________
- Postcode: __________
- Tel No: __________
- Email: __________
- Speciality: __________
- Signature: __________

**CLINICIAN (if not the reporter)**
- Name and Professional Address: __________________________
- Postcode: __________
- Tel No: __________
- Email: __________
- Speciality: __________
- Date: __________

Information on adverse drug reactions received by the MHRA can be downloaded at [www.mhra.gov.uk/daps](http://www.mhra.gov.uk/daps)

Stay up-to-date on the latest advice for the safe use of medicines with our monthly bulletin Drug Safety Update at [www.mhra.gov.uk/drugsafetyupdate](http://www.mhra.gov.uk/drugsafetyupdate)

Please attach additional pages if necessary. Send to: FREEPOST YELLOW CARD (no other address details required)
2. Advantages and Disadvantages

There are some well recognised advantages and disadvantages of using the IV route for medicine administration. Therefore any decision to give a medicine by this route should be justified. Part of the role of the nurse is to deliver individualised care to every patient; therefore the nurse should always understand the reasons for the administration of each medicine.

Advantages
There are 5 main reasons for administering a medicine via the intravenous route:

1. The medicine is not available in another form, e.g. piperacillin.
2. The patient cannot tolerate medication by another route e.g. patients who are nil by mouth, sedated/ventilated, have persistent nausea or inadequate swallow reflexes.
3. A constant or high blood level of the medicine is needed, e.g. sedation in ITU or theatre, Insulin.
4. A rapid onset of effect is needed, e.g. peri-arrest medicines, anti epileptic medicines or sedation in the patient with acute delerium tremens (DTs).
5. Some medications are more effective when given intravenously e.g. Chemotherapy medications, and some antibiotics, e.g. gentamycin, benzylpenicillin.

Disadvantages
1. Increased cost and nursing time to prepare and administer the medicine.
2. Need for the patient to remain in hospital raises issues with bed occupancy and cost.
3. Rapid onset of action means that errors may not be rectified prior to harming the patient (you can’t get the medicine back).
4. The volume of fluid needed to dilute the medicine may be excessive for the patient’s condition e.g. in renal failure.

Activity 3
Find a patient on your ward who is receiving IV medication. What medicines are prescribed and why is it being given IV?

What are the normal reasons for patients receiving intravenous therapy in your ward/department?

Look at the different types of antibiotics that are administered in your ward. Is there a “normal” dose range or blood level to be familiar with?

What other IV medicines are prepared and administered by nursing staff in your ward/department?
3. Nursing care

With all IV therapy, the nurse/midwife’s responsibilities include:

- Checking the IV access site for patency, changes and phlebitis and documenting this.
- Checking that the medication is correctly prescribed.
- Checking the infusion therapy fluid and container for any obvious damage or contamination.
- Ensuring the administration of the prescribed fluid is to the correct patient at the correct rate, carrying out any observations necessary.
- Maintaining all other appropriate documentation: fluid balance, care plan and nursing evaluation records such as the Peripheral Venous Cannula Care Plan
- If a medicine is not fully administered for any reason it should be documented in the nursing notes and medication Kardex. Action must be taken to resolve this outstanding dose. The event must be reported as a medication incident.

4. Vascular Access

Having decided that a medicine should be administered intravenously, consideration should be given to the site of administration. Intravenous access devices may be defined as peripheral or central.

**Peripheral lines** (cannulae, silastic midline catheters) lie within the peripheral venous system, normally in a vein in the forearm, hand and very occasionally in the foot.

**Central lines** have their tip within one of the major veins leading to the heart, the superior or inferior vena cava and consist of 4 main groups:

1. PICC (Peripherally inserted central catheter)
2. Skin tunnelled central venous access catheters, e.g. Hickman® lines and Broviac® line.
3. Non-skin tunnelled central venous access catheters e.g. direct entry central venous catheters, multi-lumen catheters cut-down type cannulae/catheters.
4. Indwelling central venous access devices, e.g. Port-a-caths®.

**Some medicines ideally should not be given peripherally because:**

- They cause profound vasoconstriction which could negatively affect the limb. e.g. the vasoactive agents adrenaline and noradrenaline
- They are highly irritant to the vessel and will cause pain and phlebitis e.g. parenteral nutrition solution exceeding 10% dextrose and/or 5% protein, high concentrations of potassium chloride (KCl) i.e. more than 20mmol per 500ml or solutions with a pH of less than 5 or greater than 9 (RCN 2010). For information regarding the pH of a medication, please refer to local monographs or the product information leaflet.
- They will cause severe tissue damage if they leak into the tissues (vesicants) e.g. cytotoxic medicines and some antibiotic therapies.

4.1 Peripheral Intravenous Devices – peripheral venous cannula (PVC)

There are several different types and gauges of cannulae normally sited in a vein in the forearm or hand and very occasionally in the foot.

**Advantages:**

Simple and quick to insert and remove and relatively inexpensive. (See Figure 2)

**Disadvantages:**

Should be replaced every 72-96 hrs (RCN 2010).

Cannot be used to administer all forms of IV medication (RCN 2010).
Midlines  
(See Figure 3)  
Midlines are described as peripheral vascular access devices (PVAD), ‘a long cannula’ which can be single or double lumen made of polyurethane or silicone. The distal catheter tip is situated just below the top of the arm in the axillary vein.  
**Advantages:**  
- Relatively inexpensive.  
- No need for CXR to confirm distal tip position so can be inserted at ward level.  
- Can remain in place for an average of 30 days.  
**Disadvantages:**  
- Both placement and usage require education and training.  
- There is risk of inappropriate usage.  
- Requires low haemodilution and low flow rates.  

4.2 PICC (peripherally inserted central catheter)  
(See Figure 4)  
**Advantages:**  
- Relatively low risk of infection and can be used for up to 1 year.  
- Can be used to administer irritant IV therapies.  
**Disadvantages:**  
- Inserted in X-Ray department via the antecubital fossa into the basilic vein.  
- High incidence of blockage (Giacomo, 2009).  

4.3 Non-Skin Tunnelled Central Venous Access Catheter  
(See Figure 5)  
Usually used in theatres and intensive care areas.  
**Advantages:**  
- Available as single or multi lumen, used for short term treatments for up to 14 days.  
- Can be inserted / removed in the ward area.  
**Disadvantages:**  
- Have the highest incidence of catheter related bloodstream infections (Patil et.al, 2011).  
- Risk of pneumothorax on subclavian insertion.
4.4 Skin tunnelled central venous access devices (Hickman Lines)
(See Figure 6)
Sited with the tip in a central vein and the line is tunnelled to exit the skin surface at a point distant to the entry to the vein.

Advantages:
- The catheter has a Dacron® cuff to prevent migration of infection along the vessel.
- Can remain in place for a year or more.
- All medications can be given via the catheter.
- The patient and family can be actively involved in the care of the catheter.

Disadvantages:
- A surgical procedure is required for its insertion and removal.
- The catheter requires at least weekly care to maintain patency and prevent infection.
- Occlusion – the line may occasionally occlude.
- Patient and family have to learn to care for the catheter so adequate preparation and training is required.

4.5 Indwelling Central Venous Access Devices
(See Figure 7)
An injectable port that is placed in a pouch created under the skin of the patient. A dedicated needle is required to gain access into the port to allow the administration of medicines and fluids.

Advantages:
- They are cosmetically acceptable.
- The port and central line cannot be accidentally removed.
- The risk of infection is lower due to it being a closed system.
- The port requires at least 4 weekly routine care to maintain patency when not being used.

Disadvantages:
- A needle is still required to gain access into the injection port.
- The needle can be accidentally removed during the administration of intravenous therapies.
- Repeated punctures into the injection port can damage the skin, making it painful and a source of infection.

All intravenous devices have to be treated with respect and great care, and before opting for a certain type of device, all medical and nursing staff should carefully assess the benefits and disadvantages of each type of device for each individual patient.

Therefore prior to administering a medicine IV think:
- What IV access have you got and where is it?
- What size is the cannula?
- Is it patent and what does the site look like?
- What is the Visual Infusion Phlebitis (VIP) score?
- What medication are you administering?
- What are the properties and pH of the medicine?
- How should it be administered?
- What diluent is this medicine compatible with?

Remember the 9 rights of medicine administration - right patient, right drug, right dose, right route of administration, right time, right diluent/compatibility, right flow rate, right monitoring & right documentation (Crimlisk et.al, 2009)
Scenario 2
A patient on your ward is prescribed amoxicillin IV. Her cannula has fallen out; this is the 3rd cannula that has been lost in the past 24 hrs.
What do you do?

During routine care of PVC, you notice redness and swelling around the site, the patient is pyrexial, what do you do?

What are the commonest venous access ports used in your ward/department? Describe them and discuss their advantages/ disadvantages.

5. Methods of Administering Intravenous Medications

Medicines can be administered either as a bolus injection, a short infusion or a continuous infusion. An infusion device may or may not be used in the administration. Advice regarding the administration of IV medications can be found on the monographs / BNF / Medusa monographs. Generally there should be a needle free access device through which medicines should be administered. The top port of the PVC is not suitable for routine use due to the difficulty in cleaning it adequately and should only be used in emergency circumstances.

5.1 Bolus administration
This is the giving of a medicine diluted in a small amount of diluent, normally water for injection or 0.9% sodium chloride, into a vein, over a short period of time, usually 3 – 10 minutes (Dougherty 2008).

Indications:
• When optimum levels of a medicine are required rapidly.
• If a medication is incompatible or unstable in infusion fluids.

Advantages:
• Minimises fluid administration.
• Cost effective method of administration as no further equipment is needed.
• Maximises patient and nurse contact time.

Disadvantages:
• The medicine is frequently administered too fast.
• Irritation of the vein can be caused by some medicines.
5.2 By intermittent intravenous infusion
The addition of a medicine to a small volume bag of intravenous fluid and administered over a period of time e.g. Pabrinex (Dougherty 2008).

**Indications:**
- Direct injection is likely to cause venous irritation leading to phlebitis.
- Direct injection would give toxic medication levels e.g. Vancomycin.

**Advantages:**
- Controlled rate of administration with decreased number of manipulations.
- Decreased chance of error and infection.

**Disadvantages:**
- Increased volume of fluid administered.
- Delay in medicine administration.
- Administration of additional electrolytes, e.g. sodium in 0.9% sodium chloride (also referred to as “saline”).
- Increased cost.

5.3 Continuous intravenous infusion
An addition of medicine to a small volume of fluid in a syringe to be given by a slow infusion by a motorised syringe device e.g. morphine or insulin (Dougherty 2008).

**Indications:**
- If a medicine is metabolised or excreted quickly or it is necessary to maintain a constant blood level.

**Advantages:**
- Allows for a constant blood level of medicine for optimum efficacy

**Disadvantages:**
- Restricts patient mobility.
- Increased risk of infection.
- Increased risk of medication error.

5.4 Fluid balance
Irrespective of how intravenous medicines are delivered, careful consideration of the quantity of fluid administered must be made. The amount of fluid should be recorded in the patient’s fluid balance records when they are being used. It is good practice that a patient who requires medicines administered as infusions should have a fluid record balance chart, which notes fluid output, too. The volume of fluid MUST be documented on the fluid balance chart AFTER the infusion is completed and NOT when it is being commenced. Some medicines are also recognised to affect renal function.
6. Sources of Information

- There are various sources of information including:
  - Pharmacy’s Medicine Information Department.
  - Medicine manufacturer’s information leaflet. This is normally contained in the packaging of any medicine injection (marketing authorisation).
  - BNF / BNFC

Activity 4
Describe the differences between –
- Luer slip fitting syringe:
- Luer lock fitting syringe:

Find a medication on your ward that is usually given by bolus administration, one given usually by intermittent infusion and one given usually by continuous infusion.

What are they?

Why are they given in this manner?

Is that the only method in which they can be administered?

In what situation would you consider giving them differently?

7. Mechanical Infusion Devices

Infusion devices are increasingly used to regulate the rate and volume of fluid administered to a patient. With advances in technology, devices become more complex with a consequent growth in need for training in order to maintain safety. Many medicine errors reported each year are related to the use of mechanical infusion devices (NPSA 2004). It is the responsibility of the nurse to ensure that they are appropriately trained to use each device safely and with competence.

Which device to use?
The priming volume of the administration sets used, dilution volumes and rates of infusion may dictate what type of infusion device will be required.

For example:
Syringe Device – A medicine to be administered over 1 hour in a volume of less than 50 ml could be administered safely using a syringe device.

Volumetric Infusion Device – A medicine to be administered over 1 hour in a volume more that 50 ml could, be administered using a volumetric device

Some general points are outlined below:

Siphonage: Siphonage is the free flow of fluid into the patient. It can be caused by the accidental opening of the roller clamp on an infusion line, or leaving the roller clamp in the open position when removing the infusion line from a volumetric infusion device, or by the flow of fluid from a syringe driver. This can occur even if the syringe is attached to the driver but is not secure. Siphonage can be prevented by closing the roller clamp when the door of a volumetric infusion device is opened and by keeping syringe drivers below the level of the patient’s heart. Anti siphon valves are best practice and should be used where they are available.
**Mechanical backlash:** Mechanical Backlash can occur due to inappropriate priming and purging of a device and giving set. This can result in under infusion or no infusion of the medicine.

**Battery life:** All mains operated devices have an internal battery for use when the patient is in transit. The battery should always be kept fully charged; therefore the devices should be kept plugged into the mains supply with the socket switched on, even when in storage, i.e. not in use.

**Bolus:** Syringe drivers and devices often have a bolus injection function. The patient can be given a bolus injection of the medicine at the press of a button. This bolus is usually 1 - 2 mL. It is the responsibility of the nurse to check this and to be aware when delivering a bolus injection to check how much is being administered. Please note that this is ONLY carried out in an area where the patient is high profile and monitored and the staff have been deemed competent in using the bolus facility.

**Maintenance:** Devices will fail if they are not cared for. They should be kept clean and inspected prior to use. Any faults or cracks in the casing or loose/exposed wires in the electrical cabling should be reported to Medical Physics / Bioengineering. Decontamination procedures are described in the NHS Greater Glasgow and Clyde Prevention and Control of Infection Policy Manual.

If an incident occurs which has involved a medical device:

The equipment should be taken out of use and the Medical Physics / Bio-engineer department should be informed as soon as possible. They should also be sent a copy of the incident form by the person who has completed the form.

The equipment should be clearly labelled ‘Not for use’ until it has been passed as safe to use. There are regular opportunities for device training in the local clinical areas.

**8. Complications of Intravenous Medicine Administration**

8.1 Infiltration / Extravasation

**Infiltration**

The inadvertent leakage of a non-vesicant solution from its intended vascular pathway (vein) into the surrounding tissue (Royal College of Nursing, 2009). It is increasingly seen as a benign event as it generally does not lead to tissue necrosis; however a large volume of infiltrate can cause compression of nerves and acute limb compartment syndrome (ALCS) resulting in long term disability (Doellman et al, 2009). If this is the case then surgical intervention (e.g. fasciotomy) may be required to prevent nerve compression and compromise of arterial circulation (Hadaway, 2007).

**The recommended immediate management is:**

- Immediately stop the infusion/injection (Doellman et al, 2009).
- Explain the procedure to the patient.
- If the infusion of medication is incomplete this should be given to the patient via a new cannula on another site. If for any reason the patient does not receive their intended IV medicine due to lack of alternative access this must be documented. Senior nursing staff and medical staff must be informed.
- Document accurately actions taken.

A plastic surgeon referral should be sought immediately where large volumes of infiltrate have accumulated.

**Extravasation**

The inadvertent leakage of a vesicant solution from its intended vascular pathway (vein) into the surrounding tissue (Doellman et al, 2009) A vesicant refers to any medicine or fluid with the potential to cause blisters, severe tissue injury (skin/tendons/muscle) or necrosis if it escapes from the intended venous pathway. The degree of injury may range from mild skin reaction to severe necrosis (European Oncology Nursing Society, 2007). In severe cases extravasation injury may lead to amputation (Roth, 2006; Hadaway, 2007; Doellman et al, 2009).

*Continues on next page*
Extravasation continued

The recommended immediate management is:

- Immediately stop the infusion/injection (Doellman et al, 2009)
- Explain the procedure to the patient
- Aspirate as much of the residual drug as possible (to minimise the injury caused by the residue of the drug). Under no circumstances should the device be flushed.
- Leave the cannula/port needle in situ (in case medical staff want to use to facilitate treatment and administration of any antidote(s)) but remove as soon as possible once this has occurred.
- Disconnect administration set or syringe containing drug but retain it to determine amount of drug extravasated.
- Document accurately actions taken.

8.2 Infection

Infection is one of the most serious complications associated with intravenous therapy (Hamilton 2006). The skin is the body’s most important defence system and when its integrity is breached infection is possible. In IV therapy there is a skin breach at the cannula site, every time this is accessed the risk of infection increases. Although uncommon this infection may be life threatening especially in this compromised group of seriously ill patients (Hamilton 2006).

Prevention of infection

- **Handwashing** (level II) prior to handling the cannula or preparing medicines (Hamilton 2006).
- **Cleaning ports prior to use** (RCN 2010) with disinfectant preparation.
  (See Prevention and Control of Infection Manual and epic 3 National Evidence–Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospital in England Loveday et.al (2014)).
- **Change administration sets every 72 hours** (RCN 2010).
- **Minimising** the number of manipulations to prepare a medicine, i.e. break a vial membrane once to remove desired quantity of fluid.
- **Minimising** the time between preparation and administration.
- **Minimising the length of time that the cannula is in situ.** It is recommended that the cannula is changed 72-96 hours following insertion provided that an alternative site is available and the patient continues to need IV access (RCN 2010). This should be documented on the peripheral venous cannula care plan.
- **Use of closed IV systems (needlefree devices)** and reconstitution devices.
- Aseptic non touch technique (avoiding contamination of key parts) should be used when preparing and administering all IV medicines.

Mechanism of Contamination

- **Intrinsic contamination**, i.e. faults already present, e.g. manufacturing fault.
- **Extrinsic contamination**, i.e. due to the way the system is used e.g. inadequate swabbing of surfaces or inadequate hand washing.

See Activity section opposite
Activity 5
Think of the patients in your clinical area who are receiving IV medication. Do any of them have factors which make them particularly at risk of infection?

What are they?

What can you do to prevent this?

8.3 Emboli
The risk of embolus formation in intravenous medicine therapy comes from 2 sources, blood clot formation on the cannula or central line and injected solids. Preston and Hegadoren (2004) found that the number of glass fragments found in the injectate when a medicine was aspirated using an 18g (white) needle exceeded those found when the medicine was aspirated using a 21g (green) needle.

The RCN standards (2010) recommend that a blue (23g) needle or a filter needle is used when aspirating the contents from a glass ampoule.

The cannula acts as a foreign body within the vessel, platelet clumps will stick to it and will encourage fibrin deposition, bacteria will also be attracted, with flushing of the cannula or medicine administration bits of this may break off, these may then be deposited within the capillary system of the lungs or brain causing local tissue hypoxia.

There is also the possibility that air may be injected into the vein causing air emboli. In order to prevent this all infusion lines should be well primed prior to use and air bubbles should be carefully expelled from all syringes of medication.

8.4 Insufficient mixing
This occurs with solutions of different densities, e.g. potassium chloride in dextrose solution. Insufficient mixing can result in irregularity of dose administration. The concentration may be too high and in the case of potassium chloride could cause cardiac arrest. The contents of the bag or bottle of infusion fluid must therefore be well mixed prior to administration.
8.5 Anaphylaxis

Anaphylaxis is a dangerous type of allergic reaction which is most likely to be caused by particular foods, insect bites or medicines. In anaphylaxis, cells release histamine in large amounts. This causes blood vessels to become leaky causing swelling in the surrounding tissues (Resuscitation Council, 2010).

IV medicines cause few anaphylactic reactions. Most reactions are caused by other allergens such as latex, nuts, stings, oral non-steroidal anti-inflammatory medicines and aspirin. Anaphylaxis is covered in this course because at this point in your career you will be able to administer IV medication and you should also have the skills to recognise and treat a patient in anaphylactic shock. For detail pertaining to the physiology of anaphylaxis please consult any physiology text book.

In summary, the allergen causes the immune system, in particular the mast cells to release quantities of histamine and other mediators, these cause:

1. Bronchoconstriction – Narrowing of the bronchi leading to an inability to get air in and out of the lungs.
2. Systemic vasodilation – This leads to profound hypotension.
3. Increased capillary permeability; this means that fluid tends to leak out of the blood vessels into the tissues. This can cause profound swelling, especially of the face and neck.
4. Skin reactions, itching, redness and rashes.

For diagnosis and management of anaphylaxis, see Figure 10, flow chart opposite.
Anaphylactic Reaction?

Airway, Breathing, Circulation, Disability, Exposure

Diagnosis – Look for:
- Acute onset of illness
- Life-threatening Airway and/or Breathing and/or Circulation problems (2)
- And, usually, skin changes

Call for help – Dial 222
- Lie patient flat
- Raise patient’s legs

Adrenaline (2)

When skills and equipment available:
- Establish airway
- Monitor:
  - High oxygen flow – Pulse oximetry
  - IV fluid challenge (3) – ECG
  - Chlorphenamine (4) – Blood pressure
  - Hydrocortisone (5)

1. Life-threatening problems:
- **Airway:** Swelling; hoarseness; stridor
- **Breathing:** Rapid breathing; wheeze; fatigue; cyanosis; SpO2 < 92%; confusion
- **Circulation:** Pale; clammy; low blood pressure; faintness; drowsy/coma

2. Adrenaline (give IM unless experienced with IV adrenaline)
**IM doses of 1:1000 adrenaline** (repeat after 5 minutes if no better)
- Adult 500 micrograms IM (0.5mL)
- Child more than 12 years – 500 micrograms IM (0.5mL)
- Child 6-12 years – 300 micrograms IM (0.3mL)
- Child less than 6 years – 150 micrograms IM (0.15mL)

Adrenaline IV to be given only by experienced specialists.
Titrate: Adults 50 micrograms; Children 1 microgram/kg.

3. IV fluid challenge
- Adult: 500-1000mL
- Child: crystalloid 20 mL/kg
Stop IV colloid if this might be the cause of anaphylaxis

4. Chlorphenamine (IM or slow IV)
- Adult or child more than 12 years: 10 mg
- Child 6-12 years: 5 mg
- Child 6 months to 6 years: 2.5 mg
- Child less than 6 months: 250 micrograms/kg

5. Hydrocortisone (IM or slow IV)
- Adult or child more than 12 years: 200 mg
- Child 6-12 years: 100 mg
- Child 6 months to 6 years: 50 mg
- Child less than 6 months: 25 mg
9. **Stability of Medicines in Solution**

Medications and the fluids used to reconstitute and dilute them are chemicals which may react together to produce new compounds. These may be toxic or otherwise harmful to the patient. For example, precipitation is a solid caused by the reaction of two chemicals in solution. This solid, if infused to the patient may not only block the catheter but may also cause a fatal pulmonary embolus.

**The ability of medicines to remain chemically active in solution is called stability.**

Stability may be altered by:

- **Light:** Some medicines degrade in light e.g. frusemide, amphotericin (UV radiation) and sodium nitroprusside (all light, degrades to cyanide) DTIC (Dacarbazine a cytotoxic agent).

- **pH:** Some medicines are only stable at a certain pH e.g. Sodium fucidate is supplied with a vial of buffer, when reconstituted with the buffer it can be then added to 5% dextrose, otherwise it will precipitate due to the acidity of the 5% dextrose.

- **Hydrolysis:** Many IV medicines are supplied as a powder. This must be mixed with water for injection before the medicine can be given. Water can react with the medicine making it unstable. In this situation a delay in giving the medicine may lead to a loss of its efficacy.

- **Temperature:** The solubility of some medicines is altered by temperature e.g. Mannitol tends to crystallise at lower temperatures.

Advice regarding the stability and pH of IV medications can be found on the medusa monographs and product information leaflet and pharmacy’s medicine information department.

10. **Interaction of Medicines with the Syringe / Bag**

- Sometimes the medicines stick to the surface (**Adsorption**) of the syringes / bag leading to a decrease of the medicine given to the patient e.g. insulin. For this reason insulin infusions should be changed every 12 hours.

- Sometimes the medicine migrates into the body of the bag / syringe (**Absorption**), especially if the bag is made of PVC e.g. diazepam.

- Sometimes medicines pass completely through the bag and are lost to the environment (**Permeation**) e.g. Glycerin Trinitrate (GTN) should be administered from glass or rigid plastic syringes.

Again, advice regarding the interaction of medications with the syringe / bag can be found on the medusa monographs, medicines information leaflet as well as pharmacy’s medicine information department.
Intravenous Medicine Administration
Adult 2014 Calculation
Self Evaluation

Before you start, assess your learning needs with the questions below. Then go to the relevant section for more practice.

**Can you convert between units?**

For example, express 275mg as micrograms? Express 50 micrograms as mg? (SEE SECTION 1)

**When dealing with liquid medicines how do you calculate how much of the available dose to give? (Calculating dose as volume.)**

For example, the patient is prescribed 400mg of a medicine orally. The medicine is available as a liquid containing 500mg in 5mL. How many mL are you going to administer to the patient? (SEE SECTION 2)

**Do you understand what is meant by a concentration of 1:10,000?**

This example is how much Adrenaline is in 10 mL of 1:10,000. (SEE SECTION 3)

**Do you understand what is meant by a 1% w/v (weight/volume) solution?**

For example, how much Glucose is contained in 250mL of 5% Glucose solution? (SEE SECTION 3)

**If a medicine must be diluted to a stated concentration how do you work out how much it must be diluted in?**

For example, Vancomycin must be diluted to 10mg/mL how much fluid will you dilute 750mg in? (SEE SECTION 3)

**If a medicine needs to be given at a certain rate in mg/min, how do you work out how many minutes it should be given over?**

This example is Vancomycin must be given no faster than 10mg per minute, how many minutes should 1g be administered over? (SEE SECTION 4)

**If you have an infusion which needs to run over a number of hours how do you calculate the hourly rate of the device?**

For example, if the vancomycin is diluted to 250mL in 0.9% Sodium Chloride, what should the device be set at (mL/hr) to administer it over the 100minutes? (SEE SECTION 4)

**How do you calculate the rate in mL per hour when the dose is given in micrograms per minute? (Infusion Rate Calculations)**

This example is Glyceryl trinitrate is prescribed at 10micrograms per minute. If you have a solution of 50mg in 500mL, what rate do you set the device in mls/hr? (SEE SECTION 5)
The Basic Calculations - A Quick Reference Guide

In order to administer IV medications in a safe manner it can help to know and understand the following formulae.

Converting from one unit to another
To convert from a larger unit to a smaller unit – multiply by 1000
To convert from a smaller unit to a larger unit – divide by 1000

Multiply x

Kg g mg microgram nanogram

Divide ÷

Calculating dose as volume (or tablets)
Used when calculating how much volume (or how many tablets) you need to give the patient to give the prescribed dose.

Want x IN = Volume

Got

OR

What you WANT (prescribed dose) x what is IN (ml) (or tablets) = the volume

What you have GOT (dose available)

Concentrations and Strengths
Used when calculating how much volume you need to dilute a certain drug to get it to a stated concentration.

Have Concentration = Volume

OR

What you HAVE prescribed(mg) Concentration (mg/ml) recommended = volume (ml)

Duration of Infusion
Used when calculating how long it will take to administer a drug.

Dose (mg) Rate (mg/min) = Time (min)

If calculating an hourly rate (to set a device for example) then:

Diluted Vol (ml) Time (min) = Rate (ml/min) x 60 = Rate (ml/hr)

Infusion Rate Calculations (Dose in micrograms/minute)
Used to calculate infusion rate when dose is prescribed in micrograms/minute.

Want (micrograms/min) x 60 x IN = Rate

Got

OR

What you WANT (dose) x 60 (mins in hour) x what is IN = Rate (ml/hr)

What you have GOT

(NB Make sure your units of WANT and GOT are compatible OR convert them to same unit)
Section 1: Units and Equivalences

1.1 Units – Basic Principles
As you are aware, there are many different units in medicine.

For example:

**Medicine strengths:** digoxin injection 500microgram in 1 mL

**Dosages:** dobutamine 3 microgram / kg / min

**Patient electrolyte levels:** sodium 137mmol / Litre

It is therefore important for you to have a basic knowledge of the units used in medicine and how they are derived.

It is particularly important to have an understanding of the units in which medicines can be prescribed; and how to convert from one unit to another - this last part being very important as it is the basis of all medicine calculations.

The International System of Units (S.I.) or metric system has been generally accepted in the United Kingdom and certain other countries for use in medical practice and pharmacy.

The main units are those of:

- **Weight**
- **Volume**
- **Amount of Substance**

### Standard International (SI) base units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Name of unit</th>
<th>Unit symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Kilogram</td>
<td>Kg</td>
</tr>
<tr>
<td>Volume</td>
<td>Millilitre</td>
<td>mL</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>Mole</td>
<td>Mol</td>
</tr>
</tbody>
</table>

SI Units are the standard way in which weights and volumes are described.

- Do **not** use plurals
- Always put a 0 before a decimal point e.g. 0.4 not .4
- **Litres, Micrograms, Nanograms and Units should always be written in full**

### Equivalences of weight

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kilogram</td>
<td>kg</td>
<td>= 1,000 grams</td>
</tr>
<tr>
<td>1 gram</td>
<td>g</td>
<td>= 1,000 milligrams</td>
</tr>
<tr>
<td>1 milligram</td>
<td>mg</td>
<td>= 1,000 micrograms</td>
</tr>
<tr>
<td>1 microgram</td>
<td>microgram (no abbreviation)</td>
<td>= 1,000 nanograms</td>
</tr>
<tr>
<td>1 nanogram</td>
<td>nanogram (no abbreviation)</td>
<td>= 1,000 picograms</td>
</tr>
<tr>
<td>1 litre</td>
<td>litre (no abbreviation)</td>
<td>= 1,000 millilitres</td>
</tr>
<tr>
<td>1 mole</td>
<td>mol</td>
<td>= 1,000 millimoles</td>
</tr>
<tr>
<td>1 millimole</td>
<td>mmol</td>
<td>= 1,000 microloes</td>
</tr>
</tbody>
</table>
1.2 Converting from one unit to another

In medicine calculations, it is best to work in whole numbers, i.e. 125 microgram and not 0.125mg, as fewer mistakes are then made. It is always best to work with the smaller unit to avoid decimals and decimal points. Therefore it is necessary to be able to convert easily from one unit to another. To do this you have to multiply or divide by 1000.

**In general:**
- To convert from a larger unit to the next smaller unit, multiply by 1000
- To convert from a smaller unit to the next larger unit, divide by 1000
- In each case, the decimal point moves three places either to the right or to the left, depending upon whether you are converting from a large unit to a smaller unit or vice versa.

(Move decimal point 3 places RIGHT) Multiply by 1000

Kg  g  mg  microgram  nanogram

Divide by 1000 (Move decimal point 3 places LEFT)

**TIPS!**
- To convert **BIG** to small ‘think BIG’, think ‘Go forth and MULTIPLY’
- To convert **SMALL** to big ‘think small’, think ‘DIVIDE UP’

Let’s look at the idea of something being 10x, 100x or **1000x** BIGGER or 10x, 100x or **1000x** SMALLER than something else. The relationship here is all about the ‘0’s you have – how many you add on or take off to make the number 10 times, 100 times or **1000 times** bigger or smaller.

**Let’s start with a ‘whole’ number (no decimal point – or ‘parts’):**

To make something BIGGER just ADD the SAME NUMBER of 0’s.

36  x10      = 360      (10 times bigger)
     x100     = 3600     (100 times bigger)
     x1000    = 36000   (1000 times bigger)

To make something SMALLER just TAKE OFF the SAME NUMBER of 0’s.

42,000  ÷ 10  = 4,200    (10 times smaller)
           ÷ 100  = 420    (100 times smaller)
           ÷ 1000 = 42    (1000 times smaller)

**Now let’s include decimal points:**

Which number is biggest? 0.64  
64  
6.4

If you line them up under the decimal point it becomes very clear (think of working with £s)

64.00
6.40
0.64

**To make the number BIGGER or SMALLER simply move the decimal point.**

The number of PLACES you MOVE the DECIMAL POINT depends on the NUMBER of 0’s.
When multiplying you move the POINT to the RIGHT to make the number BIGGER ↑
(The symbol ‘x’ means to multiply or ‘times’)

For example:
• 10 times bigger, you move (1 zero) 1 PLACE.................↑........36.0 becomes 360.0 (or 360)
• 100 times bigger, you move 2 PLACES......................↑........36.0 becomes 3600.0 (or 3600)
• 1000 times bigger, you move 3 PLACES.....................↑........36.0 becomes 36000.0 (or 36000)

When dividing you move the POINT to the LEFT to make the number SMALLER ↓
(The symbol ‘÷’ means to divide)

For example:
• 10 times smaller, you move (1 zero) 1 decimal PLACE...↓........42.0 becomes 4.2
• 100 times smaller, you move 2 decimal PLACES..........↓........42.0 becomes 0.42
• 1000 times smaller, you move 3 decimal PLACES.........↓........42.0 becomes 0.042

Examples
46kg as g (Bigger to Smaller ↓) = MULTIPLY 46 x 1000 = 46000g
5g as kg (Smaller to Bigger ↑) = DIVIDE 5 ÷ 1000 = 0.005kg
23mg as g (Smaller to Bigger ↑) = DIVIDE 23 ÷ 1000 = 0.023g

So to convert 3g to kilogram – would you X or ÷ ?
• To convert from a BIG unit to a smaller unit = MULTIPLY
  (Think BIG – go forth and multiply!)
• To convert from a SMALL unit to a bigger unit = DIVIDE
  (Think smaller – divide up!)

Grams (g) are smaller than kilograms (kg), so DIVIDE ........... 3 ÷ 1000 = 0.003kg
Section 2: Calculating Medicine Dose as Volume

Once you have confirmed the prescribed dose is appropriate for your patient:

**FIRST**
- Be ready to convert all weights into the same units (g, mg) and all volume into the same units (litre, mL).
  (See Section 1)
- Take calculations step-by-step and write down all your working including all the units.

To do most medicine calculations you need to find the following 3 BITS OF INFORMATION

1. **WANT**: What’s the prescription - what do you WANT to give the patient?
2. **GOT**: What strength of medicine is available – what have you GOT available?
3. **What is it IN?** This is how the medicine is presented to you. Is it a tablet or a sachet or is it in a volume of liquid?

These points are then used in:

### 2.1 The Basic Formula

\[
\frac{\text{What you WANT (1)}}{\text{What you have GOT (2)}} \times \text{What it is IN (3) (mL)} = \text{volume}
\]

**How do you remember where 1, 2, and 3 go in the equation?**

1. Patient comes first. If you didn’t have the patient and the prescribed dose you wouldn’t be doing this. Therefore 1 is the PRESCRIPTION – what you WANT.
2. Then go to the cupboard. 2 is therefore the medicine as you have GOT it.
3. Then you need to reconstitute the medicine – what volume is it now IN? 3 is that volume, and how you give it.

### 2.1 Calculate Dose as Tablets, using the Basic Formula

A patient is prescribed 10mg of Amlodipine. Amlodipine tablets are 5mg. How many tablets do you need to administer?

Break the information down. Look for 1, 2, 3.

<table>
<thead>
<tr>
<th>Amlodipine</th>
<th>Signed A. Prescriber</th>
<th>Time</th>
<th>Amlopidine 5mg tablets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>Route</td>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td>10mg</td>
<td>PO</td>
<td>05/07/14</td>
<td></td>
</tr>
</tbody>
</table>

Think of the end product, the HOW is the medicine given – and that’s the unit of your answer.

A doctor prescribes 10mg (= WANT) of Amlodipine. Amlodipine is available as 5mg (= GOT) tablets (= what it’s IN), each contains 5mg.

\[
\frac{10\text{mg}}{5\text{mg}} \times 1 \text{ (tablet)} = \frac{10}{5} \times 1 \text{ (tablet)} = 2 \text{ tablets}
\]
2.2 Calculate Dose as Volume, using the Basic Formula

A patient is prescribed Ranitidine 75mg. It is supplied as 150mg in 5mL. How much do you need to administer?

<table>
<thead>
<tr>
<th>Ranitidine</th>
<th>Signed A. Prescriber</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>Route</td>
<td>Start</td>
</tr>
<tr>
<td>75mg</td>
<td>PO</td>
<td>05/07/14</td>
</tr>
</tbody>
</table>

WANT (1) = 75mg. GOT (2) = 150mg. What it is IN (3) is 5mL. What volume containing the medicine do you need to administer?

\[
\frac{75\text{mg}}{150\text{mg}} \times 5\text{mL} = 2.5\text{mL}
\]

TIPS!

- ‘Volume’ suggests liquid / solution (measured in mL) – so the answer (how drug is given) will be in mL.
2.3 Intravenous Injections

A patient is prescribed 170mg Aminophylline IV. The ampoules available contain 250mg in 10mL. What volume containing the medicine do you need to administer?

<table>
<thead>
<tr>
<th>Aminophylline</th>
<th>Signed A. Prescriber</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>Route</td>
<td>Start</td>
</tr>
<tr>
<td>170mg</td>
<td>IV</td>
<td>05/07/14</td>
</tr>
</tbody>
</table>

\[
\frac{170\text{mg}}{250\text{mg}} \times 10\text{mL} = 6.8\text{mL}
\]

**TIPS!**

- Is the answer mg or mL? Think of the end product, the “WHAT IS IT IN” – the medicine is given as volume = solution/liquid. Liquids are measured in mL so that’s the unit of your answer.
- Check your answer looks right.
- Look at what you have GOT and what you WANT again.
- If 250mg (GOT) needs 10mL of solution, and you WANT 170mg (which is less than 250mg) then the amount of solution (what it is IN) must be less than 10mL.
Section 3: Methods of Expressing Medicines’ Strengths / Concentrations (how medicines are supplied)

### 3.1 Ratio

The strength of epinephrine (adrenaline) is generally expressed as 1:1,000 (1g in 1,000mL) or 1:10,000 (1g in 10,000mL). The ‘1’ always means 1g and the other figure refers to the number of mL.

It is important to know how such a ratio can be expressed as ‘mg per mL’.

**Example**

1:10,000 = 1g in 10,000mL. We know that 1g = 1000mg. This is equivalent to 1,000mg in 10,000mL.

How many mg would there be in 10mL?

Divide both sides by 1000.

The answer is 1mg in 10mL.

### 3.2 Percentage

The strength of the ingredients can also be expressed as a percentage. Percentage means how many parts per 100, e.g. 20% means 20 parts per 100.

<table>
<thead>
<tr>
<th>Weight in weight (w / w)</th>
<th>is a mixture of 2 solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>15% w / w means that 15g of medicine is in every 100g of the product.</td>
<td></td>
</tr>
<tr>
<td>For example, Hydrocortisone 1% (w / w) means that 1g of the medicine is present in 100g of the product.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weight in volume (w / v)</th>
<th>is when a solid is dissolved in a liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% w / v means that 5g of medicine in every 100mL of the product.</td>
<td></td>
</tr>
<tr>
<td>For example, glucose 5% (w / v) = 5g glucose in 100mL.</td>
<td></td>
</tr>
</tbody>
</table>

**Example**

A 5% (w / v) solution means that in every 100mL of solution you will find 5g of medicine. Therefore, how many g of Glucose would there be in 1000mL of 5% Glucose?

1% = 1g in 100mL

5% = 5g in 100mL (but we want to know how many g are in 1000mL)

Multiply BOTH the weight and the volume by 10 (to maintain the same proportions of w / v) = 50g in 1000mL.

### 3.3 Units in volume

This is where an international unit of measurement is a measure of biological activity, e.g. heparin 10 i.u. in 1 mL.

If heparin is supplied as 10units / mL, how many units are in 5mL?
3.4 Stated concentration – the calculation

Not everything fits into the basic concentrations' calculation. Sometimes you need to use a different one. For example, when you are working out how much volume you need to dilute a certain medicine into to achieve a stated concentration.

Example

You have a patient who is prescribed Rifampicin 240mg. Rifampicin should be diluted until it is 1.2mg / mL.

How much (mL) fluid should it be diluted in?

<table>
<thead>
<tr>
<th>Rifampicin</th>
<th>Signed A. Prescriber</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>Route</td>
<td>Start</td>
</tr>
<tr>
<td>240mg</td>
<td>IV</td>
<td>30/05/14</td>
</tr>
</tbody>
</table>

The solution should be diluted to a concentration of 1.2mg / mL (from medusa 11/2013). You need a slightly different formula for this.

\[
\frac{\text{WANT} - \text{mg (1)}}{\text{CONCENTRATION} - \text{mg/mL (2)}} = \text{VOLUME} - \text{mL}
\]

Remember the rule – avoid decimals. To change 1.2mg into a whole number, multiply by 10.

\[
\frac{240mg}{1.2mg} \times 1\text{mL} = \frac{2400}{12} \times 1\text{mL} = 200\text{mL}
\]

TIPS!

- Break the question down to find 1 = Want / prescription. (Patient still comes first!)
- 2 = Final concentration.
Section 4: Duration of Infusion – Rate (dose per min) and Infusion Rate (mL / hr)

The formula for this is very similar to the previous one for concentrations.

Example

A patient is prescribed 650mg Vancomycin. Vancomycin must be administered at a rate no faster than 10mg / minute. How many minutes would it take to give the 650mg?

<table>
<thead>
<tr>
<th>Vancomycin</th>
<th>Signed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>Route</td>
<td>Start End</td>
</tr>
<tr>
<td>650mg</td>
<td>IV</td>
<td>30/05/14 20.00</td>
</tr>
</tbody>
</table>

4.1 Stated Rate (dose per min)

\[
\text{DOSE} \quad \text{mg (1)} \quad \frac{\text{RATE} \quad \text{mg/min (2)}}{} = \text{TIME} \quad \text{minutes (3)}
\]

Look at the question to find 1 and 2.

A patient is prescribed **DOSE (1)** 650mg Vancomycin. Vancomycin must be administered at a **RATE (2)** no faster than 10mg / minute. How many minutes would it take to give the 650mg?

Rate of 10mg in 1 minute, therefore 650mg dose to be administered over:

\[
\frac{650\text{mg}}{10\text{mg} / \text{min}} = 65 \text{ minutes}
\]

4.2 Calculating Infusion (Device) Rate - in Hours

Example

Vancomycin 1000mg is diluted in 250mL of compatible infusion fluid. This infusion has to be given over 100 minutes. What rate should you set the infusion device at, in ml/hr, to deliver this dose?

Infusion rate (mL/hr)

\[
\text{VOLUME} \quad \text{mL (1)} \quad \frac{\text{Time} \quad \text{min (2)}}{} = \text{RATE} \quad \text{mL/min x 60 = mL/hr (3)}
\]

Vancomycin 1000mg is diluted in 250mL (VOLUME) of compatible infusion fluid. This infusion has to be given over 100 minutes (RATE). What rate should you set the infusion device at, in mL/hr, to deliver this dose?

\[
\frac{250\text{mL}}{100\text{mins}} = 2.5\text{ml/min x 60 minutes} = 150\text{mL/hr}
\]
**TIPS!**

- Break the question down to find (1) = Volume. (patient still comes first!) Don’t be tempted to put 1000mg as the Volume! Remember the medicine is diluted in the 250mL. Part (1) of the formula is in ‘mL’ therefore (1) must be 250mL, not 1000mg.

- (2) = Rate.

- **Remember – we are being asked to set a device rate which is in HOURS (mL/hr) not minutes!**

- You must convert your answer FROM MINUTES TO HOURS (there are 60mins per hour) by Multiplying by 60.
Section 5: Infusion Rate Calculations

5.1 Calculate dose when prescription is in micrograms / min

To do this calculation we go back to using the Basic Formula, it’s just that there’s slightly more information to deal with in part (1) of the formula first – converting units from micrograms to mg and converting minutes to hours.

Example

You are required to give a patient Glyceryl Trinitrate (GTN) as a continuous I.V. infusion at 10micrograms/minute. You have prepared a 50mg in 50mL infusion. What rate should you set the infusion device at, in mL/hr, to deliver this dose?

<table>
<thead>
<tr>
<th>Glyceryl Trinitrate</th>
<th>Signed A. Prescriber</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>Route</td>
<td>Start</td>
</tr>
<tr>
<td>10 micrograms/min</td>
<td>IV</td>
<td>30/05/14</td>
</tr>
</tbody>
</table>

You are required to give a patient Glyceryl Trinitrate (GTN) as a continuous I.V. infusion at 10micrograms (WANT) / minute. (60 mins per hour TIME) You have prepared a 50mg (GOT) in 50mL (IN) infusion. What rate should you set the infusion device at, in mL/hr, to deliver this dose?

\[
\frac{\text{WANT} - \text{micrograms/min \ (1)}}{\text{GOT} - \text{mg \ (2)}} \times \text{IN \ (3)} = \text{Rate}
\]

Write out whole formula

\[
\frac{10\text{micrograms/min}}{50\text{mg}} \times 50\text{mL}
\]

Convert to same units (micrograms to mg)

\[
10 \text{ micrograms} + 1000 = \frac{0.01\text{mg/min}}{50\text{mg}} \times 50\text{mL}
\]

Convert minutes to hours

\[
\frac{0.01\text{mg}}{50\text{mg}} \times 60 \times 50\text{mL}
\]

Cancel mg from top and bottom

\[
\frac{0.6\text{mg/hr}}{50\text{mg}} \times 50\text{mL}
\]

= 0.6mL/hr
TIPS!

- Break the question down. Look for **1, 2, 3 and 4** – where **4** is **TIME**
- **TIME** is part of the prescription, so goes with part **1** of formula.
- Start by writing out ALL parts of the formula, including all the units (to ensure you don’t forget to convert your units, micrograms to mg, and convert minutes to hours).
- The prescription is given in ‘minutes’ but device rates are set in ‘hours’. The question is asking you for the rate in mL/hr. So convert from minutes to hours. (There are 60mins per hour, so multiply by 60).
- The prescription is in micrograms, what you have **GOT** is in mg. So convert micrograms to mg by dividing by 1000.
- !! It doesn’t matter whether you convert the micrograms before or after converting from minutes to hours.
- Now you have broken down the information and are left with the Basic Formula, so you can cancel out the units (mg) from the top and bottom of the formula, which means you are left with the 2 units of your answer! (mL/hr).
Practice Questions

Answers to questions 1-14 can be found on page 39.

1. Convert 1.5g into mg.

2. Convert 80mg into g.

3. A patient is prescribed 260mg Gentamicin I.V. The ampoules available contain 80mg in 2mL. What volume containing the medicine do you need to administer?

4. A patient is prescribed 750mg Vancomycin I.V. The vials available contain 500mg. Each vial needs to be reconstituted with 10mL of water for injection. What volume of reconstituted medicine do you need to administer?

5. A patient is prescribed 5mg Phytomenadione (Konakion MM). The ampoules available contain 10mg in 1mL. What volume containing the medicine do you need to administer?

6. 1:10,000 strength means that in every 10,000mL of solution you will find 1g of Adrenaline. Therefore, how many mg of Adrenaline would there be in 10mL of 1:10,000 Adrenaline?

7. A 1% (w/v) solution means that in every 100mLs of solution you will find 1g of medicine. Therefore, how many g of Mannitol would there be in 100mL of 10% Mannitol?

8. A patient is prescribed 500mg of Phenytoin I.V. Phenytoin can be added to a bag of compatible infusion fluid giving, in this instance, a final concentration of 10mg/mL. How much infusion fluid should be used to dilute the Phenytoin to achieve this final concentration?

9. Vancomycin must be administered at a rate no faster than 10mg/minute. How many minutes would it take to give 750mg of this medicine?

10. Clindamycin must be administered at a rate no faster than 30mg/minute. How many minutes would it take to give 900mg of this medicine?

11. Vancomycin 1.5g is diluted in 500mL of compatible infusion fluid and given over 3 hours. What rate should you set the infusion device at, in mL/hr to deliver this dose?

12. Furosemide 50mg is diluted in 50mL of compatible infusion fluid and given over 12.5 minutes. What rate should you set the infusion device at, in mL/hr to deliver this dose?

13. You are required to give a patient Salbutamol as a continuous I.V. infusion at 20 micrograms/minute. You have prepared a 5mg in 500mL infusion. What rate should you set the infusion device at, in mL/hr, to deliver this dose?

14. You are required to give a patient Glyceryl Trinitrate as a continuous I.V infusion at 50 micrograms/ minute. You have prepared a 50mg in 50mL infusion. What rate should you set the infusion device at, in mL/hr, to deliver this dose?
IV Medicine Calculation Assessment Mock

Answers to these questions will be given on the study day

SECTION 1: Units and Equivalences
1. Convert 250 micrograms into mg.
2. Convert 0.5mg into micrograms.

SECTION 2: Calculating Dose as Volume
3. A patient is prescribed 3mg Lorazepam I.V. The ampoules available contain 4mg in 1mL.
What volume containing the medicine do you need to administer?

<table>
<thead>
<tr>
<th>Lorazepam</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0700-0900</td>
<td></td>
</tr>
<tr>
<td>1200-1400</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dose</th>
<th>Route</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>3mg</td>
<td>IV</td>
<td>18/01/14</td>
<td>1600-1800 P</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2200-2400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other time</td>
</tr>
</tbody>
</table>

Signature of Doctor: A. Prescriber

SECTION 3: Medicine Strengths and Stated Concentrations
4. A patient is prescribed 500mg of Clarithromycin I.V. Clarithromycin has to be reconstituted with water for injection, then added to a bag of compatible infusion fluid, giving a final concentration of 2mg/mL.
How much infusion fluid should be used to dilute the reconstituted Clarithromycin to achieve this final concentration?

5. 1:1000 strength means that in every 1000mL of solution you will find 1g of medicine.
Therefore, how many mg of Adrenaline would there be in 0.5 mL of 1:1000 Adrenaline?

6. A 1% (w/v) solution means that in every 100mL of solution you will find 1g of medicine.
Therefore, how many g of Glucose would there be in 1000mL of 5% Glucose?
SECTION 4: Duration of Infusion - Stated Rate (Dose per Min)

Infusion Rate (mL/hr)

7. Furosemide must be administered at a rate no faster than 4mg/minute.
   How many minutes would it take to give 80mg of this medicine?

<table>
<thead>
<tr>
<th>Furosemide</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>80mg</td>
<td>0700-0900P</td>
</tr>
<tr>
<td></td>
<td>1200-1400</td>
</tr>
</tbody>
</table>

Dose | Route | Start  | End     |
-----|-------|--------|---------|
80mg | IV    | 18/01/14 | 1600-1800 |
     |       |         | 2200-2400 |
     |       |         | Other time |

Signature of Doctor: A. Prescriber
Additional Comments: Give no faster than 4mg/min

8. Vancomycin 750mg is diluted in 250mL of compatible infusion fluid. This infusion has to be given over 90 minutes.
   What rate should you set the infusion device at, in ml/hr, to deliver this dose?

8. Vancomycin 750mg/250mL

SECTION 5: Infusion Rate Calculations

9. You are required to give a patient Salbutamol as a continuous I.V infusion at 15 micrograms/minute. You have prepared a 5mg in 500mL infusion.
   What rate should you set the infusion device at, in ml/hr, to deliver this dose?

<table>
<thead>
<tr>
<th>Salbutamol</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>15micrograms/minute</td>
<td>0700-0900P</td>
</tr>
<tr>
<td></td>
<td>1200-1400</td>
</tr>
</tbody>
</table>

Dose | Route | Start  | End     |
-----|-------|--------|---------|
15micrograms/minute | IV    | 18/01/14 | 1600-1800 |
     |       |         | 2200-2400 |
     |       |         | Other time |

Signature of Doctor: A. Prescriber
Additional Comments: Continuous infusion
Answers to questions 1 – 14 from page 36.
(Answers to Mock Assessment paper will be covered in the calculation practice session on the Study Day.)
1. 1500mg
2. 0.08g
3. 6.5mL
4. 15mL
5. 0.5mL
6. 1mg
7. 10g
8. 50mL
9. 75 minutes
10. 30 minutes
11. 167mL/hr (answer 166.6…so round up the 6)
12. 240mL/hr
13. 120mL/hr
14. 3mL/hr

More practice on numeracy and maths is available at the following website produced by the BBC:
http://www.bbc.co.uk/skillswise/
References


Other useful resources


