Intravenous Therapy and Infusion Devices

Pre-course Workbook

Title: IV Therapy and Infusion Devices Precourse Workbook
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Author: Irene Lavery
Category: 1
Document Version: 1
Status: Final
Review Date: 28/01/13
Authorised by: Anne Petherick
Date Authorisation: 28/01/12
Date added to intranet: 

Key Words: Intravenous therapy, Infusion Devices, Pre-course, Workbook

Comments: Covers IV Therapy and Infusion Device practice, links with Accountability
Section 1: Educational Programme

Aim and learning outcomes, timetable, pre-course requirements, theoretical assessment, process for marking, supervised practice and competency assessment, competency documentation, review of competence

Section 2: Accountability and Legal Issues

Accountability scenarios

Section 3: Principles of Safe Practice in IV Therapy

NHS Lothian’s ‘Safe Use of Medicines Policies and Procedures’ (2009), medication errors and practical aspects, e.g. environment

Section 4: Principles of Safe Practice using Infusion Devices:

General principles relating to infusion devices, e.g. volumetric pump, syringe pump, CME McKinley T34 syringe pump for SC infusions, and PCA pump (as relevant for their clinical area)

Section 5: Potential Complications:

Phlebitis, extravasation, infiltration, and siphonage, start up time, occlusion

Section 6: Pharmacy

Section 7: Infection Control

Section 8: Drug Calculations

Section 9: Recognition and Treatment of Anaphylactic Reactions:

References
Section 1: Educational Programme

Aim of the Intravenous (IV) Therapy and Infusion Devices (ID) programme

The aim of this education programme is to provide registered practitioners (e.g. nurse / midwife / ODP) with the necessary knowledge and skills to achieve competence in the safe and effective preparation and administration of IV medications and where appropriate, the use of specific infusion device(s) safely and competently.

Learning outcomes:

Mapped against the Scottish Credit Qualifications Framework at Level 9 (equivalent to degree outcome learning outcomes). By the end of the pre-course work and the full education programme, including a competency-based assessment, practitioners should be able to:

- Critically analyse the legal and professional issues related to the preparation and administration of IV medication(s) and use of infusion device(s), identifying the implications for practice
- Effectively assess and manage the clinical risks associated with IV Therapy and the use of infusion devices
- Demonstrate an ability to competently use calculation methods, and accurately calculate rates for delivering medicines, e.g. via an infusion device
- Analyse the principles of infection control relating to the preparation and administration of IV Therapy and use of infusion device(s)
- Review pharmacy aspects relating to IV Therapy administration and the use of infusion devices to deliver medication(s)
- Identify good practice principles for safe and effective IV Therapy and use of infusion devices
- Analyse the requirements necessary for effective record keeping within an IV and infusion device role
- Demonstrate an understanding of the recognition and management of anaphylaxis
- Identify relevant safety alerts and consider how they impact on safe practice
- Demonstrate an ability to competently administer and maintain an IV infusion / medication using the NHS Lothian competency framework
- Critically appraise their knowledge and competency level in relation to NHS Lothian IV Therapy and infusion device competencies in order to achieve and maintain a safe level of practice.
### Timetable

#### Day 1

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0900–0920</td>
<td><strong>Introduction and welcome</strong></td>
</tr>
<tr>
<td>0920–0950</td>
<td><strong>Accountability workshop and scenarios</strong></td>
</tr>
<tr>
<td>0950–1030</td>
<td><strong>Safe principles for IV and Infusion Device (ID) practice</strong></td>
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<tr>
<td>1030–1100</td>
<td><strong>break</strong></td>
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<tr>
<td>1100–1230</td>
<td><strong>Calculation workshop</strong></td>
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<tr>
<td>1230–1315</td>
<td><strong>lunch</strong></td>
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<tr>
<td>1315–1445</td>
<td><strong>IV workshops (bolus and additive)</strong></td>
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<tr>
<td>1445–1545</td>
<td><strong>McKinley workshop</strong></td>
</tr>
<tr>
<td>1545–1630</td>
<td><strong>PCA workshop, or finish 1545 if PCA workshop not required</strong></td>
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#### Day 2

<table>
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<tr>
<th>Time</th>
<th>Activity</th>
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</thead>
<tbody>
<tr>
<td>0900–0905</td>
<td><strong>Welcome back, review Day 2 and exam process</strong></td>
</tr>
<tr>
<td>0905–1100</td>
<td><strong>Infusion Device workshops</strong></td>
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<tr>
<td>1100–1120</td>
<td><strong>break</strong></td>
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<tr>
<td>1120–1320</td>
<td><strong>Theory assessment</strong></td>
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<tr>
<td>1320–1330</td>
<td><strong>Evaluation and post course quiz</strong></td>
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### IV Therapy / Infusion Device Pre-Course Requirements

Participants **MUST** complete the pre-course workbooks prior to the study programme, in order to prepare for the sessions and the **theoretical assessment**. This comprises:

<table>
<thead>
<tr>
<th>Element</th>
<th>Completed (initial and date)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Completion of the IV Therapy / Infusion Device pre-course workbook and all the scenarios / action boxes</td>
</tr>
<tr>
<td>2</td>
<td>Completion of the calculations practice within this workbook</td>
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<tr>
<td>3</td>
<td>Completion of accountability workbook and specific scenarios</td>
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<tr>
<td>4</td>
<td>Contacted manager / CCET for any specific advice or support, prior to attending IV / ID programme, if need is identified</td>
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</table>
During the programme participants will complete competency based infusion device training for each infusion device used in their clinical area, please discuss this with your charge nurse, and thus be aware of the infusion device(s) you will require to use in your practice area (you can then be allocated to the appropriate workshop).

Participants who have NOT completed the pre-course preparation work (IV / Infusion Device and Accountability workbooks) will be asked to leave and rebook on another date.

In addition, participants should have:
- a clear grasp of all the topics covered in the programme
- accessed reference material and updated on IV and infusion device practice
- reflected on implications for their practice
- discussed their role with their manager and identified their designated mentor
- accepted the role/s and can identify opportunities for regular practice.

If you have any specific learning differences* which require further support to enable you to successfully complete this workbook and skills programme, please get in touch with CCET staff via extension 31596 (0131 537 1596) prior to starting work on the programme, so we can help make reasonable adjustments to meet these needs.

*Specific learning difference, e.g. dyslexia, here materials can be provided on coloured paper, larger or different font, etc, as per individual requested needs.

Numeracy support is available to staff, who have identified through the pre-course work a need for this. Please call CCET via extension 31596 (0131 537 1596) to arrange an appointment with a CCET Practitioner.

Completion of Theoretical Assessment

On the study programme you will undertake a written examination based on all the material within this workbook, the accountability workbook and the subject matter presentations / handouts. This written assessment is ‘open book’ and is invigilated; and you can use a calculator (to confirm calculations). Assessment is based on a pass / fail outcome.

Participants MUST NOT start supervised practice / competency assessment until they have received confirmation from CCET that they have successfully achieved the required pass mark for the theoretical assessment.

Theoretical assessment expected pass rates:
As it is an open book assessment and you have undertaken all the pre-course work, and participated in relevant workshops, you are expected to answer all the questions.

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<tr>
<th>Section</th>
<th>Expected pass mark</th>
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<tr>
<td>Accountability</td>
<td>100%</td>
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<tr>
<td>Calculations</td>
<td>100%</td>
</tr>
<tr>
<td>Infusion device aspects</td>
<td>100%</td>
</tr>
<tr>
<td>Infection Control</td>
<td>95%</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>80%</td>
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Assessment papers will be marked within 48 hours and the lead programme facilitator will input pass or fail onto NHS Lothian’s electronic staff record system.
Process for Marking Theoretical Assessment / Communicating Results

**Required pass % achieved** – your manager (course booker) will be sent an email informing them of your pass, then you and your manager (course booker) will get a letter (6-8 working days) and you will receive all relevant competencies, instructing that you may now commence your supervised practice.

**Required % for each section not achieved / fail** – your manager (course booker) will be sent an email and you and your manager will then get a letter (6-8 working days) asking you to contact the programme lead and discuss your exam, and then your manager can book you another IV / Infusion Device exam (CCET retain all exam papers).

**Resit exam paper achieve required %** - your manager will then be sent an email informing them of your pass, and you will both get a letter and you will get all relevant competencies (6-8 working days), instructing you that you can now commence supervised practice.

If it is clear you are having difficulty or, indeed, if you want further input - an appointment can be made with the CCET clinical skill trainer / practitioner to ensure you have full understanding of the calculations or other aspects, as required.

 Please remember that participants must NOT start supervised practice / competency assessment until they have received confirmation from CCET that they have successfully achieved the required pass for the theoretical assessment.

Supervised Practice and Competency Assessment Process

This may be commenced only:

- Once you have received confirmation of successful completion of the IV Therapy and infusion devices theoretical assessment
- Supervised practice should be commenced within 2 months of attendance (passed theory) of the IV and infusion devices study programme
- The assessment of competence should be achieved within 3 months of attendance at the IV and infusion devices study programme
- At least 4 supervised practices must be undertaken in each role you will undertake in your clinical area (i.e. IV bolus and/or IV additive to syringe/bag, McKinley T34, etc) before the final assessment of competence
- Areas of concern relating to competency achievement MUST be discussed first with your charge nurse / manager, and if necessary CCET staff.

Assessor of Competence:
Discuss the supervision process with your manager. A designated mentor (registered practitioner) must be identified by your manager, and must be competent and experienced in IV practice (IV bolus and / or IV additives) and infusion device(s) (specific to area of practice). Your final assessment of competence may be required to be completed with a registered senior IV and infusion device practitioner from within your clinical area.

Submission of Competency Documentation

Once the final assessment of competence has been achieved, the competency statement on each document must be completed in full by the participant, the designated mentor and the manager (e.g charge nurse / team lead).
• Once complete, your charge nurse / manager will record this on NHS Lothian’s electronic staff system, this will also include a 2 year alert
• You should keep the original competency document(s) in your personal portfolio / profile
• A photocopy should be given to your manager, forming evidence of learning for your personal development plan review (PDPR) and annual appraisal
• These can also form part of your CPD / PREP requirements (HPC 2008; NMC 2011).

Following the satisfactory completion of the programme, including competency assessment and ‘sign off’, you may assume an IV Therapy and infusion devices role within your ward / department.

Review of Competence

NHS Lothian standardised the clinical skills competency process and review of competence in 2010. All NHS Lothian’s clinical skills now require a formal 2 year review, and all the review competencies can be located and downloaded from the intranet.

NHS Lothian intranet front page > Training and Development links > Clinical Skills Pre-course Workbooks and Competencies

Due to the standards stipulated in the NMC Code (2008) and the Health Profession Council’s Standards of Conduct, Performance and Ethics (2008), individual practitioners are also required to review their competence on an ongoing basis. The HPC code (2008) stipulates registrants must make sure their knowledge, skills and performance are of good quality, up to date and relevant to the registrant’s scope of practice, and the standards for continuing professional development (CPD) require registrants to link their learning and development to their continued registration.

It is recommended that you discuss the role(s) at your annual performance and development review, and ensure that your personal development plan and supervision support the maintenance of these skills to meet the NMC requirements (NMC 2008). The updated PREP (NMC 2011) suggests, “you may find it helpful to routinely collect documentation from any learning activity you undertake such as appraisals, attendance or completion certificates”.

Section 2: Accountability and Legal Issues

Prior to completing this section of the education package, attendees must read and complete the generic Accountability Workbook and skill specific scenario(s). This is intended to give any registered practitioner, learning a new clinical skill, insight into their personal accountability and the concept of vicarious liability, and will ensure participants have the required knowledge to complete the theoretical assessment and proceed to supervised practice. Participants are expected to achieve a pass mark of 100% for the accountability section of the IV and infusion devices therapy theoretical assessment.

If you do not have the Accountability Workbook, this can be obtained from extension 31596 (0131 537 1596).

Whilst most medicine administrations / infusions in the UK are provided safely, mistakes do occur, often resulting in serious clinical incidents. The National Patient Safety Agency (NPSA 2009) reported the number of medication incidents rose to 86,065 in 2007 (up 20,000 from 2006), with incidents involving injectable medications accounting for 62% of all reported incidents leading to death or severe harm.

71% of these medication incidents resulted in fatal and serious harm, and were classified into three categories of error:
- Unclear / wrong dose or frequency
- Wrong medication
- Omitted / delayed medicines.

**Please remember:**
As a professional you are personally accountable for actions and omissions in your practice and must always be able to justify your actions / omissions (HPC 2008; NMC 2008).

**Accountability Scenarios**

Participants should read the following scenarios, and consider the questions asked, in preparation for the accountability session in the IV Therapy and infusion device programme.

**Action box 1**

**Scenario 1**
You have been asked by surgeon to draw up 40mls of Bupivicaine 0.5% to infiltrate Mr A’s wound following surgery. Mr A has a history of heart block.

1. What would you do in this situation?

2. Who is accountable if the medicine is given?

3. What procedure would you follow if you were unsure about a prescription?

4. If a practitioner is called to account for their actions in this scenario, what could they offer as a defence?

**Scenario 2**
Mrs Y is prescribed Amoxicillin 500mg IV as she is suffering from a chest infection and is having difficulty swallowing. You check and prepare the medicine as per NHS Lothian policy (e.g. red book) and proceed to give as a bolus. Later she complains of an upset stomach and diarrhoea.

1. Are you accountable?

2. If following the incident you check the prescription chart and find no entry in the allergies section — Who is accountable?
3. If you were asked to defend your actions in this case, what could you offer as a defence?

4. What actions would you take in this situation?

**Scenario 3**

Staff Nurse A returns from her IV Therapy course and while awaiting her results, is asked to prepare and administer an IV medicine as the ward is busy, and the only other registered nurse is a bank nurse.

Nurse A proceeds and uses the bank nurse as the witness.

1. Can Nurse A defend her actions?

2. What action should she have taken?

3. Who is accountable here?

4. What is the process for achieving competence in NHS Lothian (clinical skills)?

**Scenario 4**

Mr B refuses to have an IV injection, and you are unsure if he is aware of what he is saying because he is confused, due to an acute infection.

1. How would you proceed?
Section 3: Principles of Safe Practice in IV Therapy

This education programme has been designed to prepare registered practitioners for a role in the administration of IV Therapy: the administration of a prescribed medicine as an additive to an infusion bag / burette or syringe, or as an IV bolus injection. The next section will address principles of safe practice with the use of infusion devices.

Intravenous Therapy is the term used to describe the administration of sterile preparations of medicines / fluids directly into the venous circulation. This is most commonly achieved by bolus injection via an established peripheral venous access cannula / catheter (PVC), or by intermittent or continuous infusion.

IV Therapy is a shared role and thus local arrangements should be agreed to ensure patients receive therapy from the most appropriate registered practitioner.

All practitioners who are involved in IV Therapy are responsible for utilising and adhering to the principles and procedures identified in this educational programme and package (NHS Lothian 2012) and NHS Lothian policies and procedures (e.g. Parenteral Guide NHS Lothian version 4). The widespread use of IV Therapy can lead to complacency about the risks and may result in poor standards of practice, putting patients at risk of clinical harm (Scales 2008). Taxis and Barber (2003b) observed IV preparations and their administration, and detected 265 errors; with lack of knowledge and experience with medicines or equipment accounting for 79% of all errors. The IV role therefore requires knowledge and skills relating to pharmacology and hazards, e.g. anaphylaxis, the principles of infection control, medicine dosage calculations and accountability for the role. Each of these aspects is addressed within the educational programme.

Practitioners must at all times work within the standards required by their registering body, for example, the NMC Standards for Medicines Management (NMC 2010a), and their Code (HPC 2008; NMC 2008).
In addition, practitioners must understand and adhere to NHS Lothian’s Safe Use of Medicines Policy and Procedures (2011a), available on the staff Intranet at the webpage link given below. The policy stipulates best practice to protect patient safety and to provide practitioners with guidance on medicines preparation and administration.

NHS Lothian: Safe Use of Medicines Policy and Procedures 2011 is accessible via the intranet:


Principles of Best Practice Relating to IV Therapy,

Taken from NHS Lothian’s ‘Safe Use of Medicines Policy and Procedures’ (2011a):

- Medicines for injection that require complex calculation or manipulation to prepare, or that pose a health and safety risk during preparation, should be supplied in a ready to use form from the pharmacy
- Additional competencies are required for the administration and checking of intravenous medications, medicines administered via electronic (infusion) devices and doses requiring complex calculations
- Persons authorised to administer and check medicines must have sufficient knowledge of the medicine being administered and of the patient to whom the medicine is being administered, to be able to intervene in circumstances where administration is not appropriate
- Only registered doctors and nurses, who have successfully completed the NHS Lothian intravenous therapy training programme or equivalent, may prepare and administer intravenous injections. *Assessment of competence must be repeated every 3 years*
- It is generally recommended that intravenous medicines are prepared by two practitioners. Under exceptional circumstances when delay in administration may cause harm to the patient, preparation and administration should not be delayed by the absence of a second practitioner. Other local exceptions must be defined, documented and approved by the appropriate manager for the clinical area
- Student nurses / midwives and medical students may not administer or check intravenous medications, medicines administered via an infusion device and doses requiring complex calculations
- Administration of IV Therapy, medicines administered via electronic medical devices such as infusion pumps and syringe drivers or doses requiring complex calculations, must be checked by a second person authorised to administer the medicine, except in circumstances where it is not possible, for example, takes place in the patient’s home, or where it is not feasible for operational reasons, for example, in theatres
- Complex dose calculations must be carried out independently by two registered practitioners to check accuracy. A senior nurse, doctor or pharmacist must be contacted in cases of uncertainty. In calculations involving patient’s weight, the date of the weight measurement must be recorded
- The following procedure must be undertaken before administering an intravenous medicine. If a witness is required, *each step of the procedure must be witnessed*.
  - Read the prescription carefully
  - Check that the medicine is correct for the patient
  - Ascertain that the prescribed dose has not already been given
  - Select the medicines required and check the label against the prescription
  - Check the expiry date
  - Identify the patient by checking the name on the prescription against the name on the patient’s identity band, or ask the patient to state his or her name and date of birth (Page198).
- The person administering the intravenous medicine must sign the patient’s medicine administration recording chart
• Persons who witness administration are responsible for observing that administration has taken place.
• Injections prepared in the near patient area must be prepared immediately before administration. They must not be prepared or stored in the near patient area.
• Injections prepared in the near patient area must only be administered by those individuals who are either involved in the preparation, or who are able to check that the prepared medicine is correct.
• Medication incidents must be reported and investigated in order to ensure that the appropriate corrective action is taken, and to agree the appropriate preventive action to be taken to avoid recurrence.

For full policy, refer to Safe Use of Medicines Policies and Procedures (2011a).

In July 2011 the latest quality targets were published (NHS Lothian 2011c) and these now recommend, “Both nurses involved in IV administration to be IV competent”.

Please also check for any drug safety alerts or updates, these can be located on:
NHS Lothian intranet home page > Healthcare > A-Z > Drug Safety > Drug Safety Updates

In addition, the Royal College of Nursing’s “Standards for Infusion Therapy” (2010) 3rd ed, outlines best practice criteria:

• The practitioner should review the prescription for appropriateness for the patient’s age and condition, access device (e.g. cannula), dose, route of administration, and rate of administration.
• The practitioner administering medications and solutions should have knowledge of indications for therapy, side effects and potential adverse reaction and appropriate interventions particularly related to anaphylaxis.
• Prior to administration of medications and solutions the practitioner should appropriately label all containers, identify the patient; verify all contents, dose rate, route, expiry dates and integrity of solution.
• The practitioner is accountable for evaluating and monitoring the effectiveness of the prescribed therapy including; documenting patient response, adverse events and interventions; and achieving effective delivery of the prescribed therapy.
• The practitioner should report any adverse events to the MHRA (previously the Medicines Control Agency) via the Yellow Card system (www.yellowcard.gov.uk) and as per NHS Lothian policies and procedures.

Medication Errors / Patient Safety

The National Patient Safety Agency (NPSA 2007a) received 800 reports a month relating to injectable medicines (January 2005 to June 2006) and these represented 24% of the total reported medication related incidents. Of these 24%; 25 led to death and 28 led to serious harm, and whilst the majority resulted in low or no harm; practitioners must not be complacent. A further NPSA report noted 5 deaths and over 4,200 dose-related patient safety incidents concerning opioids (NPSA 2008).

The Scottish Patient Safety Programme (SPSP) was launched across Scotland in 2008 and aims to improve the safety and reliability of hospital care, through recognising the complexities involved in delivering modern healthcare and the need to standardise our approach to making care safer. One of the key workstreams of the SPSP relates to medicines management: preventing adverse drug events and preventing harm from high alert medications.
Brady et al (2009) cited medication errors as the most common type of error affecting the safety of patients, and as the most common single preventable cause of adverse events. Taxis and Barber (2003a) studied the incidence and severity of IV medication errors and found that 7% occurred during preparation, 36% during administration and 6% during both. Furthermore, most of the errors were associated with multiple step preparations, and typical errors included wrong dose or diluents with only a few errors occurring in identifying prescriptions.

The NPSA (2009) identified three incident types that accounted for medication errors:

**Prescribing and unclear prescription incidents**, e.g. medicine prescribed as .5mg, and as 0 missed in front of the decimal point, the patient received the wrong dose

**Administration and wrong medicine incidents**, e.g. Cefotaxime given not Cefuroxime

**Administration and omitted medicine incidents**, e.g. patient out of the ward and not recorded on chart correctly, therefore patient missed dose.

Vincent’s (2003) framework acknowledges that incidents often have multiple contributory factors; and thus organisations’ need to *learn* from these adverse events, not just investigate (Table 1).

<table>
<thead>
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<th>Table 1: Factors in clinical practice that contribute to patient safety</th>
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<tr>
<td><strong>Factors</strong></td>
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<td>Patient</td>
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<tr>
<td>Task / technology</td>
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<tr>
<td>Staff / individual</td>
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<td>Team</td>
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<td>Environment</td>
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<td>Organisation / management</td>
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<td>Context</td>
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Etchells et al (2008) reviewed medication errors and human factors, and advocated a system-centred approach which indicated that error is unavoidable, that processes can be designed to reduce the possibility of error and thus errors are detected and corrected before harm occurs.

Johnson et al (2011) recommended three key safety features relating to managing the risk of medication errors:

- Use of calling cards – left at patient bedside if out of ward, so they alert nurse on their return, thus patient does not miss their medication
- Checking of medication chart signatures at any handover – reduced risk of staff forgetting to sign for any medicine administration
- Wearing tabard / administration vest during medicines administration – reduce risk of interruption and distraction.

**In summary:** Crimlisk et al (2009) proposed practitioners must follow nine ‘rights’ to ensure risk free IV medicine administration:

- Right patient
- Right medication
- Right dose
- Right route
- Right time
- Right dilution / compatibility
• Right flow rate
• Right monitoring
• Right documentation.

Failing to follow these could lead to patient harm and litigation. One particular protocol often neglected is checking the patient’s identity wristband, and Jones (2009) cited a study where only 57% nurses stated they had checked the patient’s ID.

**Action box 2**
What steps could you take to ensure a dosage is correct before proceeding to give a prescribed dose of IV medication?

One area to focus your attention on would be the prescription chart and the standard of the prescription. Should you have questions about legibility, completeness, dosage, etc, you **must** seek advice from the prescribing doctor, or clinical pharmacists and senior colleagues. Also refer to the BNF, the Preparation and Administration of Parenteral Medicines (the red book; version 4) and NHS Lothian Safe Use of Medicines Policy and Procedures (NHS Lothian 2011a).

The second area to concentrate on is, your knowledge relating to medicines being given by the intravenous route, their interactions, side effects, modes of actions and appropriateness (refer to section 6 Pharmacy).

Ndosi and Newell (2008) stated pharmacology knowledge is essential for nurses as they administer the majority of medicines, and in a typical NHS hospital approx 7,000 medicine doses are administered daily, as well as changes in medicine regimes or new medications. Also significant, is an increasingly older population with co-morbidities and associated multiple medication requirements. In Ndosi and Newell’s (2008) study, they found only 26% of nurses’ demonstrated adequate knowledge of medicine interactions and mechanisms of action; the remaining 74% had insufficient knowledge.

It is your responsibility to ensure you seek advice and further information regarding medicines specific to your area of practice. It is expected that practitioners complete an approved competency based education programme relating to their field of practice and also be familiar with the medicines and policies (RCN 2010).

**Action box 3**
Ask colleagues what IV medications are commonly prepared in your area? Locate ‘The Preparation and Administration of Parenteral Medicines version 4’ (‘Red Book’) and familiarise yourself with the commonly used medications.

You can check dosages with the prescriber, other staff, BNF / MIMMS, local policies or procedures, pharmacy or intranet / internet. If you are still unsure then do not proceed, informing both medical and nursing staff of your actions.

**Practical IV Considerations**
Environment

IV medications for peripheral vascular cannula / catheter (PVC) or administration through an infusion device must be prepared in an area with adequate lighting and ventilation. Preparation surfaces should be cleaned with mild detergent and water, rinsed and left to dry. Surfaces should be free from clutter and with enough space and light to work. Ideally, prepare IV medications in an area free from distractions (CRAG 2002).

Checking

According to the NHS Lothian Safe Use of Medicines Policy (2011a) administration involving IV Therapy must be checked by a second person authorised to administer the medicine, and since 2011, both practitioners must be IV trained (NHS Lothian Quality Targets 2011c). It is only in exceptional circumstances, where a risk assessment has been undertaken and procedures put in place to minimise risks, that an authorised checker may not be required.

Preparation Technique

Firstly, check that the medication does not come in a ready to use form, as this is obviously the safest option. If it does not, then consideration must be given to your safety and that of your patient during the preparation stage, in accordance with NHS Lothian Policies. The Infection Control Manual (NHS Lothian 2010a) highlights the issue of Occupational Exposure Procedures and recommends:

- All cuts and abrasions must be covered with waterproof dressings
- Hand hygiene should be followed as per infection control guidelines
- Gloves should be used when handling sharps and though won’t prevent you from sustaining a needle stick injury, will wipe the outer surface of the needle and thereby reduce the amount of blood transferred
- Aprons should be used when dealing with patients with breaks in skin, wounds or dressings and with aerosol generating procedures
- Needles should not be re-sheathed. (Also refer to Working with Bloodborne Viruses Strategic Policy (NHS Lothian 2010b)).

The checking technique should ensure that the medicine ampoule / vial is undamaged and has been stored correctly, i.e. in original packaging, at the correct temperature and it is within date. Please note if medicines are stored outwith their original packaging, they are no longer covered under their product license.

Follow NHS Lothian policies: Preparation and Administration of Parenteral Medicines (NHS Lothian version 4) and Infection Control Policy Manual (NHS Lothian 2010a) when cleansing, and using an aseptic non-touch technique (ANTT) is essential (Ingram and Murdoch 2009):

- Commence the procedure following hand hygiene and ensure all equipment is intact and in date and sterile
- The tops of ampoules / vials and the insertion points of bags of fluids should be cleaned with 2% Chlorhexidine / 70% Isopropyl swabs (or alcohol swabs if these are unavailable) for 30 seconds and then left to dry for 30 seconds to allow the drying process to assist with the decontamination process (Separate swabs should be used for each surface contact)
- Clean / disposable trays should be used to collect equipment and needles and syringes should be opened using the peel open section of the outer cover. The package should be checked to make sure the equipment, like the medication, is in date and intact.
Additional information to support preparation technique:

- Each syringe should be checked to ensure there are no cracks or flaws in the casing
- The inner surface area of the plunger should not be touched on aspirating fluids as this may lead to contamination and increases the potential for infection when the plunger is then depressed into the syringe barrel to expel the contents
- Care should be taken not to scrape needle tips off the base of glass vials and ampoules as this blunts the needle tip
- Blunt ended needles should be considered, as recommended by infection control, to minimise needle stick injuries. Filter needles should be considered when using glass ampoules or if there is a risk of rubber particulates (Ingram and Murdoch 2009)
- Rubber particulate is minimised if a needle is introduced at a 45 degree angle into a rubber topped vial, or by use of a filter needle
- Mixing diluents with powder is best achieved using the “push pull” method. This method allows equalisation of pressure in the syringe and vial. If assistance is required to dissolve the powder, the needle should be retained in the vial. The vial, in the upright position, should then have the needle withdrawn until the tip sits above the fluid level. The syringe plunger should then be released. The air will fill the syringe until the pressure within the two is equal. When this happens, the vial with needle inside should be gently rotated together, by hand, until the powder dissolved. The needle is removed from the vial only when the diluent and powder are completely dissolved and drawn into the syringe. A fresh, capped needle or a sterile blind hub is then applied, to remove air from syringe, before priming the line, thus minimising aerosol spray
- When priming syringes to clear air bubbles, the syringes should be tapped gently with knuckles and not banged on hard surfaces as this creates cracks, weakens the casing and is a potential infection source and siphonage risk
- The risk of rubber particulate and infection by contamination is increased if the same needle is removed and then reinserted prior to withdrawing the dissolved powder. This should therefore be discouraged.

Medication Expiry Dates and Stability

There should be as short a duration as possible between the moment the medication has been reconstituted / drawn up and completion of administration. The Preparation and Administration of Parenteral Medicines Policy (NHS Lothian Version 4) suggests a maximum of 24 hours unless a risk assessment is carried out; however the stability of medications differs and must be checked on each monograph. CRAG (2002) guidelines suggest, where possible, this is reduced to 12 hours. Please note also that it is the batch number on the actual vial / ampoule, not the outer packaging which should be recorded.

Labelling

It is important that all preparations are labelled with the patient’s name, the medicine’s brand and generic name, the strength (amount per unit volume), total amount in volume, route of administration, dosage, time of preparation and expiry time, and any warning messages (DH 2004).

How and where to attach the label should be considered: care should be taken not to occlude the syringe markings which will be required to check medications, once attached to the syringe pump. (Also consider this when labelling bags, take care not to cover bag information, e.g. expiry date.) Additionally, if the label is folded when attached, care should be taken so that the ‘syringe barrel size recognising clamp’ is not affected as this could interfere with the rate of the pump and is a risk. “Flags” are an ingenious way of allowing labels to be attached to the syringe, whilst allowing the syringe markings to be viewed at all times and prevent any risk of interference with the syringe barrel clamps (Millar et al 2005).
Flushing

Sodium Chloride 0.9% is used to flush PVCs in most cases. There are a few medications, e.g Amphotericin, which are not compatible with Sodium Chloride 0.9%; in this case Glucose 5% would be used. Refer to The Preparation and Administration of Parenteral Medicines Policy (NHS Lothian Version 4) to check the compatibility of infusion fluids.

The Safe Use of Medicines Policy (2011a, p152) states that the Sodium Chloride 0.9% flush solution, used before and after IV injections, does not need to be prescribed. This, however, does not mean that the method of preparing the flush, the administration of the flush and personal accountability in the whole procedure is any less important than the medication(s) the flush supports.

PVCs can be “straight” (no wings or ports), “winged” or ported and winged. Flushing through a port should not be considered. The injection port on PVCs should only be used at the time of insertion or in an emergency situation; the integral port is difficult to keep clean and provides a reservoir for bacterial growth (Scales 2008; RCN 2010). A needleless ‘closed system’ is therefore recommended to reduce risks of contamination.

Potential risks with flushing:
- infection during the preparation and administration stages if infection control measures (ANTT) are not adhered to
- confusing the flush for the medicine if the flush is not identified, with serious consequences to the patient
- damage to the venous system if the correct flush technique is not adhered to
- medicine incompatibility / reactions if the flush is not administered in the correct sequence.

The rate of flush:
The flush should be administered at the same rate as the medicine to ensure that the infusing medication, e.g. Dobutamine which requires a slow rate, is not bolused through at a faster rate than is safe (Nicol and Casey 2008).

When to flush:
Flushing with 0.9% Sodium Chloride solution to ensure and maintain patency and to prevent mixing of incompatible medications should be performed before, between and after the administration of medications and/or solutions, and the volume of the flush should be equal to at least twice the volume of the catheter and any add-on devices – usually 5 to 10ml (RCN 2010).

For PVC’s which are not being used regularly but are still required, frequency of flushing should be daily, to promote and maintain patency (RCN 2010).

Flushing technique (RCN 2010):
- Using less than a 10 ml syringe can generate an increased amount of pressure and thus could lead to damage to the vein. It is recommended that a 10 ml syringe or larger is used to flush the line
- A pulsating push-pause, positive pressure method should be used
- The pulsating flush creates turbulence within the catheter lumen, removing debris from the internal catheter wall
- Positive pressure within the lumen of the catheter should be maintained to prevent reflux of blood
- If during flushing, resistance is felt, do not continue as this may dislodge a clot at the end of the PVC.
Flushed should not be attempted if:
- The patient reports pain or discomfort
- There are signs of catheter dislodgement, swelling, fluid leak
- There are signs of local infection – redness, increased temperature at site, exudate or pus around the PVC insertion or swelling.

Peripheral Vascular Catheters Care Bundles will help with your clinical decision about the device, flush and continued use of the catheter (refer to infection control section).

Prior to making up IV medications, always ensure there is a patent cannula in situ, as delays in administering IV medicines are often caused by a lack of indwelling cannula (Brady et al 2009).

**Needle Free / Needleless Systems**

The use of needle free systems or ‘add-ons’ on PVCs helps prevent risk of blood contact when infusion lines are disconnected.

The needle free system used in NHS Lothian is Smartsite (see photograph of a double lumen needleless system).

When using needleless closed systems:
- clean with 2% Chlorhexidine / 70% Isopropyl swabs (or alcohol swabs if these are unavailable) for 30 seconds
- check the valve is intact, with no indentations
- allow to dry for 30 seconds
- insert and quarter turn the syringe (to ensure secure)
- inject flush or medicine at the designated, controlled rate (refer to NHS Lothian Parenteral Guidelines, Version 4).

The risk of phlebitis is minimised with an ‘extension set’ (as part of the closed system), as this removes manipulations at proximity to the cannula, thus reducing the risk of contamination. The flexibility of the extension set absorbs any movement without dragging on the less flexible cannula (Finlay 2008).

**Route of Administration: Bolus, Intermittent and Continuous Infusion**

The IV injection route is more hazardous than other routes of medicine administration (see pharmacy section) and should be prescribed only if no other route is suitable, for example:
- the medicine is not available for administration by another route, and there is no therapeutically equivalent medicine that could be used by another route
- the oral, naso-gastric, rectal or other possible route is not suitable due to the clinical condition of the patient
- the medicine needs to be administered by injection to achieve immediate effect, or the required therapeutic level (NHS Lothian 2011a).

IV infusions must be reviewed regularly and discontinued as soon as the patient’s condition allows, areas should have a ‘step down’ policy for changing IV medication from IV to oral. The Safe Use of Medicines Policy (2011a) indicates review of an IV prescription every 24 hours, thus change to less hazardous route as soon as suitable.
### Table 2: IV Medication Routes: Bolus, Intermittent Infusion and Continuous Infusion

<table>
<thead>
<tr>
<th>Rationale for Route</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| **Bolus injection** | • Quick response required  
• High blood concentration required  
• Patient is fluid overloaded  
• Medicine is not chemically stable in a solution  
• Anaphylaxis / anaphylactoid reactions  
• Speedshock  
• Infiltration / extravasation  
• Phlebitis |
| **Intermittent infusion** | • High blood concentration required  
• Patient is fluid overloaded  
• Medicine not chemically stable for continuous route, e.g. Benzylpenicillin  
• Reduces risk of adverse reactions, e.g. bolus antibiotics  
• Anaphylaxis / anaphylactoid reactions  
• Infiltration / extravasation  
• Phlebitis  
• Fluid overload  
• Medicine error – rate too fast or slow |
| **Continuous infusion** | • Constant blood level required  
• Constant effect required  
• As above  
• Incorrect rate - overdose |

(Adapted from Ingram and Lavery, 2005)

In the event that no other route is suitable, the bolus route is considered more convenient for the patient, wherever possible, than the infusion route (NHS Lothian 2011a), due to the fact that there is no need for infusion lines and infusion devices to administer the dose, therefore allowing freedom of movement. (NB any infusion fluid should be prescribed too). Additionally, the bolus injection is given over a short time frame therefore, and providing infection control mechanisms are used at the interface between the patient and administrator, the risk of infection is minimised compared to that of intermittent infusion.

The individual patient’s condition is central to the decision regarding the route of administration; The Preparation and Administration of Parenteral Medications (NHS Lothian Version 4) gives the advice required to determine the route for individual patients and infusions, and to safely prepare and administer medications. This guidance should be referred to before preparing any medication (Table 2 offers rationale for route choice).

Remember that infusion devices are not needed for every infusion; some infusions involving medications can be administered via gravity; each patient/infusion should be assessed for suitability, and only use an infusion device when precise flow rates are essential (NHS Lothian version 4). Advice is given in the ‘Red Book’ (NHS Lothian version 4) for the medicines that must be given via an infusion device; staff should also check for local policies/protocols. Practitioners are reminded that they will require competence-based training in the use of infusion devices.

**Administration Lines – Labelling and Changing**

If an infusion is being established, it is good practice to label the line with the date and time the infusion was started.

**When to change lines:**

If infusing continuously, administration lines should be changed at the following periods (Refer to Table 3):
Table 3: When to Change IV Lines

<table>
<thead>
<tr>
<th>Crystalloids (no added medication)</th>
<th>Every 72 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication</td>
<td>Every 24 hours</td>
</tr>
<tr>
<td>Blood administration sets</td>
<td>Every 12 hours or once the transfusion (or unit if there is to be a break) is complete</td>
</tr>
</tbody>
</table>

In all cases, lines must be changed with adherence to antimicrobial instructions.

Infusion Charts

There are several versions of infusion charts used across NHS Lothian at present; only approved NHS Lothian versions should be used, unless specialised for a particular service area. It is practitioners’ responsibility to ensure that they familiarise themselves with the chart in use in their area, in order to use the chart effectively.

Staff must adhere to the NHS Lothian Clinical Documentation Standards (2010c), which sets out the standards which all clinicians should apply when making any entry in clinical health records. Reference should also be made to the NMC standards for Record Keeping (2010b). NHS Lothian’s Safe Use of Medicines Policy and Procedures (2011a) also states standards for the use of supplementary and recording charts.

Minimum information required on charts includes:
- Patient details: name, date of birth, CHI number
- Name, dose (and concentration) of medication
- Required frequency of monitoring, administration times etc
- Name, expiry date, batch numbers of medications may also be required.

Action box 4
Find out which infusion chart(s) are used in your area; familiarise yourself with the chart and its use.

Other Related Aspects

Patient Information
- You must listen to the people in your care and respond to their concerns and preferences
- You must ensure people are informed about how and why information is shared by those who will be providing their care
- You must make arrangements to meet people’s language / communication needs
- You must share with people, in a way they can understand, the information they want or need to know about their health (HPC 2008; NMC 2008).

First Dose
All the medicines included in the Red Book (NHS Lothian Version 4) may be administered as a first dose by registered practitioners who have successfully completed the IV Therapy / Infusion Devices programme.

Allergies
The patient’s identification must be checked via the records, prescription chart, and ID bracelet and verbally with the patient, to ensure any known allergies are identified and recorded. This is part of the two practitioner preparation and administration procedure.
Preparation of Injections in Patient Areas (CRAG 2002)
This is the NHS Lothian procedure for preparing bolus and IV additive medications, which will be demonstrated during the workshops on the IV/infusion device programme. All departments received this poster via pharmacy.

Section 4: Principles of Safe Practice Using Infusion Devices

Infusion devices are used frequently within the acute and community setting and to meet the demands of advancing health care, infusion devices such as volumetric and syringe pumps are becoming more technically complex. To ensure that more complicated equipment do not result in higher risk of adverse incidents; training needs to ensure that practitioners are competent and confident in the use of these devices (Quinn 2000).

The Medicines and Healthcare products Regulatory Agency (MHRA) is a UK-wide government agency responsible for ensuring that medicines and medical devices meet appropriate standards of safety, quality, performance and effectiveness (MHRA 2006).

The MHRA recognises that no device is risk-free, however, their role is to identify and publicise problems and ensure that action is taken to protect the public from repeated adverse incidents. Recommendations are made to manage devices effectively, including processes for acquiring new equipment, maintenance and repair, and ensuring that all users are trained appropriately. Professionals in healthcare are personally accountable for their use of devices and must therefore ensure they have had appropriate training (MHRA 2008). The MHRA (2008) recommends the following checklist to ensure that practitioners use infusion devices safely.

Before use: assessment
- What are the patient’s or clients clinical and social needs?
- Which of the infusion devices available best meets those needs?
- Has a risk assessment been undertaken? Are the risks associated with this device acceptable and can they be minimised?
- If the device has been bought privately is the patient or client aware of their personal responsibility?
- If the infusion device is to be used by patients and / or carers, have the following been taken into account:
  1. Physical capabilities – e.g. manual dexterity
  2. Sensory capabilities – e.g. vision, hearing ability to understand and remember
  3. Previous experience with the infusion device
  4. The patient’s or client’s expectations
  5. The environment in which the device will be used.

Before use: knowledge of device
- Is the device to be used in the way intended by the manufacturer?
- What are the limitations and contra-indications for use?
- Has the device been maintained in line with the manufacturer’s instructions?
- Has the device been checked/calibrated after maintenance?
- Is the device within its expiry or use-by date?
- Who is able to carry out pre-use checks?
- Are there any signs of wear, damage or faults?
- Where can a replacement device be obtained?
Ask yourself:
- Do I know how to set up and use this device?
- Have I read the user instructions, and are they attached to the device (if this is possible)?
- Have I been trained in its use?
- How was my competency in relation to this device assessed?
- Do I know how this device should perform and the monitoring that needs to be done to check its performance?
- Am I using the correct additional equipment, e.g. disposable infusion sets for an infusion pump?
- Do I know how to recognise whether the device has failed?
- Do I know what to do if the device fails?
- Do I know how and to whom to report a device-related adverse incident?
- Has the device been modified, if so, has liability been checked with the manufacturer?

During use
- Does checking the medical device indicate it is functioning correctly and to the manufacturer’s specifications?
- What action should be taken if the device is not functioning properly?
- Has this been documented?
- Is there up-to-date documentation to record regular checking of the device?
- Have I documented the details (name / serial number) of the device being used?
- Is the equipment still appropriate for the patient or client’s changing needs?

After use
- What cleaning and / or decontamination is required?
- Does the infusion device show any signs of wear, damage or faults that should be reported?
- Is any servicing, maintenance or repair required?
- Were there any problems in using this device which should be noted and could be rectified for the future? - e.g. was any information missing from the patient / carer guidance which would have been useful?
- If used in the home, how will the medical device be returned to the owner, disposed of, or safely stored?
Table 4: Further Guidance from MHRA (2010) Specific to Infusion Devices include:

<table>
<thead>
<tr>
<th>Action required by infusion device users: When?</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before use</strong></td>
<td>Check that leads, administration sets, bags and cassettes or syringes are in good working order and properly assembled / loaded. Carry out relevant functional and calibration checks (start-up checks). Note results. Check control settings. Check that correct flow rate has been set.</td>
</tr>
<tr>
<td><strong>A problem occurs</strong></td>
<td>Stop the infusion. Make sure that all clamps on the giving sets are closed. Seek technical advice. Record problems and action taken. If necessary, withdraw the device from service.</td>
</tr>
<tr>
<td><strong>At specified intervals</strong></td>
<td>Check that the observed flow rate corresponds to the rate displayed on the infusion pump. Inspect infusion site. Note results. If checks fail, withdraw the device from service if necessary.</td>
</tr>
<tr>
<td><strong>After use</strong></td>
<td>Clean as recommended by the manufacturer. Safely dispose of single-use devices and other accessories that cannot be reused.</td>
</tr>
<tr>
<td><strong>When sending an infusion system to be repaired or serviced</strong></td>
<td>Include all the leads and accessories needed to operate the device. Enclose a full account of any problems and faults. Decontaminate / Fill in decontamination form.</td>
</tr>
<tr>
<td><strong>When an infusion device has undergone service</strong></td>
<td>Carry out all standard pre-use inspections. Check the set-up of protocols and programs, as these may have been altered during servicing.</td>
</tr>
<tr>
<td><strong>When an adverse incident has occurred</strong></td>
<td>First take steps necessary for the well being of the patient and/or staff, then: Do not alter settings or remove administration sets. Leave any fluids in the infusion system if possible. Note details of all medical equipment attached to the patient. Note details of device: type, make, model / serial number. Retain packaging for details of consumables. Note setting of controls and limits of alarms. Note the content volume remaining in the bag, container, set or syringe. If relevant, record the contents of computer memory logs of the infusion pump. Seek the assistance of the medical physics department.</td>
</tr>
</tbody>
</table>
Action Box 5
Take some time to reflect on the requirements from the NMC/HPC and MHRA. Do you have these skills at present?
Would being ‘shown’ how to use a device by another nurse on the ward be sufficient training to meet these requirements? Explain your answer.

NHS Lothian Infusion Devices: Volumetric Pump and Syringe Pump

Devices used for the Delivery of Intravenous Medications / Fluid

Volumetric pump (e.g. Alaris Signature, B Braun Infusomat Space, Graseby 500) – for the delivery of intravenous medications and they are the preferred choice for medium and high flow rates and large volumes (MHRA 2010).

All volumetric pumps require the use of a dedicated administration set, thus the fluid is pumped accurately, whilst retaining a sterile fluid pathway to the patient (Morling 1998). Users must always follow the pump manufacturer’s recommendations when selecting an administration set, while the medicine / fluid will be contained within a bag, bottle or burette. The user sets the infusion rate and a volume to be infused (VTBI), which will be displayed on the main screen. The pump will also measure the volume that has been infused to the patient (remember to clear the volume prior to commencing the infusion to get an accurate record of individual infusion episodes) and tells the user the volume left to infuse. All volumetric pumps are fitted with an air-in-line detector, as even if there appears to be no air in the line the pumping action can often draw air out of solutions, furthermore if there is a leak upstream air can be drawn into the line (MHRA 2010).

These devices infuse by employing a linear peristaltic pumping mechanism applied to the infusion tubing or use a special cassette within the set (MHRA 2010). Therefore, regular visual checks of the infusion site are essential, and must be documented.

It is important that users also check that the fluid level in the bag / bottle or burette is decreasing as it infuses, as the pump measures the pumping action and not actual flow.

Each device will have a variety of alarms, e.g. air in the line, upstream and downstream occlusion and also when the infusion is completed. When the line is removed from the pump it has a mechanism to clamp the line, known as an anti-free flow device. This ensures patient safety and prevents uncontrolled flow of fluid to the patient. Where there is a roller clamp this should also be used.

Each device will have a variety of alarms and it is important that you understand the different types and be able to troubleshoot alarms.

Most volumetric pumps have the following features:
- automatic alarm and shut-down: this is triggered if air enters the system, an occlusion is detected or the reservoir or bag is empty
- pre-set control of the total volume to be infused and digital read-out of volume infused
- automatic switching to keep the vein open (KVO) rate at the end of infusion
- automatic switch to internal battery operation if the mains supply fails. Battery power can also be used if no mains power is available e.g. during transportation.
Additional features can include:
- micro and macro delivery modes
- computer interface
- operator call alarm
- a drop sensor – used for monitoring and alarm purposes (such as an empty container) rather than as a control of the delivery rate
- primary and secondary (‘piggyback’) infusion capability
- technical memory log for incident analysis – some can record the settings and alarms for operations over the past two days or a thousand data points
- set based anti free-flow mechanism (MHRA 2010).

This pump exerts pressure, if required, to deliver the infusion which can be a potential risk to the patient, e.g. infiltration or extravasation. Therefore, regular visual checks of the infusion site are essential, and should be documented.

Table 5: recommendations – volumetric pumps

<table>
<thead>
<tr>
<th>Recommendations for the use of administration sets for volumetric pumps:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always use the administration set recommended by the infusion pump manufacturer</td>
</tr>
<tr>
<td>Check the administration set is compatible with the infusion pump</td>
</tr>
<tr>
<td>Always check the administration set for damage before priming the line</td>
</tr>
<tr>
<td>Inspect the drop chamber to check that the drip rate matches the expected rate both after loading the administration set and during the infusion</td>
</tr>
<tr>
<td>Check – does the administration set have an anti-free flow clamp</td>
</tr>
<tr>
<td>Even if the administration set has an anti-free flow device, always use the roller clamp to occlude the line when removing from the administration set</td>
</tr>
<tr>
<td>To maintain delivery accuracy and minimise the risk of infection, change giving set as appropriate</td>
</tr>
</tbody>
</table>

Adapted from Morling (1998), MHRA (2010).

Devices used for the Delivery of Intravenous Medications

Syringe Pump (e.g. Graseby 3000 series, Alaris Asena GH, Asena GS) – for the delivery of intravenous medications.

These pumps are the preferred choice for lower volume and low flow rate infusions.

This equipment uses a syringe and administration line to administer medication at a prescribed rate; the user sets the required rate in ml per hour. Syringe pumps work by pushing the plunger of a disposable syringe along at a pre-determined rate thus ensuring the correct infusion delivery (MHRA 2010). The volume infused will either be displayed on the main screen (Alaris Asena) or can be accessed by pressing the display button (Graseby 3000 series), the amount of fluid remaining in the syringe should also be visually checked, as it is the pumping action that the device records as the ‘volume infused’, not the actual fluid delivery to the patient. A volume to be infused can also be set on the Alaris Asena.

There is no air-in line detector with these machines; therefore care must be taken when priming the lines to ensure there is no air in the line.

Each device will have a variety of alarms and it is important that you understand the different types and be able to troubleshoot alarms.

As above the pump exerts pressure, if required, to deliver the infusion which can be a potential risk to the patient, e.g. infiltration or extravasation. Therefore, regular visual checks of the infusion site are essential, and should be documented.
When the syringe is removed from the pump at any time the line clamp should be used to prevent inadvertent administration of medicine to the patient.

The Line used for Graseby 3000 series and Alaris Asena GH and Alaris Asena GS is the Wescott Sae-flo MD Luer-lock tubing with an anti-siphon valve and clamp.

**Table 6: Recommendations – Infusion Pumps**

<table>
<thead>
<tr>
<th>Recommendations on the use of syringes in infusion pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always confirm that the syringe size and brand to be used matches those displayed by the pump</td>
</tr>
<tr>
<td>Check that the syringe barrel clamp is secured over the syringe barrel</td>
</tr>
<tr>
<td>Confirm that the syringe plunger clamp is correctly secured</td>
</tr>
<tr>
<td>Ensure the syringe finger grips are secure within the recess located on the pump body</td>
</tr>
<tr>
<td>Before use inspect all disposables for any damage</td>
</tr>
<tr>
<td>Position the pump at the height of or below the infusion site</td>
</tr>
<tr>
<td>Use the prime or purge facility on the pump to reduce start up delays, never prime or purge the line with the extension set attached to the patient</td>
</tr>
</tbody>
</table>

*Adapted from Morling (1998), MHRA (2010).*

**Devices Used for the Delivery of Subcutaneous Medications**

**Syringe Pump** (CME McKinley T34)

The CME McKinley T34 syringe pump is used within Lothian to administer continuous subcutaneous infusions of medications to manage pain, nausea / vomiting and other symptoms in palliative care. The knowledge and skills underpinning competent practice in the use of the CME McKinley T34 relate to the technical operation of this device, the administration of medications for symptom management and the palliative care of the patient and their family / carers.

The CME McKinley T34 is configured to infuse the contents of a syringe over a 24 hour period. A new syringe should be made up each 24 hours. A plunger mechanism, the same as on the other syringe pumps, is used to push the plunger which subsequently then means the medication is delivered. Rate is calculated in mls / hr calculated by the pump using the syringe volume and infusion duration.

A specific Infusion line is to be used with the McKinley T34 syringe pump. This is labelled ‘100cm infusion line with anti-syphon valve for use with CME-McKinley T34 for subcutaneous infusions’. The line includes an anti-syphon valve (blue, at the patient-end of line) to help prevent free flow due to gravity. **There is not a clamp on this line.**

**Devices used for the Delivery of Intravenous Patient Controlled Analgesia**

**Syringe Pump** (Graseby Omnifuse PCA).

Patient Controlled Analgesia is a method by which the patient self-administers a prescribed dose of intravenous opioids, using a handset connected to a pre-programmed and designated Graseby Omnifuse device. The PCA is programmed to deliver a pre-set IV dose when the button on the handset is pressed. Following administration the pump shuts down for a set period. This lock out period allows time for the opioid to start working. If the patient presses the button during the lock out period the pump will not respond (Chumbley and Mountford 2010).

This form of analgesia is primarily used to control acute post-operative pain and episodes of uncontrolled pain. The PCA enables the patient to administer their own analgesia, but nurses must
provide the same level of care to patients using PCA as patients receiving analgesia by other means (Chumbley and Mountford 2010).

All staff that have been trained on this pump should be able to set up the pump and check that all values have been correctly entered. Setting up the pump and the changing of values should always be performed by 2 trained staff.

The anaesthetist will select patients for PCA pre-operatively. The nurse specialists or ward nursing / recovery staff will explain the principles of PCA and how to use it. The opportunity for the patient to familiarise themselves with the handset should ideally be given if possible. A PCA information booklet may be given at Pre-assessment clinic and the opportunity to ask questions allowed.

The Line used for Graseby Omnifuse PCA is the Wescott Sae-flo MD with Y connector and antireflux valve, luer-lock tubing with an anti-siphon valve and clamp.

**Programming options**

PCA pumps can be programmed by clinical staff in different ways. Options include:

- loading dose
- continuous infusion (basal rate)
- continuous infusion with bolus on demand
- bolus on demand only, with choice of units (ml or µg/ml, etc)
- variable lockout time
- drug concentration.

Once programmed, a key or software code is needed to access control of the pump (MHRA 2010).

Patients are given no access to change parameters.

**Syringe size/type for use in the syringe pumps, see picture 1.**

Although different sizes of syringe fit into the devices; to ensure safe infusion delivery, the machine **must recognise the syringe size and make correctly.**

![Syringe comparison](image)

**Picture 1**
The picture above illustrates the difference in barrel diameter between two different 50ml syringes available in NHS Lothian.

**Action Box 6**
List all the risks involved in using a luer slip rather than a luer lock syringe when infusing medications to patients.
Medical Physics have configured all NHS Lothian syringe pumps to use only one make of syringe: **BD Plastipak luer lock**.

If you put a BBraun luer slip syringe into a syringe pump that is expecting a BD plastipak syringe, then the device will not recognise the correct syringe size and the infusion rate will increase by about 10%. The plunger will drive at a different rate and may cause an adverse incident, e.g. over-infusion of medication to the patient.

BD Plastipak luer lock are the ONLY syringes that should be used with syringe pumps – if you do not have a BD plastipak luer lock syringe in stock, you should seek one from another area – **do not set up the infusion until you have the correct syringe**.

Setting up a device with the incorrect syringe is a clinical risk and constitutes an adverse incident (potential medication error).

**Setting up, Monitoring and Documenting an Infusion**

When setting up and monitoring any type of infusion device there are some basic principles that apply (Table 7).
<table>
<thead>
<tr>
<th>Principle</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>The user must be competent in the use of the device</td>
<td>Attended IV / infusion device programme, successfully completed the IV / infusion device exam and completed supervised clinical competencies</td>
</tr>
<tr>
<td>Consider whether the infusion could be run as a gravity infusion. (This is not relevant for subcutaneous infusions).</td>
<td>Check NHS Lothian’s The preparation and administration of parenteral medicines, (version 4) whether the medicine you are infusing must be administered via a device or whether it can be run via a gravity administration set, “Only use infusion pumps when precise flow rates are essential otherwise use a gravity administration device for infusions”. Consider the needs of your patient, and whether you are competent in the skill of gravity infusions.</td>
</tr>
<tr>
<td>The device should be fit for use / purpose.</td>
<td>Is it clean, has it been serviced within the last year, are there any obvious defects, is the battery adequately charged?</td>
</tr>
<tr>
<td>Ensure the device is plugged into a mains socket (whenever possible).</td>
<td>Use a device on the mains rather than the battery within clinical areas to minimise the risk of low battery if pump then needs to be used on battery out with clinical area.</td>
</tr>
<tr>
<td>Select the appropriate administration line and for syringe pumps also the correct syringe type.</td>
<td>You may have access to several different administration lines, thus it is important that you choose the correct line for the device and also relevant for the purpose of the infusion (e.g. blood giving line). You should use the simplest option for your purpose, as there is cost and risk implications if inappropriate sets are used (e.g. a line with multiple access ports for a simple intermittent infusion of an antibiotic).</td>
</tr>
<tr>
<td>Ensure the administration line is carefully primed and giving set/syringe is properly fitted into the device.</td>
<td>When manually priming the line, check for and deal with air bubbles to reduce risk of air embolus. Some infusion pumps have a purge facility for priming lines, if this is available this should be used following manual priming, prior to connection to the patient, as this helps to reduce start-up time.</td>
</tr>
<tr>
<td>For infusion pumps check that the pump has recognised the correct type &amp; size of syringe.</td>
<td>If the infusion pump registers the incorrect syringe type or size you must not use the infusion device. Take the device out of service and report to medical physics.</td>
</tr>
<tr>
<td>The infusion rate on the device should be checked by 2 nurses*.</td>
<td>When setting the infusion rate on the device, read the prescription and calculate the flow rate; 2 nurses should do this independently. Check that you have the same answer and that you are both confident that this is correct. Set the rate on the device, then prior to pressing the start button ask the 2nd nurse to tell you what rate you have set (do not prompt the answer). Before starting the infusion, record details of the volume in the container to be infused (after priming/purging), the infusion rate - read from the device, and ensure that the device’s totaliser is set at zero. ALWAYS check the rate for a final time before pressing the ‘start’ button.</td>
</tr>
<tr>
<td>Record the serial number and type of model of the device being used on the infusion chart.</td>
<td>To aid in the investigation of incidents.</td>
</tr>
</tbody>
</table>

*NHS Lothian policy is that 2 nurses must check the rate prior to commencing an infusion through an infusion device, and also at any rate change.

Roughly 35 – 60% of all harmful medication errors can be directly related to the use of an infusion device. This is often attributed to single nurse checks during critical situations (Hursch et al/2005).
Action Box 7
List 3 factors/circumstances which you think may contribute to errors made when using an infusion device. Also consider how you could help reduce the risk of making an error by dealing with these factors?

Monitoring and Documenting the Infusion

Keeping good records is an integral part of professional practice and is essential to the provision of safe and effective care; it is not an optional extra to be fitted in if circumstances allow it NMC (2010b).

Good record keeping has many functions some of which are particularly relevant to practice with infusion devices and are listed below:

- Helps to improve accountability
- Supports effective clinical judgments and decisions
- Provides documentary evidence of services delivered
- Helps to identify risks and enabling early detection of complications
- Shows how decisions relating to patient care were made
- Supports patient care and communications
- Makes the continuity of care easier NMC (2010b).

For further information the NMC Guidance on record keeping can be accessed at: http://www.nmcuk.org/Documents/Guidance/nmcGuidanceRecordKeepingGuidanceforNursesandMidwives.pdf

The clinical record should contain sufficient information to enable any professional to honour the duty of care to the patient, by ensuring that entries in the patient’s record or omissions from the record do not compromise patient safety in any way NHS Lothian (2010c). It is recommended that you read this document in full.

The Clinical Documentation Standards can be accessed at:


The MHRA (2010) suggest the following should be documented:

At the start of any infusion:
- type of model, serial number etc. of device
- time infusion started (24 hour clock)
- volume at start of infusion
- volume to be infused
• initial infusion rate setting
• expected completion time
• name(s) of person(s) setting and checking rates.

On each check: (including taking over established infusion)
• time (24 hour clock) – actual time not a tick in a box
• volume remaining
• total volume infused
• infusion rate setting
• name of person carrying out the check.

In cases of variable prescribed dose regimens (e.g. Heparin, Insulin sliding scale) where the concentration of the drug is not altered:
• time (24 hour clock)
• rate setting
• name(s) of person(s) setting and checking rates
• indication for alteration
• appropriate notification if completion / replacement time altered.

Table 8: Monitoring and Documenting an Infusion

<table>
<thead>
<tr>
<th>Principle</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check all infusions 15 minutes after being started.</td>
<td>To detect problems early and to ensure the infusion is running safely.</td>
</tr>
<tr>
<td>Thereafter, check infusions hourly.</td>
<td>For safety, to prevent errors, and to monitor the patient's reaction to the infusion. <em>Clinical assessment will determine whether more frequent monitoring is needed.</em></td>
</tr>
</tbody>
</table>

For syringe pumps and volumetric pumps
At the hourly check record:
· Date / Time
· condition of the infusion site
· The infusion rate
· Total volume infused – visual check of volume remaining in the container (bag / syringe)
· The total volume infused – device reading
· Volume infused since last check.

· Document on NHS Lothian’s Intravenous infusion chart. *

· Does it match the prescription?
· Is this the amount you would expect to have been administered since the last check?
· Does the visual total volume infused you have noted match the total volume infused as displayed on the device?
· Is the patient responding to the medication as expected, e.g. patient’s BP stabilising on an inotropic agent, patient’s pain level responding to analgesia? Is the patient experiencing any side effects? Are there any signs of infiltration / extravasation at infusion site?

<table>
<thead>
<tr>
<th>Principle</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record the exact time you check the device / infusion.</td>
<td>Do not round the time up or down to the nearest hour. Documentation must be accurate. Date and time should be recorded in real time and in chronological order (NMC 2009). Entries to the record should occur as soon as possible after each intervention NHS Lothian (2010c).</td>
</tr>
</tbody>
</table>

You must also check that there is no unexpected air within the container (syringe).

Air can enter the infusion container if there is a crack in the syringe or through a faulty connection, causing risk of air embolus.
Legibly sign the entry in the patient’s record.  
To maintain accurate records (NMC 2009). Entries to clinical records must be legible, clear and unambiguous (NHS Lothian 2010c).

At the end of an infusion, document any volume remaining in the syringe.  
You may be required to record disposal with a second nurse (e.g. if the infusion contains a controlled drug).

Any discrepancy found when monitoring an infusion must be discussed with nurse in charge / clinician in charge of the patient.  
Prompt action must be taken if any discrepancy is noted. This should be reported as a clinical incident, making sure all disposables are kept safely.

For the CME McKinley T34 there is a specific monitoring chart. The initial check should be the same 15 minutes from commencing the infusion. The checks should then be 4 hourly (within inpatient settings) daily / at each visit (in the patient’s own home). Clinical assessment will determine whether more frequent monitoring is needed, e.g. where problems have occurred or are specifically anticipated during the infusion.

For the CME McKinley T34 Syringe Pump the subcutaneous infusion set-up and monitoring chart must be used. In addition to documenting important information, the information fields developed on this chart support clinical practice e.g. by requiring the user to confirm whether the infusion has run to time over the monitoring period. Where problems are identified, prompt action must be taken.

**Table 9: At Each Monitoring Check:**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>The patient</th>
<th>Are the symptoms controlled? Is breakthrough medication required? Is the patient experiencing any side effects from the medications?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>Cannula site</td>
<td>Check for inflammation, leakage, hardness or blood. If any of these is present, change the site in case it affects the absorption of medications and increases the risk of infection.</td>
</tr>
<tr>
<td>Step 3</td>
<td>Infusion line</td>
<td>Check for security, kinking and leakage and if the patient is or has been lying on the line.</td>
</tr>
<tr>
<td>Step 4</td>
<td>Syringe</td>
<td>Check the syringe for cloudiness, discolouration or precipitation indicating incompatibility. Check the syringe is securely placed on the syringe pump.</td>
</tr>
<tr>
<td>Step 5</td>
<td>Syringe pump</td>
<td>Check the time remaining and the flow rate displayed on the screen is correct. Press the ‘info’ key once to show the infusion summary. Record the volume infused and the volume remaining to assess that the syringe pump is running to time. Confirm this by visual inspection of the syringe.</td>
</tr>
<tr>
<td>Step 6</td>
<td>Documentation</td>
<td>Record the checks on the McKinley T34 infusion chart. Any incidents must also be fully documented in the patient’s notes. If any checks are not carried out (e.g. not checking the cannula site so as to avoid disturbing the patient’s sleep), record this on the monitoring chart.</td>
</tr>
</tbody>
</table>
Patients’ Experience of Technology at the Bedside

Technology in the healthcare setting has the potential to affect the patient and their personal experience of illness (Pelletier 1992).

Infusion devices are usually in close proximity to the patient and can be with the patient for up to 24 hours per day, therefore have the potential to have a detrimental effect on a patient’s wellbeing. It is important not to overlook the fact that the patient may not be as comfortable as the practitioner is with technology.

The experience may affect the patient in the following ways:

- The presence of the device may be threatening or at least puzzling for the patient
- May make the patient less mobile / restrict their movement
- Cause difficulty of manipulating tubing through clothes, may mean the patient is not fully dressed
- A device that alarms frequently may make the patient anxious if they do not understand why it is alarming
- Patients may be fearful of loss of independence if they are unable to manage tasks with the intravenous / subcutaneous infusion and device attached
- Anxious if clear explanation and understanding of why the device is being used is not given
- If the device alarms frequently during the night can have a detrimental effect on a patient’s sleep pattern (Pelletier 1992)
- It is important that practitioners’ are mindful not only of the safety aspects relating to caring for a patient with an infusion device, but also of the psychological impact this might have on their patients.

You may wish to access the patient safety alliance website to obtain more information [http://www.patientsafetyalliance.scot.nhs.uk/default.aspx](http://www.patientsafetyalliance.scot.nhs.uk/default.aspx)

Infusion Devices and Labelling Aspects

Some aspects reviewed in the IV section, however, infusion device labelling indicates:

- Injections must be clearly identifiable at all stages during preparation and administration
- Prepare the label before starting to prepare the injection so that it may be affixed immediately after preparation is complete
- If the injection is to be given by bolus, and will be supervised at all times during preparation and completion of administration, write the name of the medicine on a sticker and use it to label the final container (the syringe, bag, etc). Keep the finished preparation and original containers in an individual tray between preparation and administration
- If the injection is not to be given by bolus, or is unsupervised at any time between preparation and completion of administration, label the container (the syringe, bag, etc), using the standard approved label
- For syringe pumps, affix the label to a flag to avoid obliterating the graduations on the syringe, and to allow inspection of the solution. Do not use the flag more than once – always use a new flag when preparing a new syringe. **NB. the flags cannot be used with the CME McKinley T34 syringe pump** – an alternative way of labelling the syringe in these circumstances must be used
- Label syringes containing solutions to be used as flushes with a pre-printed label to avoid the risk of selection error.

Incident Reporting and Learning from Mistakes

Risk management in the NHS has been influenced by documents such as the Department of Health’s *Building a safer NHS for patients* (2001), which acknowledges that adverse incidents occur in around 10% of admissions, and that related service failures can have serious consequences for patients.
In the 5 years from 2005 – 2010, the MHRA (2010) investigated 1,085 incidents involving infusion devices in the UK:

- In 68% of these incidents no cause was established
- 21% were identified as user error
- 11% were due to device related issues.

The majority of serious problems related to over-infusion of medicines (MHRA 2010).

The most common user errors were cited as:

- Misloading the administration set
- Misloading the syringe
- Setting the wrong rate
- Confusing primary and secondary rates
- Not confirming the set rate
- Not confirming the syringe size
- Confusing the pump type
- Not stopping the infusion correctly
- Not confirming the pump mode
- Not confirming the configuration of the pump.

In addition to the growing numbers of reported adverse incidents involving infusion devices in the UK, it is believed that there are many more unreported incidents, perhaps due to the fear of disciplinary action amongst nursing staff (Quinn 2000). A degree of risk is inherent in medicine administration, and human error is to some extent inevitable; however, it is learning from these errors in order to influence future practice that is vitally important.

It should be noted that using an infusion device is associated with three times more likelihood of an error than any other medical device (Quinn and Upton 2006). Risks associated with infusion devices may arise from design, manufacture, storage or lack of user understanding and competence, and other contributing factors (Amoore and Ingram 2002).

NHS Lothian’s Incident Management Policy (NHS Lothian 2011e) clearly outlines the responsibilities and processes to ensure a safe working environment. While the Quality Improvement Strategy 2011-2014 (NHS Lothian 2011b) advocates patient centred, safe, effective and efficient care is provided to every patient, every time.

**Frequently Asked Questions (FAQs)**

- **I have used exactly the same devices in another Trust / Division / Health Board / Country: do I still have to attend the IV/infusion device programme?**
  
  Yes, you must attend the IV Therapy / Infusion Device programme. No two hospitals configure equipment in exactly the same way (this refers to the clinical applications that are chosen to operate the device). The devices in NHS Lothian will have unique settings that you require to learn and be assessed on.

- **I am moving from a ward, e.g. at St John’s to a ward at the RIE, do I require to attend training?**
  
  If the device is the same as the one you are already trained on: it may appear the same, but may still be configured slightly differently; you are advised to approach the charge nurse in your new area of work to go over the device configuration and to do a subsequent competency assessment. However, if the device is different or a different model and you have previously attended a NHS Lothian infusion device programme you can be trained locally by your designated link nurse on this one specific device.
• Is the infusion device programme the only approved method of training for infusion devices in Lothian?
Yes, except for the CME McKinley T34 where there is a full study day for staff who work in the community or for staff who only deliver medicines via the subcutaneous route.

• I have completed my training on the IV / Infusion devices programme, and have successfully passed the IV /infusion device exam and feel confident in having my competence assessed. Who can complete this for me?
The assessors in your ward are chosen by your charge nurse and must be someone who is registered, competent and experienced in, e.g. the use of the infusion device you are being assessed on. The final sign off (competency assessment) must be countersigned by the manager / charge nurse too.

• I have been involved in a near-miss incident. I would like to check / revise my skills with the infusion device involved. How can I organise this?
In the first instance, you should discuss this with your manager. Consider whether you need further training or an update to increase your confidence / competence in the use of infusion devices. There may be a designated link nurse in your area that can go over the device with you. You can also contact one of the CCET staff if you would like further support, advice and /or training.

• I haven’t had training on how to use the Datix incident reporting system, and don’t have a log-in and password – how do I get these?
To report an incident you do not require a Datix log-in or password. The reporting system can be accessed by all staff via the Intranet. If you require training on how to complete the online forms, inform your charge nurse. The only log-in and password required is to access the actual PC itself.

Summary

To ensure safe and consistent practice in IV administration and use of infusion devices, Billings and Kowalski (2005) developed a mnemonic tool called CATS;PRRR, to aid staff follow standardised protocol and care (Table 10).

Table 10: CATS, PRRR and IV Safety (Billings and Kowalski (2005))

<table>
<thead>
<tr>
<th>C = compatibilities</th>
<th>Is the medicine / fluid compatible with the current medicine / fluid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = allergies</td>
<td>Does the patient have medicine allergies?</td>
</tr>
<tr>
<td>T = tubing</td>
<td>Is it the correct tubing for the medicine, e.g. blood set for blood or blood products; is tubing OK, e.g. not kinked?</td>
</tr>
<tr>
<td>S = site</td>
<td>Is the site safe, e.g. no evidence of infiltration / phlebitis?</td>
</tr>
</tbody>
</table>
| P = the 4 P’s of pump safety | Pump programmed precisely?  
Is it the correct tubing for device & connected correctly?  
Personality? Is it the right pump for this medicine?  
Pumping? Is device pumping correctly? Alarms working?  
Plugged in? Is it plugged in? |
| R = right rate      | Is it programmed correctly for this medicine? |
| R = release         | Check all clamps released? |
| R = return and reassess | How did patient tolerate medicine?  
Is the medicine helping?  Remember to chart findings. |
Section 5: Potential Complications

Careful monitoring of patients receiving IV Therapy, and if via an infusion device, is essential, as there is a significant risk of complications. In this section three frequently occurring, but preventable, IV related complications will be discussed.

Patients at most risk of phlebitis, extravasation and / or infiltration:
- Elderly
- Neonates and very young children
- Confused patients
- Patients who have a communication problem, e.g. stroke, unconscious patients
- Patients who have diabetes, cancer, peripheral vascular disease, Raynaud’s phenomenon (this causes arterial spasm and may compromise peripheral circulation and reduce venous flow), superior vena cava syndromes (elevated venous pressure may predispose to leakage at the intravenous site), blood abnormalities or circulatory problems
- Patients who have had repeated intravenous infusion and or injections (this may thrombose vessels and limits the number of accessible veins). This could also apply to substance abusers
- Patients on chemotherapy.

Phlebitis

Phlebitis is inflammation of the interior wall of the vein, usually linked to the presence of a vascular access device / cannula. Phlebitis is the commonest complication of PVC and IV infusions, with 30-70% incidence reported (Cokmez et al 2003). The typical indication of a potential problem is a pyrexia of 38° and above, and the patient reporting pain at the site.

Classification:
Phlebitis can be classified into mechanical, chemical and infective, depending on the cause of the problem.

Mechanical phlebitis:
- predominantly due to cannula problems, which cause trauma to the intimal wall of the vessel (e.g. insecure cannula)
- could occur on insertion or be due to displacement of the cannula following manipulation.

Chemical phlebitis:
- a consequence of the compositions and concentration of the infusate and in particular infusates with extremes of PH or osmolarity, resulting in damage to the endothelium of the vessel wall (Philpot and Griffiths 2003).

Infective phlebitis:
- where infection is at the tip of the catheter (usually confirmed when blood cultures show the same microbiology as the tip, which is sent for culture).

Assessment:
Early assessment and action means symptoms will often resolve without further intervention, regular monitoring of sites is therefore essential (Ingram and Lavery 2005). It is recommended that each patient who has a PVC has this site assessed using the PVC Care Bundle (refer to Infection Control section) and Jackson scale (see table 11). The condition of the site, cannula and dressing must be documented.
Practitioners must provide evidence to support their action plan to either keep the catheter / cannula in situ or to have it removed. PVC care bundles are maintained in some areas within the patient care plans, whilst in other areas they are separate documents maintained to support patient records.

Peripheral Vascular Catheter (PVC) Care Bundles require daily assessment:
- Checking the PVCs in situ are still required
- Removing PVCs where there is extravasation or inflammation
- Checking PVC dressings are intact
- Considering removal of PVCs in situ longer than 72 hours
- Performing hand hygiene before and after all PVC procedures.

Table 11: A Phlebitis scale is also a useful Tool to Monitor PVC Sites:

<table>
<thead>
<tr>
<th>IV site appears healthy</th>
<th>0</th>
<th>No signs of phlebitis OBSERVE CANNULA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE of the following is evident:</td>
<td>1</td>
<td>Possibly first signs of phlebitis OBSERVE CANNULA</td>
</tr>
<tr>
<td>Slight pain near IV site OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slight redness near IV site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TWO of the following are evident:</td>
<td>2</td>
<td>Early stage of phlebitis RESITE CANNULA</td>
</tr>
<tr>
<td>Pain at IV site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swelling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL of the following signs are evident:</td>
<td>3</td>
<td>Medium stage of phlebitis RESITE CANNULA CONSIDER TREATMENT</td>
</tr>
<tr>
<td>Pain along path of cannula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL of the following signs are evident and extensive:</td>
<td>4</td>
<td>Advanced stage of phlebitis or the start of thrombophlebitis RESITE CANNULA CONSIDER TREATMENT</td>
</tr>
<tr>
<td>Pain along path of cannula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palpable venous cord</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL of the following signs are evident and extensive:</td>
<td>5</td>
<td>Advanced stage thrombophlebitis INITIATE TREATMENT RESITE CANNULA</td>
</tr>
<tr>
<td>Pain along path of cannula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palpable venous cord</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrexia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Phlebitis scale (Jackson 1998 cited in the RCN Standards for Infusion Therapy 2010)

**Treatment:**
Treatment for phlebitis is usually heat and analgesia (Lavery and Smith 2007). However, the use of transdermal anti-inflammatory gel has also been reported to be beneficial (Cokmez et al 2003). This is thought to work as the gel acts as a vasodilator, counteracting the vasoconstriction caused by the phlebitis. When deciding on a suitable analgesia, anti-inflammatory agents can be beneficial in reducing the inflammation at the catheter / cannula site; note, all treatments must be prescribed.

**Extravasation:**
Extravasation is the inadvertent administration of a vesicant medication or solution into the surrounding tissue instead of into the intended vascular pathway (RCN 2010). The medications with the highest destructive powers include vinca alkaloids (De Vega et al 2002). However, many substances which are used regularly can also cause damage and should be used with caution.
Examples include Sodium bicarbonate, Potassium chloride, 10% Glucose and Erythromycin. Chemotherapy also presents a high risk to patients and only qualified personnel should administer this therapy following training on administration, side effects and action for specific medications should an extravasation occur. Neonates are particularly at risk of extravasation.

It is essential that nurses have knowledge of the medication being administered, the side effects, contra-indications, route and dose. The medication must be given strictly as per the manufacturer instructions re. diluting and duration (refer to The Parenteral guidelines, NHS Lothian Version 4).

**Treatment:**
Local policies for treating extravasations vary, often due to the speciality, age group and medications being used. Common treatments can vary from wound exposure, occlusive dressings, infiltration with Hyaluronidase and saline, to plastic surgery. Patients should be counselled appropriately if an extravasation does occur.

The NHS Lothian ‘Safe Use of Medicines Policy and Procedures’ (2011a) recommends that all wards and departments administering cytotoxic agents should have access to an extravasation ‘kit’ maintained by pharmacy, which contains the key medicines, equipment and documentation required to treat an extravasation. Clinical areas which do not have extravasation kits should contact pharmacy for advice, should an extravasation occur.

**Infusion:**
Infusion refers to the inadvertent administration of a non-vesicant drug, e.g. crystalloid, into the surrounding tissues (Dougherty and Lamb 2008). It is often referred to as ‘tissuing’. Classification is linked to the medication causing the problem. The clinical symptoms of infiltration are coolness, leakage at the site, swelling and tenderness.

**Action box 8**
Does your clinical area use the PVC care bundle and a phlebitis score? Locate copies of these and familiarise yourself with them. How would you recognise an extravasation and what would be your actions?

For further PVC complications relating to IV practice please refer to NHS Lothian’s Adult Venepuncture and Peripheral IV Cannulation pre-course workbook (2012).

**Infusion Device Complications**
There are some complications that relate to the use of infusion devices; siphonage, start up time and occlusions, and these are explored briefly here and during the programme workshops.

**Siphonage (free flow due to gravity)**
Siphonage is the uncontrolled flow of infusion fluid from any raised container (e.g. syringe or fluid bag), with gravity being the driving force. Over-infusion of medication to patients through siphonage has been the cause of fatalities in the UK.

Common causes of siphonage:
- The device is mounted higher than the infusion site
- Air leakage through a broken seal between the syringe barrel and the plunger, or through a damaged or cracked syringe.
Prevention:

- Use an administration set with an anti-siphon valve with a Luer Lock syringe
- Check for damage to the syringe particularly around the seal between the syringe plunger and barrel
- Ensure a closed air tight fluid pathway to the patient is established
- Place the syringe securely in the pump before attaching the line to the patient. Ensure that the plunger and barrel of the syringe are secure and the syringe lip is located in the groove
- Best practice is to mount syringe pump at or below the height of the patient’s infusion site
- Clamp the infusion line before removing the syringe from the syringe pump
- With volumetric pumps check the drip rate in the drop chamber initially after loading the administration set and at checks whilst pump is infusing
- Volumetric pumps have an anti-free flow device that clamps the line when removed from the device. However, if the line also has a clamp (e.g. roller or slide clamp) then this should be closed before removing the line. Also ensure that the correct administration set is used for the device
- When the administration set has been connected to the infusion site, the vertical position of the infusion pump and giving set in relation to the site should be altered as little as possible. If the pump is raised above the infusion site whilst the liquid is being delivered, it can result in a large bolus being delivered to the patient (MHRA 2010).

**Start-up Time**

Start-up time is the delay between starting a syringe pump and the delivery of fluid at the set infusion rate. This delay in fluid delivery to the patient is caused by the time required to take up the mechanical slack in the pump-syringe system, both in the pump’s driving mechanism and in the fitting of the syringe into the pump. The lower the infusion rate the longer the start up time will be (Amoore et al 2001).

Implications:

- Start-up time delays the delivery of medication to the patient and therefore causes a delay in therapy (e.g. pain relief, anti-coagulation, Insulin etc)
- When monitoring progress of the infusion there will be a difference between the volume delivered recorded by the pump’s totaliser and that read from the barrel of the syringe (the volume actually delivered). This could lead to confusion if the user does not fully understand the concept of start-up time.

Techniques to reduce the start-up time delay (Amoore et al 2001):

**Fit the syringe tightly into the pump.** After manually priming the line, fit the syringe tightly into the pump before connecting the line to the patient. Before clamping the plunger, push the plunger clamp hard against the plunger, moving the plunger forward a few millimetres until a few drops of fluid flow out of the line.

**Use the purge facility, if available, on the pump.** If the pump has a purge (or ‘prime’) facility, use it before connecting the line to the patient. This takes up the mechanical slack in the drive mechanism as well as the looseness in the fit between the syringe and pump. The purging infusion rate may be at the pump’s highest flow rate so purging must take place prior to connecting the line to the patient. Purged fluid volume is not added to the totaliser.

**Use a smaller syringe size.** The driving rate of the plunger for a given infusion rate depends on the syringe size. If possible, a smaller syringe should be used when infusing at low-flow rates, as the start-up delay will be reduced. Care should be taken to check that the device also registers the correct syringe size, to ensure accurate infusions.
Use of the bolus administration facility. If the patient requires a bolus dose of the medicine being administered, this should be prescribed before commencing the infusion. Most syringe pumps have a bolus key that should be used when a patient requires a bolus rather than removing the syringe from the pump.

Occlusion Pressure
The occlusion pressure of a pump is the pressure in the tubing, registered at the pump, when the pump is still operating but cannot sustain the flow rate. The resultant build up of pressure sets off the occlusion alarm. All powered infusion devices have mechanisms for detecting when the flow has ceased. These are based on measuring the increase in pressure, either directly or remotely (MHRA 2010).

For an infusion to run successfully, the pressure being exerted by the infusion (even without a device) must be greater than the pressure in the vein and associated apparatus. If this is not the case then the infusion will not run.

In volumetric pumps the occlusion alarm pressure is pre-set by medical physics, or automatically defaults, usually to around 500 mmHg in adults. Thus you must know what the occlusion alarm is set at. In some syringe pumps the pressure level is pre-set. Others default to a set level, but can be adjusted up or down by the clinical user. If the occlusion alarm pressure is set too low, the infusion has the potential to alarm frequently.

The pressure build-up in the line can be due to the syringe, the infusion line, the type of medication, the rate of infusion, more than one infusion running into the same cannula and can cause so much opposing pressure that the line occludes immediately the start key is pressed. These are often then referred to as ‘nuisance’ alarms, as there is no clinical problem other than the resistance.

If an infusion device is set at too high a pressure there is a delay in it alarming when there is a pressure build up, which means a delay in alerting staff that the patient is not receiving their medication / therapy. Occlusion alarms are a useful tool but will not prevent clinical complications such as phlebitis and extravasation, thus regular observation of infusion sites is vital before, during and after an infusion.

N.B. from the onset of total line occlusion the patient will receive no therapy

In an infusion system this resistance to flow is usually caused by:

- The relatively small diameter of the cannula
- Filters for air or particulate
- Additional components e.g. anti-syphon valves
- Infusion administration set tubing
- Intravascular or intra-compartmental pressure at the infusion site, at a level substantially higher than atmospheric pressure
- Length of the line.

Pressure at Infusion Site
In a typical adult, venous pressure can vary between small negative values (-10 mmHg) in the large veins situated vertically above the heart, up to 80 mmHg in dependent peripheral veins.

Since a column of liquid exerts pressure at its base, pressure in the leg veins can sometimes rise to quite high values. An ambulant patient with a cannula situated in a peripheral arm vein might present a baseline site pressure of up to 30 mmHg.
Minimising Patient Risk
Alarms are principally provided to minimise the hazard to the patient. For some of the more ‘critical’ medicines, current technology cannot provide alarms that activate sufficiently rapidly to provide ‘safe’ warning of the cessation of therapy. Staff must therefore be extra vigilant in these circumstances.

What triggers an occlusion alarm?
An occlusion alarm can be set off by:
- a blockage in the delivery tubing – often inadvertently caused by leaving a roller clamp or three-way tap closed
- a clotted-off cannula
- a partially occluded cannula, if it causes the required driving pressure to rise above the occlusion alarm level
- a very narrow or very long cannula.

NB. Extravasation does not trigger an occlusion alarm.

What are the hazards to the patient caused by occlusion?
Occlusion causes two main hazards to the patient:
- interruption to therapy
- a potential sudden injection of an unwanted bolus, on release of the occlusion (MHRA (2010)).

Ensure you document variables that may cause an increase in resistance and therefore justify increasing the pressure setting, and patients who are more at risk of complications who may justify a reduced level. These variables and rationale for a change in the alarm settings should be documented in the patient’s notes.

Post-occlusion bolus – syringe pumps
This is when there in an occlusion in the line and the pump stops. Pressure will build up as the pump tries to ‘overcome’ the occlusion, resulting in the expansion of the line with the medication immediately proximal to the occlusion. When the occlusion is then released (e.g. unkinking the line), the patient will receive an unintentional ‘bolus’ of the medication. Some syringe pumps have an automatic “back off” facility which prevents the patient receiving a post occlusion bolus, others do not.

You will learn about this at the individual workshop sessions.

When resistance is detected in the patient’s line or vein, the infusion device will exert as much pressure as it can to overcome the problem, i.e. it will pump up to its set occlusion pressure.

When the device alarms ‘OCCLUSION’, pressure has built up in the line / system and, if this pressure is not resolved, there is a risk that the patient will receive an unintentional post-occlusion bolus of the medicine.

Section 6: Pharmacy

Aim
1. To promote safe and effective medicine administration
2. To introduce participants to medicine administration by the intravenous (IV) route and identify potential hazards.

Objectives
- Describe the indications for IV medicine therapy
- List appropriate sources of information to refer to when preparing IV medicines
- Describe factors to be taken into consideration when preparing IV medicines
- Explain therapeutic medicine monitoring.
Introduction
As well as understanding how medicines work, it is also important to understand that different methods of administration may have an effect on the therapeutic outcome for each individual patient.

The aim of this section is to offer an insight into intravenous medicine administration. It will also offer practical guidance on the preparation and administration of medicines by the IV route and highlight some possible problems.

IV Medicine Administration

Intravenous administration is the only method of medicine administration which is given directly into the circulation avoiding the need for absorption. This makes IV Therapy very effective and the only therapy with 100% bioavailability.

Advantages of the IV Route:
- Achieves rapid onset of action, as the medicine reaches the circulation with minimum delay
- Maximises plasma concentrations of the medicine, as the bioavailability is 100%
- Is indicated in situations when oral medicine administration is not available e.g. “nil by mouth”, oedematous gut, malabsorption, medicine inactivation before reaching the circulation.

Disadvantages of the IV Route:
Some disadvantages are common to all IV Therapy:
- Once a medicine is injected there is no recall, there are risks of anaphylaxis, extravasation, infiltration and of haemolysis or agglutination caused by hypotonic or hypertonic solutions
- The risk of speed shock is greater with rapid bolus injections
- The risk of fluid overload (e.g. renal, cardiac patients) is greater where large volume rapid infusions are used
- Infection

Selecting the Site – Peripheral IV Route
- An arm vein is usually used / recommended
- Choose the patient’s non-dominant arm
- Use alternate arms for prolonged IV Therapy
- Choose the most distal part of the arm, i.e. the hand and move upward if needed
- Choose a large vein for rapid infusions or large quantities of solution, and for viscous or hypertonic solutions
- Avoid siting over the wrist joint or in the antecubital fossa.

Methods of IV Administration

Bolus Intravenous Injection (rapid / slow injection / IV push)
Bolus IV administration is associated with more frequent and severe adverse reactions than other forms of intravenous therapy.

This involves injection of a medicine solution from a syringe into the injection port in the drip line or preferably directly into an indwelling catheter via a closed system, e.g. Smartsite. It resembles a direct injection into the vein. For a slow IV injection the medicine is administered over 3 to 10 minutes. Rapid IV injection is faster and is also known as an IV push. The rate of bolus administration may be limited to the amount of discomfort to the patient, but the recommendations in the package insert / monograph must always be followed.
Example: Furosemide injection rate not to exceed 4mg per minute.

Indication: Medicines given by this method achieve an immediate high plasma concentration.

Possible problems:
- Tendency to administer the dose too quickly. This could cause damage to the veins, e.g. phlebitis or extravasation
- Fast intravenous medicine administration into the circulation may cause toxic concentrations to accumulate causing a shock-like syndrome that involves facial flushing, headache, chest tightness, irregular pulse, tachycardia, reduced blood pressure, progressive syncope, cardiovascular collapse and cardiac arrest
- Sudden anaphylactic reaction.

Intermittent Infusion
This involves addition of a medicine to a small volume infusion bag connected to the main drip line set or to a secondary administration set connected to a junction in the main drip line.

Many antibiotics are administered via this method as it is a compromise between bolus injection and a continuous infusion. It achieves high plasma concentrations rapidly to ensure clinical efficacy and yet reduces the risks of adverse reactions associated with fast or inappropriate administration of an antibiotic.

Indications:
- When a medicine must be diluted in a volume of fluid larger than is practical for bolus injection, e.g. Vancomycin 1g in 250ml Sodium Chloride 0.9% concentration ≤ 5mg/ml
- When the plasma concentrations required are high and toxicity would result if the medicine was given by continuous infusion
- When a medicine is not chemically stable, so cannot be given continuously, e.g. Benzylpenicillin.

Continuous Infusion
This involves the addition of a medicine to a volume of infusion fluid for continuous infusion, either in a bag or syringe, via a syringe pump.

Indications:
- When a constant therapeutic medicine concentration is required, e.g. Aminophylline
- When a constant clinical effect is required, e.g. Morphine in a post-op patient
- When a medicine has a short duration of action and the rate of administration can be used effectively to control the clinical effect, e.g. Dopamine.

Principles for Safe Administration of IV Medicines

Calculation of Dose
The amount of medicine required for an infusion may require a calculation to determine the volume which should be added to the bag. Some medicines may require to be reconstituted with a volume of diluent and then a proportion of this is added to the infusion. Various units of issue may be found, e.g. grams, milligrams, micrograms, units, mmoles, % w/v, thus this will have to be taken into consideration in any calculations (refer to section 8).
Displacement Values
When a set volume of diluent is added to a vial of medicine to reconstitute it, the final volume in the vial is sometimes greater than the volume added because the medicine has displaced some of the diluent. For example to make up a 250mg vial of Amoxicillin for intramuscular injection, the Preparation and Administration of Parenteral Medicines manual specifies the addition of 1.5ml of water for injections. But the final volume of the injection is not 1.5ml but 1.7ml. If the dose to be administered is 250mg there is not a problem. However, problems can arise with smaller doses.

Recording of Doses Given
It is important that all IV doses either bolus or infusion are recorded on the patient’s drug / medicine record. If non-recording reflects non-administration, the patient may receive inadequate treatment and therapy may be prolonged. If a dose has been given, but not recorded, a serious implication could occur if a second practitioner notices the omission of a recording and seeks to redress the situation by giving a dose; the patient could therefore receive two doses within a short period of time, which could have an adverse effect.

Non-recording could also have medico-legal implications as it is a requirement that all patient procedures be documented, with the documentation retained for a set period. Missed and unrecorded doses could also be a problem when dosage adjustments are required. When an adjustment involves measuring therapeutic drug levels it is important to know the exact number of doses, and time of the last dose the patient has received, e.g. Gentamicin.

Particulate Contamination
Particulate contamination is the presence of any undissolved substance in the solution. This can occur during preparation with pieces of rubber bung or glass from the ampoule being added to the solution. A precipitate may also occur, due to a physical incompatibility or medicine within the fluid. There is a link with particles in solutions causing an increased risk of phlebitis.

In order to prevent this type of contamination:
1) Examine product after preparation for clarity and absence of particles
2) Work in a clean area
3) Use the appropriate needle to draw up the solution; e.g. filter needle or 23 gauge hypodermic needle.

Factors Affecting Stability of Medicine Preparations:
Medicines in the vial or ampoule are chemically stable, particle free, sterile preparations with a manufacturer’s expiry date. The same is true for the diluent, be it in an ampoule or infusion bag. When the two are mixed together before administration to a patient a “third product” has been produced with unknown chemical stability and sterility. The potential for incompatibility with the diluent or other therapy, degradation of the medicine or microbiological contamination of the infusion have to be considered. You are responsible for the infusion or injection prepared, which must be efficacious and not harmful to the patient under your care.

1 Physical / Chemical Incompatibility
Mixing two or more medicines in the same solution can result in medicine incompatibilities which may present as:
- colour change
- haze
- turbidity
- gas
- precipitate - solid particles settling out
- no visible change.
Examples:
- Sodium Bicarbonate and Calcium Chloride when given together form Calcium Carbonate, an insoluble precipitate
- Phenytoin and Diazepam, when administered together form a precipitate
- Penicillin, which is most stable in a slightly acidic environment, becomes rapidly inactivated in a very acidic or alkaline one.

2 Mixing of Medicines
The potential for interaction increases with the greater number of medicines mixed together in a syringe or infusion bag. It is probably best to adopt the policy of not mixing medicines.
(Regarding subcutaneous infusions for palliative care via the McKinley T34 syringe pump, the compatibility and stability of medicines must be checked in the Palliative Care guidelines prior to preparation).

Consideration also has to be given to medicines, which given as separate infusions, will mix at the Y-connector before being infused into the patient.

Medicines MUST NOT be added to:
- blood / blood products
- amino acid solutions
- sodium bicarbonate solutions
- Mannitol 20%
- intravenous fat emulsions
- total parenteral nutrition.

3 Temperature
Some medicines are susceptible to high temperatures and are stored in the refrigerator. Medicines diluted or prepared as infusions should be used immediately. However, if they are to be stored they are usually kept in the refrigerator to minimise microbial growth (e.g. Acyclovir). This is not the case with all medicines, for example, some medicine infusions must be stored at room temperature to avoid precipitation, therefore always consult the package insert for storage data.

4 Time
Most medicines are chemically stable for a limited period of time once reconstituted, after which they degrade. The medicine then obviously becomes less effective. However, if the degradation by-products are toxic this will lead to problems, e.g. Flucytosine degrades to 5-Fluorouracil. Degradation can be a chemical reaction such as oxidation or hydrolysis.

5 Light
Photodegradation by exposure to light is a problem with some medicines but can be minimised by covering the infusion bag with black plastic and if necessary covering the drip tubing with aluminium foil, e.g. Sodium Nitroprusside.

6 Diluent
Medicine formulations are sometimes complex containing buffer, antioxidant, solubiliser and preservative. Thus to prevent incompatibilities, medicines must be reconstituted and diluted in the recommended fluids. For example, Cefuroxime must initially be reconstituted with water for injection and then further diluted with Sodium Chloride 0.9% or Glucose 5% solution.
7  pH
Glucose 5%  pH  3.5 - 5.0
Sodium Chloride 0.9%  pH  5.7 - 7.0

Medicine preparations, when reconstituted with the appropriate diluent; usually have the pH of maximum stability. The pH of a medicine preparation may limit the choice of diluent. For example, Phenytoin injection has a pH of 12 and if diluted in Glucose 5%, which is acidic, will precipitate almost immediately. Some infusion solutions require to be buffered or adjusted so that the pH of the resultant solution gives minimal degradation. For example, Amphotericin will degrade below pH 4.2, but is incompatible with Sodium Chloride 0.9%. When preparing this in Glucose 5%, 2ml of a buffer solution must be added to the infusion bag before the Amphotericin to ensure the pH is greater than 4.2. **NB** Follow instructions in the current edition of The Preparation and Administration of Parenteral Medicines (Version 4).

8  Container
The material used in the manufacture of the infusion bag or syringe can affect the drug added to it or vice versa. A number of medicines are adsorbed on to surface of the plastic, e.g. Insulin, Diazepam, Nimodipine. The amount of medicine received by the patient is only a percentage of the amount added to the bag.

The opposite, desorption, can occur where plasticisers are leached out of PVC plastic bags. Any injection in an oil base will leach phthalates from PVC and as these phthalates are toxic this affects the expiry time given to the infusion, e.g. Ciclosporin.

Parenteral nutrition solutions, which contain Intralipid, must be prepared in bags made of ethyl vinyl acetate (EVA).

9  Layering
Any infusion must be well mixed either in the syringe or infusion bag before administration. To mix in a syringe draw some air into the syringe and gently move it back and forward allowing the air bubble to travel up and down, then remove the air. Infusion bags should be shaken. For example, Potassium Chloride is a dense solution and will remain at the inlet port if the bag is not shaken. If in doubt contact the clinical pharmacist or the pharmacy information department.

References
Smith M *Drug side-effects and interactions Hazards of Intravenous Therapy* Mims (83) 37-38

Section 7: Infection Control
Aim
To highlight the importance of the prevention of infection in peripheral vascular catheter / cannula (PVC) infusions, sites of infusions, and infusion devices and lines.

Objectives
- Describe the principles of the prevention of infection
- Identify common sites for PVC therapy and their management from an infection control point of view
- Describe common intrinsic and extrinsic factors which may affect PVC infusions
- Identify which types of organisms are likely to infect PVC sites and lines, and why
- Describe how to detect infection in PVC sites and lines
• Define the term asepsis
• Describe how the risk of contamination and infection in PVC infusions, sites, devices and lines may be minimised by the use of aseptic technique and surveillance
• Identify the role of the practitioner in educating patients and colleagues about infection control policies.

Introduction
IV Therapy is an indispensable part of modern medicine for the administration of fluids, blood products and chemotherapy. Zingg and Pittet (2009) noted that as many as 80% of hospitalised patients will have a cannula in situ, while the Department of Health (2007a) estimated that 6000 patients acquire a catheter-related bloodstream infection each year in the UK.

While, Amoore and Ingram (2002) suggested risks associated with infusion devices may arise from design, manufacture, storage or lack of user understanding and competence, and other contributing factors. The Medicines and Healthcare Products Regulatory Agency (MHRA) investigated 1,085 incidents involving infusion devices in the UK, over a five year period (MHRA 2010).

Aspects of Infection Control
A strict policy for the insertion and care of IV catheters/cannulae and the use of infusion devices is an essential component of an infection control programme.

Complications
Complications associated with the use of PVC include the following:
1. Phlebitis (also discussed in section 5)
2. PVC-associated bacteraemia.

Phlebitis usually requires two or more of the following signs:
• Pain
• Tenderness
• Erythema
• Swelling
• The presence of pus.
Phlebitis may occur up to 48 hours after the PVC has been removed.

Portal of entry for pathogens:
Either of two routes: both result in colonisation of the catheter tip:
1. Migration from the PVC catheter/skin interface over the external surface of the cannula
2. Down the internal surface of the PVC catheter to the catheter tip.
Bacteria subsequently may begin to replicate within and on the fibrin sheath and are eventually released into the bloodstream; once the organisms are in the bloodstream a bacteraemia has occurred.

Most of the micro-organisms causing PVC related infections arise from the skin. There are several other potential sources of infection, however, as detailed in Figure 1.

**FIGURE 1**

![Potential Sources of Infection Diagram]

**Microbial contamination**
- When drugs are prepared in the ward situation there is a possibility of microbial contamination
- The infusion fluid could be heavily contaminated with bacteria with no obvious change in the visual appearance
- Peoples’ hands are one of the sources of contamination having approximately 10,000 organisms per cm², while other sources of PVC infection are the patient’s skin, PVC hub and the infusate.

**Solutions should be:**
- Stored as per manufacturer's instructions
- Checked undamaged and within expiry date before use
- Prepared immediately before use
- Date and time of solution preparation should be documented.

**Solutions used for dilution:**
Pharmacy now recommends that solutions used for dilution should be discarded immediately after use.

**Surveillance:**
- Document specimens taken from site for Bacteriology
- Report an increase in infected sites to the IC Team for investigation and resolution of potential problems.

**Predisposing risk factors to infection with PVC and IV Therapy:**
- Insertion technique
- Location of catheter
- Maintenance of PVC device
- Duration of PVC catheter
• Immunocompromised, very young, very old patients, and patients who have experienced an increased length of stay in hospital.

**Please,** also review sharps management practice:
Ensure temporary closures are used on sharps containers, that sharps containers are not contaminated with blood or left on floors, and must be signed and dated (NHS Lothian report: HEI Unannounced Inspection Report 2011d).

**Infusion Devices and Infection Control Aspects**
It is essential to decontaminate equipment correctly. Alcohol wipes cause damage to infusion device keypads and encourages bacterial resistance, so should NOT be used.

Wipe over infusion devices with a damp cloth and mild detergent / mild detergent wipes after every patient and between infusions.

While most infusion devices protect against minor fluid spillage, they are not waterproof, pumps should not be taken into the shower or bath. If a device has suffered excessive fluid spillage or fluid ingress (fluid infiltration into the actual machine) then it should be sent to medical physics for checking prior to use.

Do not use a device that has been dropped until it has been checked by Medical Physics, internal damage may not be visible externally. Complete a service request form (these should be held in your clinical area, also available on the NHS Lothian intranet), indicating that the device was inadvertently dropped, noting if came into contact with water when dropped i.e. dropped into a bath. Ensure the device is clean and complete a decontamination certificate, then send the device to be checked over.

**PVC Care Bundle**
A bundle is a straightforward set of 3 to 5 practices that, when performed collectively, reliably and continuously, have been proven to improve patient outcomes (see bundle example over). Routine monitoring and review of compliance with the bundle form part of the quality improvement strategy (SPSP 2008). The care bundle may have been adapted for use in your area’s clinical documentation.

The PVC bundle can be accessed at:

**NHS Lothian intranet home page > Healthcare > Clinical Governance > SPSP > Clinical Documentation > PVC Folder**
In summary, to prevent microbial contamination:

- Follow the PVC Care bundle
- Use an aseptic technique for insertion and all contacts with the infusion line and / or device
- Prepare infusate in a clean area and practise aseptic technique at all times
- Audit the PVC care bundle weekly in your area.

Section 8: Numeracy Calculations (Numeracy)

This section is intended to help prepare participants for practice in relation to IV Therapy and infusion devices, i.e. rate calculations for medicines, for volumetric pumps and syringe pumps (the CME McKinley T34 syringe pump works out the rate for the practitioners but you are still responsible for checking this rate is correct).

Examples are given using formulae, although not everyone may wish to use these. It is important that you strengthen your ability to carry out medicine calculations prior to attending the course, so we ask that you complete this section as precourse work for the IV / Infusion device study programme and bring this workbook along with you to the programme. Answers are supplied to allow you to check responses. There will be a medicine calculations workshop and practical workshops on the programme, with the opportunity to go over more examples prior to the theoretical assessment.

Learning outcomes:

- Demonstrate the ability to carry out medication dosage calculations correctly
- Demonstrate the ability to select relevant information from prescription scenarios in order to carry out the medicine calculation
- Apply calculation formulae appropriately in order to calculate the correct volume of medicine required for administration of the prescribed dose.
Our experience in Clinical Education and Development is that practitioners find medicine calculations the most daunting part of this programme; however we hope that, with learning support, it will prove not to be as hard as you expected.

It is essential for the registered practitioner to be competent in medicine calculations to promote patient safety. Brady et al (2009) cited medication errors as the most common type of error affecting the safety of patients, and the most common single preventable cause of adverse events.

Calculators must be used with caution, as it is easy to make a mistake. Some calculators will round up your answer which could lead to an inaccurate answer, thus we recommend you use a scientific calculator. You should not use the calculator on your mobile phone. Finally calculators are useful for checking your own answer – however you should never assume the answer from a calculator is correct.

NHS Lothian’s ‘Safe Use of Medicines Policy and Procedures’ (2011a):
Complex dose calculations must be carried out independently by two registered practitioners to check accuracy. A senior nurse, doctor or pharmacist must be contacted in cases of uncertainty.

This part of the workbook comprises five parts:
Part 1: Numeracy
Part 2: Metric units and conversions
Part 3: Medicines: Tablets and solutions
Part 4: Infusion device
Part 5: Additional calculations.
Answers to the calculation questions will be at the end of each section, so that you can check your understanding as you go along.

Further calculation / numeracy practice:
The following websites have examples of calculations for further practice.
http://www.testandcalc.com/
http://www.lanpdc.scot.nhs.uk/calculations/dcdrugsq.asp?id=1
http://mathcentre.ac.uk/

A useful booklet aimed at refreshing fundamental numeracy skills, including work on decimals, fractions, percentages and ratios (answers included in the booklet) can be found at:

http://www.mathcentre.ac.uk/resources/Refresher%20Booklets/numeracy%20refresher/mathcentreNumeracy1.pdf

If you are registered with Flying Start please visit the Authentic World under the clinical skills section.

NB: Snow (2008) noted the latest NMC figures show that nearly one in ten complaints against nurses relates to the maladministration of medicines. Between April 2005 and March 2006, 9.7% of the 1,378 allegations against nurses, concerned medicine errors. Please do not take risks – if you are unsure: speak up at the time, ask for help and support, do not be rushed and do not compromise patient safety.

Medicine Calculations: Part 1 Numeracy

It is important to remember that not everyone works out calculations in the same way, what works for one person may not work for another. It is important that you work out calculations in your own way and then check with your colleague. Using a formula does not suit everyone. What is
important is that you understand the process of calculations in order that you can apply the process to different calculations.

When using calculators you need to be very careful as they will only respond to the numbers and actions you type in. It can be easy to make a mistake.

The NMC’s Standards for Medicines Management (2010a) state that calculators should not act as a substitute for arithmetical knowledge and skill. Therefore, you should work out your answer yourself, and you may then use the calculator to check your answer.

When completing complex calculations the NMC states that 2 registered practitioners in IV Therapy should independently calculate (NMC 2010a).

Some general points regarding medicine calculations:
• Always do any calculations independently from the other practitioner
• Further advice can be obtained from pharmacy, colleagues, internet / intranet, policies, etc. If you are still unhappy do not proceed
• Before doing the actual calculations look at what you think would approximately be a logical answer; if this varies vastly from the answer you get, seek advice
• Calculators can be used to ‘check’ your answer but calculations should, where possible, be done manually (McMullan et al 2010). Ensure you are familiar with the calculator being used as some models can be complicated
• Use this pre-course work to identify areas which need further work and seek further practice or help if necessary (see start for contact details for CCET, also websites listed at the start of this section)
• Pay particular attention to the units which have to be written out in full as these may lead to errors in practice and will be marked as wrong in the assessment if not written correctly
• Always put in the decimal place if the number is under one, e.g. 0.5 as if this was written on a prescription chart as .5 the decimal place may not be obvious, potentially leading to a medication error
• When dealing with whole numbers, e.g. 4 then this should be only written as 4 not 4.0 as again the decimal point may be misread
• Put in a decimal place where necessary for conversions.

Reasonable Answers and Estimation

One of the key things to remember when performing calculations is to first consider what a reasonable answer might be, e.g. would you expect the answer to be around 10 or around 100, which answer is the most reasonable for what you are trying to work out? It is about having a ‘feel’ for what might be the right answer.

It is very useful if you can look at a calculation and estimate using much simplified numbers:

For example you could simplify 1236 ÷ 62 by making it 1200 ÷ 60 = 20.

The real answer is 19.9354, but our estimate is close enough for us to get a ‘feel’ for the size of the answer – we know that the answer will not be 2, or 200.

This is a useful first step in the calculation process to check your understanding, however when dealing with medication calculations you need to work out the exact number required.
Basic Functions

It is important that you understand basic functions as a foundation for medicine calculations, methods for teaching arithmetic / numeracy have changed over the years so you may find a colleague has a different understanding or uses different terms from you. The following (table 12) is an explanation of terms commonly used for basic functions:

Table 12: Common Terms

<table>
<thead>
<tr>
<th>Operation</th>
<th>Overall effect</th>
<th>Examples of when to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition + (total, altogether)</td>
<td>increases original number</td>
<td>To find the total of a set of numbers</td>
</tr>
<tr>
<td>Subtraction - (take away, minus, difference)</td>
<td>decreases original number</td>
<td>To find the difference between numbers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To find how many more/less are needed</td>
</tr>
<tr>
<td>Multiplication x (times, lots of)</td>
<td>increases original number</td>
<td>To find total quantity required per day or week</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To find quantity required for each dose, or day</td>
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<td></td>
<td></td>
<td>To find an average per dose, week or day</td>
</tr>
<tr>
<td>Division ÷ (shared by, shared between, parts of)</td>
<td>decreases original number</td>
<td>To find repeated additions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations

Some units of measurement must not be abbreviated due to the risk of misreading them and vastly over / under dosing the patient.

According to NHS Lothian’s Safe Use of Medicines Policy (2011a), only the following abbreviations may be used.

- g = gram
- mg = milligram
- ml = millilitre

All other dose units must be written in full.

In particular, micrograms and nanograms should not be abbreviated as this can lead to errors.

Can the following be abbreviated (yes or no)?

- milligrams (yes or no)?
- micrograms (yes or no)?
- grams (yes or no)?
- millilitres (yes or no)?
- litres (yes or no)?
- nanograms (yes or no)?

Furthermore, the National Patient Safety Agency (NPSA 2010) noted common errors in relation to insulin and which had led to severe outcomes, e.g. death, where the use of abbreviations could be misread, e.g. U or IU. For example, 10U could be read as 100, or 6IU which was read as 61 units,
and not 6 international units. This rapid report further highlights a risk with the use of incorrect syringes, e.g. using non-insulin syringes, which are marked in ml and not in insulin units (NPSA 2010).

Part 1 - Answers
Abbreviation answers: Can the following be abbreviated (yes or no)?
Milligrams: yes (mg)
Micrograms: No
Grams: yes (g)
Millilitres: yes (ml)
Litres: No
Nanograms: No

Drug Calculations: Part 2 Metric Units and Conversions

The metric units you are most likely to come across are: 

| Weight: | kilograms, grams, milligrams, micrograms, nanograms |
|---------|------------------------------------------------|---|
| Volume: | litres and millilitres |
| Length: | metres, (centimetres), millilitres |
| Amounts: | moles and millimoles. |

Although medical staff should prescribe in the unit of measurement you have in stock (e.g. milligrams), it is important that you understand how to convert from one unit of measurement to another. There are a few different ways of doing this; use the one that you are comfortable with (confident / competent).

In the following table, working from the left to the right - units are calculated as 1000’s:

<table>
<thead>
<tr>
<th>bigger by 1000 for each vertical line</th>
</tr>
</thead>
<tbody>
<tr>
<td>nanogram</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>smaller by 1000 for each vertical line</th>
</tr>
</thead>
<tbody>
<tr>
<td>micromole</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Worked Examples: Using the conversion table:
1. To convert into a unit that is one box to the right you must divide by 1,000.

Example: convert 182 milligrams to grams
182 ÷ 1,000 = 0.182 grams

2. To convert to a unit that is two boxes to the right, you must divide by 1,000,000.

Example - change 125 milligrams to kilograms
125 ÷ 1,000,000 = 0.000125 kilograms
3. To convert to a unit that is one box to the left you must multiply by 1,000.

Example - change 41 grams to milligrams
   $41 \times 1,000 = 41,000$ milligrams

4. To convert to a unit that is two boxes to the left, you must multiply by 1,000,000.

Example - change 35 milligrams to nanograms
   $35 \times 1,000,000 = 35,000,000$ nanograms

Alternatively, this can also be converted using the principle below:

**IF YOU MULTIPLY YOU WILL GET A LARGER NUMBER**
- Multiply by 10 - move decimal point 1 digit to the right
- Multiply by 100 – move the decimal point 2 digits to the right
- Multiply by 1000 – move the decimal point 3 digits to the right

- So, if you are converting to a smaller unit e.g. grams to milligrams you move the decimal point to the right. REMEMBER “IF GOING TO A SMALLER UNIT MOVE DECIMAL POINT TO THE RIGHT” (multiplying by 1000), or use BSM principle, which is: big (g) to small (mg) multiply.

**IF YOU DIVIDE YOU WILL GET A SMALLER NUMBER**
- Divide by 10 – move the decimal point 1 digit to the left
- Divide by 100 – move the decimal point 2 digits to the left
- Divide by 1000 – move the decimal point 3 digits to the left

- So, if you are converting to a larger unit e.g. milligrams to grams you move the decimal point to the left. REMEMBER “IF GOING TO A LARGER UNIT MOVE DECIMAL POINT TO THE LEFT” (dividing by 1000).

**Calculate the following:**

<table>
<thead>
<tr>
<th>1. How many milligrams are there in:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 4 grams</td>
<td>a)</td>
</tr>
<tr>
<td>b) 6.7 grams</td>
<td>b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. How many grams are there in:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 3000mg</td>
<td>a)</td>
</tr>
<tr>
<td>b) 474mg</td>
<td>b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. How many micrograms are there in:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 6mg</td>
<td>a)</td>
</tr>
<tr>
<td>b) 0.065mg</td>
<td>b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. How many milligrams are there in:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 63 micrograms</td>
<td>a)</td>
</tr>
<tr>
<td>b) 1684 micrograms</td>
<td>b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. How many nanograms are there in:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 9 micrograms</td>
<td>a)</td>
</tr>
</tbody>
</table>
### Part 2 – Answers

<table>
<thead>
<tr>
<th>1. How many milligrams are there in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>c) 4 grams</td>
</tr>
<tr>
<td>d) 6.7 grams</td>
</tr>
<tr>
<td>a) 4000 milligrams</td>
</tr>
<tr>
<td>b) 6700 milligrams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. How many grams are there in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 3000mg</td>
</tr>
<tr>
<td>b) 474mg</td>
</tr>
<tr>
<td>a) 3 grams</td>
</tr>
<tr>
<td>b) 0.474 grams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. How many micrograms are there in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 6 milligrams</td>
</tr>
<tr>
<td>b) 0.065 milligrams</td>
</tr>
<tr>
<td>a) 6000 micrograms</td>
</tr>
<tr>
<td>b) 65 micrograms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. How many milligrams are there in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 63 micrograms</td>
</tr>
<tr>
<td>b) 1684 micrograms</td>
</tr>
<tr>
<td>a) 0.063 milligrams</td>
</tr>
<tr>
<td>b) 1.684 milligrams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. How many nanograms are there in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 9 micrograms</td>
</tr>
<tr>
<td>b) 0.068 micrograms</td>
</tr>
<tr>
<td>a) 9000 nanograms</td>
</tr>
<tr>
<td>b) 68 nanograms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. How many moles are there in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 876 millimoles</td>
</tr>
<tr>
<td>b) 4324 millimoles</td>
</tr>
<tr>
<td>a) 0.876 moles</td>
</tr>
<tr>
<td>b) 4.324 moles</td>
</tr>
</tbody>
</table>

Drug Calculations: Part 3 Medicines: Tablets and Solutions

In this section we will look at calculating doses of tablets and solutions to be drawn up into a syringe. Formulae will be suggested, but using formulae is only one means of working out a calculation; you may have your own way which you are confident with, e.g. breaking a concentration down to a more manageable number. Another strategy, “proportional reasoning” uses the markings on syringes to work out doses.

There are no right or wrong methods; being able to demonstrate how the answer was reached would be vital if required to justify your actions in an incident. You must work out the answer independently and check this with the other practitioner.

It is recognised that contextualising the calculation gives meaning to the numbers, therefore try to visualise the area in which you work, the medicines you will be using, where they are stored, how they present: vials, ampoules, bags, etc, and keep focused on their units of measurement. This all helps keep these mathematical questions clinically orientated.

Tablets / Capsules

The following formula is useful in working out the number of tablets required from a prescription; you probably use this every day without thinking of it as a formula.

Formula:

$$\frac{\text{Prescribed Dose}}{\text{Strength of tablet}} = \text{Number of tablets to be given}$$

Which is the same as saying:

$$\frac{\text{What you want}}{\text{What you've got}} = \text{Number of tablets to be given}$$

i.e. divide what you want by what you’ve got to work the number (tabs) to be given

Worked example

Name:…Tom Patient............... D.O.B……01.01.50...........

REGULAR THERAPY

<table>
<thead>
<tr>
<th>Date</th>
<th>→</th>
<th>Time ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Drug (approved name)

Ampicillin

16

8
<table>
<thead>
<tr>
<th>Dose</th>
<th>Route</th>
<th>Signature</th>
<th>Start date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>500mg</td>
<td>oral</td>
<td>M. Rose</td>
<td>29.10.11</td>
<td>Pharmacy</td>
</tr>
</tbody>
</table>

**Question:**

You have 250mg capsules of Ampicillin in stock. How many capsules should be given at 0600?

**Answer:**

\[
\begin{align*}
500\text{mg (what you want, i.e. prescribed dose)} & = 2 \text{ capsules} \\
250\text{mg (what you've got, i.e. the tablet/capsule strength)} &
\end{align*}
\]

**Please note:**

For clarity, the “oral” route must be written in full. This differs from the IV route, which can be abbreviated; NHS Lothian (2011a) recommends you encourage prescriptions to be written this way. Prescriptions, which are poorly written, do not comply with the Safe Use of Medicines Policy (NHS Lothian 2011a) and are potential risks.

**Calculate the following:**

1. You have scored tablets strength 10mg each. How many tablets would you give if the doctor prescribes:
   
   a) 20mg  
   b) 5mg  
   c) 0.03g

2. An antibiotic is available in 500mg capsules. How many would you give if the doctor prescribes:
   
   a) 1000mg  
   b) 1.5g
Solutions

The following formula is useful in working out how much of a solution needs drawn up from a vial or ampoule to give the correct dose prescribed for the patient. You might use this for making up a bolus injection or an additive to a bag or syringe.

Where you see a ‘forward slash’ sign, this means ‘per’.
- For example, 2mg/ml means there are 2mg of drug per millilitre of the solution.

Formula:

\[
\frac{\text{Dose prescribed}}{\text{Stock strength}} \times \text{Volume} = \text{Volume of stock solution to be given}
\]

This may be more easily remembered by using:

What you want \times \frac{\text{What it's in}}{\text{What you've got}} = \text{Volume to be given}

i.e. First of all: divide what you want by what you've got
Then, multiply the answer by what it's in to work out the volume to be given

Worked example:

Name: Tom Patient D.O.B...01.01.50...D.O.B......01.01.50...

<table>
<thead>
<tr>
<th>Date</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drug (approved name)</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furosemide</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dose</th>
<th>Route</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>40mg</td>
<td>IV</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature</th>
<th>Start date</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. Rose</td>
<td>29.10.11</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>By infusion</td>
<td></td>
</tr>
<tr>
<td>Pharmacy</td>
<td>22</td>
</tr>
</tbody>
</table>

How much of the stock solution is required to make up the dose required at 0600?

The stock available = Furosemide 10mg/1ml
Formula:

<table>
<thead>
<tr>
<th>What you want</th>
<th>X</th>
<th>Volume it’s in</th>
<th>=</th>
<th>Volume to be given</th>
</tr>
</thead>
<tbody>
<tr>
<td>Want</td>
<td>40mg</td>
<td>X</td>
<td>what it’s in</td>
<td>1ml</td>
</tr>
<tr>
<td>Got</td>
<td>10mg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate the volume of stock required for the following intravenous medication:

<table>
<thead>
<tr>
<th>Prescription</th>
<th>Stock available</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 20mg as an additive for infusion.</td>
<td>20mg ampoules in 10ml volume</td>
<td></td>
</tr>
<tr>
<td>2. 8mmol to be added to an intravenous infusion.</td>
<td>2mmol per ml</td>
<td></td>
</tr>
<tr>
<td>3. 250mg for bolus injection</td>
<td>The stock dose available is 800mg in 20ml volume</td>
<td></td>
</tr>
<tr>
<td>4. 500mg to be added to a bag for intermittent infusion</td>
<td>The stock dose available is 250mg in 5ml volume</td>
<td></td>
</tr>
<tr>
<td>5. 50000 units heparin for a continuous infusion.</td>
<td>The stock dose available is 1000units/ml</td>
<td></td>
</tr>
<tr>
<td>6. 50 units insulin</td>
<td>The stock dose available is 100 units/ml</td>
<td></td>
</tr>
</tbody>
</table>
PERCENTAGE WEIGHT / VOLUME calculations:

The solutions formula can also be used for what at first may seem like a more complicated calculation. You may have noticed that the solution in a bag of crystalloids is described as percentage weight / volume (%w/v)

   e.g. Sodium chloride 0.9%w/v

Drugs measured using %w/v come in differing forms, e.g. 500ml bags or 10 ml ampoules, etc. But what does this mean in practice?

Percentage weight / volume (%w/v) means: number of grams of solute per 100ml.

For example:
Dextrose 5%w/v = 5g of dextrose per 100ml
Potassium Chloride 15%w/v = 15g of potassium chloride per 100ml
Sodium Bicarbonate 8.4%w/v = 8.4g sodium bicarbonate per 100ml
Magnesium Chloride 40.6%w/v = 40.6g magnesium chloride per 100ml
Calcium Gluconate 10%w/v = 10g calcium gluconate per 100ml

The simplest way to consider a percentage weight / volume question is to remember what %w/v means: grams of solute per 100ml. If you hang on to this principle then you can use this throughout as part of your calculation.

Worked example:

4g of a drug is prescribed to add to a 100ml IVI. The stock available is 10%w/v in 10ml ampoules
What volume of the drug is required to make up the prescription?

Step 1
Work out what does 10%w/v actually mean?
   = 10%w/v means there are 10g solute per 100ml

Step 2
Use the Solutions formula to work out the answer:
What you want  x  what it's in
What you've got

So, adding the information we have to the formula:

Want: 4g   x Volume 100ml = 40ml
Got: 10g

Answer:
The volume of drug required = 40ml.

Keeping it in context:
The stock of 10%w/v comes in 10ml ampoules. So, you will need 4 x 10ml ampoules of stock to make up this prescription.

500ml bags
You may also want to know how much of a solute is in a 500ml bag of fluid.

Using other familiar examples:
**0.9% Saline w/v** means 0.9g Saline per 100ml and 0.9g Saline x 5 in 500ml bag = 4.5g Saline in 500ml bag 0.9% w/v Saline

**5% w/v Dextrose** means 5g dextrose per 100ml and 5g dextrose x 5 in 500ml bag =25g dextrose in 500ml bag 5% w/v Dextrose

Or, using the formula:

- For 0.9% w/v saline in 500ml bag: (means 0.9g sodium chloride in 100ml)
  - Want 500ml
  - X Volume 0.9g
  - = 4.5g sodium chloride in 500ml bag
  - Got 100ml

- For 5% w/v Dextrose in 500ml bag: (means 5g dextrose per 100ml)
  - Want 500ml
  - X Volume 5g
  - = 25g dextrose in 500ml bag 5% w/v Dextrose
  - Got 100ml

### Calculate the volume of stock required for the following prescriptions:

<table>
<thead>
<tr>
<th>PRESCRIPTION</th>
<th>STOCK AVAILABLE</th>
<th>ANSWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1g of a drug is prescribed for a 100ml I.V.I.</td>
<td>10ml ampoules which are 10% w/v</td>
<td></td>
</tr>
<tr>
<td>2. 5g of a drug is prescribed for a 100ml I.V.I.</td>
<td>10ml ampoules which are 20% w/v</td>
<td></td>
</tr>
</tbody>
</table>

### RATIO Calculations:

Some medications are described as, for example 1:1000 or 1:10000. These can either be calculated with the solutions formula, or proportionately; you should use whichever method you are comfortable with.

### Question:

Adrenaline 1:1000 contains 1g in 1000 ml

How many mg per ml?

Using the solutions formula:

\[(1g \text{ in } 1000 \text{ ml} = 1000 \text{mg in } 1000\text{ml})\]
**Adrenaline 1:10,000 contains 1g in 10000 ml**

**How many mg per ml?**

(You do not have to use both of these methods; use whichever you are comfortable with).

**Using the solutions formula:**

(1g in 10000 ml = 1000mg in 10000ml)

<table>
<thead>
<tr>
<th>Want 1mg</th>
<th>X What it’s in 10000ml</th>
<th>= 10ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Got 1000mg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Or, using proportion:**

(1g in 10000 ml = 1000mg in 10000ml)

<table>
<thead>
<tr>
<th>1000mg in 10000ml</th>
<th>100 mg in 1000 ml</th>
<th>10 mg in 100 ml</th>
<th>1mg in 10 ml</th>
<th>0.1 mg in 1 ml</th>
</tr>
</thead>
</table>

**Calculate the following:**

10ml ampoules of Adrenaline 1 in 1000 (1g:1000ml) are available on the ward. How much is required to give a dose of 15mg?

**Concentration and Syringe Driver Rates**

To run a highly concentrated medicine in its presenting, undiluted state via an IV may be toxic to the body’s systems. To make it less toxic the medicine must be diluted in saline or another prescribed fluid. This changes a highly concentrated medicine, e.g. Cyclazine (50mg in 1ml), to one where the concentration is more dilute. This diluted medicine then runs at a slow rate over a prescribed period of time for longer lasting, positive effects.
What you will need to consider when changing the concentration from stock to a diluted state is the end result of this dilution process: how much of the medicine (mg/micrograms, etc) is now in each ml of the prescribed fluid; this is the final medicine concentration (after dilution).

When prescribing, the doctor considers this final medicine concentration state. The prescription reflects the number of, for example, mg / micrograms / units per ml required in the final medicine concentration process. The diluting solution (e.g. saline, dextrose etc) plays an active part in transforming the concentrated medicine state into the diluted state, so the diluting fluid will also be prescribed by the doctor. The choice of diluting fluid depends on medicine interaction / compatibility; the Preparation and Administration of Parenteral Medicines (NHS Lothian Version 4) should be used for reference.

The formula for working out concentration:

\[
\text{Concentration} = \frac{\text{Total amount of medicine used}}{\text{Total volume in syringe}}
\]

The formula for working out syringe pump rate:

\[
\text{Rate of infusion (ml per hour)} = \frac{\text{Dose Prescribed}}{\text{Concentration of infusion (per ml)}}
\]

Medicines that require a specific rate of administration may be delivered via a syringe pump or driver. This section deals with syringe drivers; the Alaris Asena or Graseby 3000 series.

**Worked Example:**

Name: ...Tom Patient...................  
D.O.B......01.01.50............... 

<table>
<thead>
<tr>
<th>Drug (approved name)</th>
<th>Dose</th>
<th>Route</th>
<th>Signature</th>
<th>Start date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAMADOL</td>
<td>100mg</td>
<td>IV</td>
<td>M. Rose</td>
<td>29.10.11</td>
<td>Dilute to 20ml, rate 20mg per hour</td>
</tr>
</tbody>
</table>

So:

```
- The doctor prescribes Tramadol at a rate of 20 mg per hour
- The concentrated stock of Tramadol is 50mg in 1ml
- The prescription requests the stock to be diluted so that 100mg Tramadol is in 20ml.

**Question:**
What is the final medicine concentration of this prescription?

**Formula:**

\[
\text{Concentration} = \frac{\text{Total amount of medicine used}}{\text{Total volume in syringe}} = \frac{100\text{mg}}{20\text{ml}} = 5\text{mg per ml}
\]

Or, by diluting the concentrated stock (50mg per ml) down, the prescription requires Tramadol to be delivered to the patient as 100mg in 20ml = 5mg per ml (100mg ÷ 20ml = 5mg per ml). The final medicine concentration of this diluted stock of Tramadol is now = 5mg per ml.

**Answer:**
The final medicine concentration of this prescription is 5mg per ml.

**Question:**
What volume of Tramadol stock is required to make up the prescribed final medicine concentration?

**Formula:**

\[
\text{Want} \quad 100\text{mg} \quad \times \quad \text{Got} \quad 50\text{mg} \quad \times \quad \text{Volume 1ml} = 2\text{ml}
\]

**Answer:**
So, using the stock solution, 2ml of Tramadol is required.

**Question:**
What volume of the diluent is required to make up prescribed final medicine concentration?

Total volume of medicine and diluent = 20ml
Volume of medicine from stock = 2ml
So, diluent required for the final medicine concentration = 20ml – 2ml = 18ml of diluent required.
**Answer:**
18ml of the diluent is required.

**Question:**
The doctor has prescribed Tramadol to run at an hourly rate of 20mg per hour. What will the rate setting be?

**Formula:**

\[
\text{Rate} = \frac{\text{Prescribed dose}}{\text{Concentration of diluted stock per ml}} = \frac{20\text{mg/ml}}{5\text{mg/ml}} = 4\text{ml per hour}
\]

**Answer:**
The rate setting will be 4 ml per hour.

**Calculate the following:**
You are given the total medicine used for this infusion and the total volume of medicine and diluent.

Name:…Tom Patient….............. D.O.B……01.01.50………………

<table>
<thead>
<tr>
<th>Drug (approved name)</th>
<th>Start Date</th>
<th>Signatures</th>
<th>Route</th>
<th>Time</th>
<th>Dose</th>
<th>Notes</th>
<th>Date</th>
<th>Time</th>
<th>Pharmacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALFENTANIL</td>
<td>29.10.11</td>
<td>M. Rose</td>
<td>IV</td>
<td>12</td>
<td>15mg</td>
<td>Dilute to 60ml</td>
<td>14</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

**Question 1:**
What would the final medicine concentration be?
Formula:

\[
\text{Concentration} = \frac{\text{Total amount of medicine}}{\text{Total volume in syringe}}
\]

Answer:

Question 2:
Your patient is prescribed 3mg per hour. What rate would you set the pump at in order to deliver the prescribed hourly dose?

Formula:

\[
\text{Rate of infusion (ml per hour)} = \frac{\text{Dose prescribed}}{\text{Concentration of diluted stock per ml}}
\]

2. Answer:

Herarin

Heparin is calculated in units rather than milligrams. The recommended approach is to prepare an infusion with a final concentration of Heparin 1000 units per ml. This can then be administered according to patient requirements (dependant on clotting time), usually on a ‘sliding scale’ designated by the doctor.

Please note: Although Heparin 1000 units/ml is the most commonly stocked strength, staff need to be aware that, in some areas, Heparin is supplied in different strengths; check the heparin monograph in the Preparation and Administration of Parenteral Medicines (NHS Lothian Version 4) and be aware of the risks of confusing strengths.

For standard use of heparin, staff must use the new NHS Lothian Adult Heparin Infusion Chart (Sept 2010) with a total dose of 40000 units Heparin in 40ml (final concentration 1000 units/ml). The chart is accessible on the Staff Intranet, via Homepage>Healthcare>A->Haematology>Haematology documents> Policy documents. Ensure you familiarise yourself with this chart/policy.
**Worked example:**
Calculate how to prepare a Heparin infusion so that a dose of 1600 units is delivered at a rate of ml per hour. Final concentration is to be 1000units/ml.

Stock strength Heparin available:

**Question:**
Using the stock above, how would you make an infusion of 40 ml containing 40000 units (i.e. final concentration 1000 unit/ml)?

**Formula:**

<table>
<thead>
<tr>
<th>What you want</th>
<th>x</th>
<th>what it’s in</th>
<th>=</th>
<th>volume required</th>
</tr>
</thead>
<tbody>
<tr>
<td>40000 units</td>
<td>x</td>
<td>1ml</td>
<td>=</td>
<td>40ml required</td>
</tr>
<tr>
<td>1000 units</td>
<td></td>
<td></td>
<td></td>
<td>1000 units/ml</td>
</tr>
</tbody>
</table>

**Answer:** 40ml Heparin required.

**Question:**
To make up the final medicine concentration prescribed; does this infusion need to be further diluted?

**Answer:**
Total volume is to be 40ml. If 40 ml of the drug is required to make up the prescribed volume of, then NO diluent is required to reconstitute this medicine.

**Question:**
The prescription requires 1600 units Heparin per hour. What will the rate setting be?

**Formula:**

\[
\text{Rate of infusion (ml per hour)} = \frac{\text{Dose prescribed}}{\text{Concentration}}
\]

\[
= \frac{1600 \text{ units per hour}}{1000 \text{ units/ml}}
\]

\[
= 1.6 \text{ml per hour}
\]

**Answer:**
The rate setting will be 1.6ml per hour.

**Calculate the following:**
A Heparin infusion is requested to contain 1000 units per ml. You are required to prepare a total volume of 40 ml. The stock strength Heparin you have available is 1000units/1ml.
### Questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How many units of Heparin will be required, in total, to make up this infusion?</td>
<td></td>
</tr>
<tr>
<td>2. What volume of stock Heparin would you require to prepare the infusion?</td>
<td></td>
</tr>
<tr>
<td>3. What volume of NaCl 0.9% would you add to the syringe to make up this infusion?</td>
<td></td>
</tr>
<tr>
<td>4. If the patient was prescribed 1400 units per hour. At what rate would you set the infusion device?</td>
<td></td>
</tr>
<tr>
<td>5. How many m\text{\text{l}} of Heparin will have been delivered after 12 hours?</td>
<td></td>
</tr>
<tr>
<td>6. How many m\text{\text{u}}\text{n}its of Heparin will have been delivered after 12 hours?</td>
<td></td>
</tr>
</tbody>
</table>

### Weight Related Drugs

A number of medicines are prescribed according to body weight in kg, i.e. a quantity of medicine (e.g. nanogram, mg or some other metric unit of measurement) per kg of body weight. A time factor may also be included (e.g. per minute, per hour). Gentamicin and Acetylcysteine are examples of medicines which require to be prescribed according to the patient’s weight.

NHS Lothian issued guidance on the use of Gentamicin and Vancomycin in December 2010 (Antibiotic Prescribing Guidelines in Adults, NHS Lothian 2010e), available on the Intranet at healthcare>A-Z>Antimicrobial management team. These must be referred to for all patients requiring these medicines.

### Calculate the following:

A 60 kg patient is to receive an infusion of Dopamine at 2.5 microgram/kg/min.

### Formula:

\[
\text{Metric unit} \times \text{weight} = \text{dose per minute}
\]

\[
\text{Metric unit} \times \text{weight} \times 60 \text{ minutes} = \text{dose per hour}
\]
1. How many micrograms would this patient receive every minute?

Answer:

2. How many micrograms would this patient receive every hour?

Answer:

Part 3 – Answers

Tablets / Capsules answers:

1. You have scored tablets strength 10mg each. How many tablets would you give if the doctor prescribes:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 20mg</td>
<td>20 = 2 tablets</td>
</tr>
<tr>
<td>b) 5mg</td>
<td>5 = ½ tablet</td>
</tr>
<tr>
<td>d) 0.03g</td>
<td>Convert 0.03g to milligrams: 0.03 x 1000 = 30mg</td>
</tr>
<tr>
<td></td>
<td>30 = 3 tablets</td>
</tr>
</tbody>
</table>

Solutions Answers:

2. An antibiotic is available in 500mg capsules. How many would you give if the doctor prescribes:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 1000mg</td>
<td>1000 = 2 capsules</td>
</tr>
<tr>
<td>b) 1.5g</td>
<td>Convert 1.5g to milligrams: 1.5 x 1000 = 1500mg</td>
</tr>
<tr>
<td></td>
<td>1500 = 3 capsules</td>
</tr>
<tr>
<td>Prescription</td>
<td>Stock available</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>1. 20mg as an additive for infusion.</td>
<td>20mg ampoules in 10ml volume</td>
</tr>
<tr>
<td>2. 8mmol to be added to an intravenous infusion.</td>
<td>2mmol per ml</td>
</tr>
<tr>
<td>3. 250mg for bolus injection</td>
<td>The stock dose available is 800mg in 20ml volume</td>
</tr>
<tr>
<td>4. 500mg to be added to a bag for intermittent infusion</td>
<td>The stock dose available is 250mg in 5ml volume</td>
</tr>
<tr>
<td>5. 50000 units heparin for a continuous infusion.</td>
<td>The stock dose available is 1000units/ml</td>
</tr>
<tr>
<td>6. 50 units insulin</td>
<td>The stock dose available is 100 units/ml</td>
</tr>
</tbody>
</table>

**Percentage Weight / Volume Answers:**

<table>
<thead>
<tr>
<th>PRESCRIPTION</th>
<th>STOCK AVAILABLE</th>
<th>ANSWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1g of a drug is prescribed for a 100ml I.V.I.</td>
<td>10ml ampoules which are 10% w/v</td>
<td>10%w/v means 10g of the drug per 100ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1g x 100ml = 10ml</td>
</tr>
<tr>
<td>2. 5g of a drug is prescribed for a 100ml I.V.I.</td>
<td>10ml ampoules which are 20% w/v</td>
<td>20%w/v means 20g of the drug per 100ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5g x 100ml = 25ml</td>
</tr>
</tbody>
</table>

**Ratio Answer:**

10ml ampoules of Adrenaline 1:1000 (1g: 1000ml) are available on the ward. How much is required to give a dose of 15mg?
(You do not have to use both of these methods, use whichever you are comfortable with).

**Using the solutions formula:**

1g in 1000ml = 1000mg in 1000ml

Want 15mg x What it's in 1000ml = 15ml
Got 1000mg

**Or using proportion:**

\[
\begin{align*}
1g & \text{ in } 1000ml = 1000mg \text{ in } 1000ml \\
1000mg & \text{ in } 1000ml \\
100mg & \text{ in } 100ml \\
10mg & \text{ in } 10ml \\
1mg & \text{ in } 1ml \\
15mg & \text{ in } 15ml \\
\end{align*}
\]

**Concentration and Syringe Driver Rate Answers:**

What would the final medicine concentration be?

**Formula:**

\[
\text{Concentration} = \frac{\text{Total amount of medicine}}{\text{Total volume in syringe}}
\]

**Answer:**

\[
\begin{align*}
\text{Concentration} & = \frac{\text{Total amount of medicine}}{\text{Total volume in syringe}} \\
& = \frac{15mg}{60ml} \\
& = 0.25mg/ml
\end{align*}
\]

Your patient is prescribed 3mg per hour. What rate would you set the pump at in order to deliver the prescribed hourly dose?

**Formula:**

\[
\text{Rate of infusion (ml per hour)} = \frac{\text{Dose prescribed}}{\text{Concentration of diluted stock per ml}}
\]
Rate of infusion (ml per hour)  = \( \frac{\text{Dose prescribed}}{\text{Concentration of diluted stock per ml}} \)

\[ = \frac{3\text{mg}}{0.25\text{mg/ml}} = 12\text{ml/hr} \]

**Heparin answers:**
A Heparin infusion is requested to contain 1000 units per ml. You are required to prepare a total volume of 40 ml. The stock strength Heparin you have available is 1000 units per ml.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How many units of Heparin will be required, in total, to make up this infusion?</td>
<td>40ml x 1000units = 40000units</td>
</tr>
</tbody>
</table>
| 2. What volume of stock Heparin would you require to prepare the infusion? | What you want x what it’s in = volume required  
What you’ve got  
\[ \frac{40000}{1000} \times 1\text{ml} = 40\text{ml} \] |
| 3. What volume of NaCl 0.9% would you add to the syringe to make up this infusion? | Total volume - volume of heparin = diluent required  
\[ 40\text{ml} - 40\text{ml} = 0\text{ml} \text{ diluent required} \] |
| 4. If the patient was prescribed 1400 units per hour. At what rate would you set the infusion device? | Rate of infusion = \( \frac{\text{dose prescribed}}{\text{concentration}} \)  
\[ \frac{1400\text{units}}{1000\text{units/ml}} = 1.4\text{ml/hour} \] |
| 5. How many ml of Heparin will have been delivered after 12 hours? | 1.4ml / hour x 12 = 16.8ml |
| 6. How many units of Heparin will have been delivered after 12 hours? | 1400units / hour x 12 = 16800units |
Weight related drugs answers:
A 60 kg patient is to receive an infusion of Dopamine at 2.5 microgram / kg / min.

Formula:

Metric unit X weight = dose per minute
Metric unit X weight X 60 minutes = dose per hour

1. How many micrograms would this patient receive every minute?

Answer:

2.5 micrograms x 60 = 150 micrograms per minute

2. How many micrograms would this patient receive every hour?

Answer:

2.5 micrograms x 60 x 60 = 9000 micrograms per hour

Medicine Calculations: Part 4 Infusion Device Calculations

SETTING THE RATE OF INFUSIONS – volumetric pumps

Dealing with whole hours:

Formula:

Volume of Fluid (ml) = Rate (ml per hour)
Number of Hours

Worked example:

A patient is prescribed 500ml, 5%w/v Dextrose, over a period of 4 hr

500ml = 125ml per hr
4hr
Dealing with part of hour:

If the time of infusion contains parts of an hour e.g. 1hr 30minutes, the following formula can be used.

**Formula:**

\[
\frac{60 \text{ minutes}}{\text{Number of minutes}} \times \frac{\text{Volume}}{1} = \text{Rate (ml per hour)}
\]

**Worked example:**

A patient is prescribed 150 ml, 5% w/v Dextrose, over a period of 1.5hrs

1.5 hours = 90minutes

So,

\[
\frac{60 \text{ minutes}}{90 \text{ minutes}} \times \frac{150 \text{ ml}}{1} = \frac{900}{9} = 100 \text{ ml per hr}
\]

**Calculate the rate for the following Infusions:**

<table>
<thead>
<tr>
<th>Infusion</th>
<th>Rate (ml per hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 500ml over 6hr</td>
<td></td>
</tr>
<tr>
<td>2 500ml over 8hr</td>
<td></td>
</tr>
<tr>
<td>3 1litre over 12hr</td>
<td></td>
</tr>
<tr>
<td>4 100ml over 0.5hr</td>
<td></td>
</tr>
<tr>
<td>5 250ml over 1hr</td>
<td></td>
</tr>
<tr>
<td>6 100ml over 20minutes</td>
<td></td>
</tr>
</tbody>
</table>

**Setting the Rate of Infusions - Syringe Pump Rates**

Medicines that require a specific rate of administration may be delivered via a syringe pump.

**NB.** The CME McKinley T34 automatically calculates and displays the deliverable volume, duration of infusion and rate of infusion. It is important that as practitioners you check the details on the display screen are correct before pressing Yes / start button.
A patient has been prescribed 30mg per hour of Tramadol via an Alaris Asena syringe pump. The medicine concentration in the syringe is 5mg of Tramadol per 1 ml of solution i.e. 5mg/ml.

**Question**
What will the rate setting be in order for the patient to receive the prescribed hourly dose?

**Formula:**

<table>
<thead>
<tr>
<th>Rate = Prescribed dose</th>
<th>30mg/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration</td>
<td>5mg/ml</td>
</tr>
<tr>
<td></td>
<td>= 6ml per hour</td>
</tr>
</tbody>
</table>

**Answer:**
The rate setting will be 6 ml per hour.

**Please calculate the following:**

1. A patient has a prescription of Morphine made up in a syringe of 1mg/ml. What will the rate setting be of this infusion if the doctor prescribes 2mg per hour?

2. A patient’s prescribed for an IV infusion of Alfentanil 30mgs, added to a diluent to make a final volume of 60mls. The patient is prescribed 2mg per hour. What rate should you set the infusion device to deliver the prescribed hourly dose?

3. A syringe for IV administration is prepared following the prescription with a final concentration of Heparin 1,000 units per ml
   (a) The patient is to receive 1200 units Heparin per hour. What will the rate setting be?

   (b) Following the patients APPT result, the patient is to receive 1600 units of Heparin per hour. What will the rate setting now be?
Answers to Rate Calculations
Rate calculations for volumetric pumps:
1. 83.3 ml/hr
2. 62.5 ml/hr
3. 83.3 ml/hr
4. 200 ml/hr
5. 250 ml/hr
6. 300 ml/hr

Rate calculations for infusion pumps:
1. 2 ml/hr
2. 4 ml/hr
3. (a) 1.2 ml/hr
3. (b) 1.6 ml/hr

Medicine Calculations: Part 5 Additional Calculations

The following are examples of more challenging calculations. If you are going to be working in a critical care or other specialist areas where you may require these skills, it is recommended that you attempt them. NONE OF THESE CALCULATIONS ARE INCLUDED IN THE ASSESSMENT. If you are likely to encounter complex calculations in your clinical area, you should ensure you familiarise yourself with the medications used and the types of calculations required. Please approach the Clinical Education Practitioner/Charge Nurse in your area for help and direction with this.

1. An infusion of Dopamine is to be prepared in a 50 ml syringe with a concentration of 4 mg/ml. The stock strength of Dopamine contains 40 mg/ml in 5 ml ampoules.

   a) How much stock strength Dopamine is required to make up this infusion?

   b) How much NaCl 0.9% will be required to be added to make up to the final volume prescribed?

   A 75 kg patient is prescribed Dopamine 2.5 microgram/kg/min.

   c) How many micrograms will this patient receive per hour?

   d. At what rate will you set the infusion device to administer the prescribed dose? (Note you will need to convert into mgs first).
2. Your patient requires an Amiodarone infusion. The loading dose is 5 mg / kg and your patient is 80 kg. To administer the loading dose it must be diluted to 45 ml with dextrose 5%. The stock solution of Amiodarone is 150 mg in 3 ml.

<table>
<thead>
<tr>
<th>a)</th>
<th>How many ml of the stock solution do you require for the loading dose?</th>
</tr>
</thead>
<tbody>
<tr>
<td>b)</td>
<td>The prescription states the loading dose is to be delivered over 45 minutes. At what rate in ml per hour do you set the syringe pump?</td>
</tr>
</tbody>
</table>

3. A patient is prescribed Sodium Thiosulphate IV infusion 25grams over 60 minutes. Stock available is 5gram ampoules, drug concentration 500mg per ml. The drug does not need to be diluted.

<table>
<thead>
<tr>
<th>a)</th>
<th>How many mls of drug would you prepare for infusion and what size of syringe is required?</th>
</tr>
</thead>
<tbody>
<tr>
<td>b)</td>
<td>What rate would you set your infusion device at?</td>
</tr>
</tbody>
</table>

4. The stock of Noradrenaline comes in ampoules containing 2mg per ml.

| What volume of this stock strength would you require to add to 500ml bag of dextrose 5% to make a final concentration of 80 micrograms per ml? |

5. The patient requires an Insulin/Dextrose infusion for hyperkalaemia. The prescription is for 50units Actrapid Insulin in 50ml 50% dextrose in a 50 ml syringe over 30 minutes. (50 units Actrapid = 0.5ml).

<table>
<thead>
<tr>
<th>a)</th>
<th>How would you prepare the infusion?</th>
</tr>
</thead>
<tbody>
<tr>
<td>b)</td>
<td>What rate would you set your infusion device at?</td>
</tr>
</tbody>
</table>
Part 5: Answers

**Additional Calculations Answers**

**Q1**  4mg x 50ml = 200mg

Want  200 mg x 1ml = 5ml Dopamine required to make up infusion
Got  40mg

a) 50 – 5ml = 45ml 0.9% sodium chloride

b) 75kg x 2.5micrograms x 60 minutes = 11250 micrograms per hour

➢ 11250 micrograms = 11.25mg per hour

c) 11.25 (what you want per hour)  
4 (concentration 4mg per ml) = 2.81ml per hour

**Q 2**  5 x 80 = 400mg loading dose

a) Want 400 mg  x 3 = 8ml stock required
Got 150mg

b) 400mg over 45 mins

60mins x 45ml = 59.9ml per hour
45mins

**Q 3** a) 50ml drug, 50 ml syringe

B 50ml/hr

**Q 4** Stock = 2mg per ml = 2000micrograms per ml

Prescription = 80 micrograms in 500ml

Want 80micrograms x 500ml = 20ml

Got 2000micrograms

**NB** to keep the final concentration of 80 micrograms per ml, 20ml should be withdrawn from the 500ml bag of dextrose before the drug is added. It should also be noted that each manufacturer provides an average in 500ml bags to allow for priming lines and pumps. This means of providing an accurate final drug concentration therefore relies on knowledge of how much each manufacturer adds to 500ml bags. Final drug concentration using this method is liable to error and should be used with caution.

**Q5a)** Draw up 50 units (0.5ml) Actrapid in an insulin syringe.

Draw up 49.5ml 50% dextrose in 50ml syringe.

Add insulin to the 50ml syringe to make the total volume of 50mls.

b) To deliver over 30mins:

60 x 50 = 100ml/hr

30
Section 9: Recognition and Treatment of Anaphylactic Reactions

Learning Objectives

On completion of reading this section, participants will be able to:

- Define Anaphylaxis
- Recognise the role of the immune system
- Identify the common causes
- List the signs and symptoms
- Describe the treatment.

Anaphylaxis

Anaphylaxis is a severe, life threatening generalised or systemic hypersensitivity reaction. Anaphylaxis has a broad range of potential triggers but the most common include food, drugs and venom. In many cases however no cause can be identified. This is termed an idiopathic reaction. Anaphylaxis can be a fatal event and when it is, death usually occurs very soon after contact with the trigger.

A diagnosis of anaphylaxis is likely if the patient:

- Is exposed to a trigger (allergen)
- Develops a sudden unexpected illness (within minutes of exposure)
- Have rapidly developing skin changes with life threatening airway and / or breathing and / or circulation changes.

Life threatening problems:

- **Airway** – swelling, hoarseness, stridor
- **Breathing** – rapid breathing, wheeze, fatigue, cyanosis, SpO2 less than 92%, confusion
- **Circulation** – pale, clammy, hypotension, faint, drowsy / coma.

Generalised signs such as urticaria (rash), angioedema (rapid swelling of the skin and mucosal tissue) and rhinitis (irritation and inflammation of the nose) would **NOT** be described as an anaphylactic reaction as there is no life threatening features.

All patients who have an anaphylactic reaction should expect the following as a minimum:

- Recognition that they are seriously unwell
- An early call for help
- Initial assessment and treatment
- Adrenaline therapy if indicated
- Investigation and follow up by an allergy specialist.

Treatment

Adrenaline is the most important drug and is the first line treatment for anaphylaxis. Adrenaline can reverse peripheral vasodilatation and oedema to help restore cardiac output and dilate the airway to ease breathing. Adrenaline also reacts directly on mast cells inhibiting the allergic response.
The intramuscular (IM) route is the safest and best route to give adrenaline to treat an anaphylactic reaction. Adrenaline is absorbed quickly and adverse effects are extremely rare when the correct dose is injected IM. Intravenous (IV) adrenaline is for use only by clinical experts such as anaesthetists, intensive care doctors and emergency physicians.

The NHS Lothian Protocol and Procedure for the Administration of Adrenaline (IM) in Life-threatening Anaphylaxis should be followed.

If the patient is conscious:

- Get Help
- Position patient for maximum relief
- Give high concentration oxygen if available
- Stop trigger if possible
- Give IM adrenaline as per chart below if there is life threatening Airway and/or Breathing and/or Circulation problems associated with skin and mucosal changes
- Monitor patient response and provide supportive treatment as required
- The dose of adrenaline may be repeated at 5-minute intervals until condition improves or help arrives
- Document in patient notes
- Complete prescription.

**Intramuscular Adrenaline 1: 1000 (1mg/1ml)**

<table>
<thead>
<tr>
<th>Patients Age</th>
<th>Dose and volume of adrenaline 1:1000 (1mg/1ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose</td>
</tr>
<tr>
<td>6 years and under</td>
<td>150 micrograms</td>
</tr>
<tr>
<td>6 –12 years</td>
<td>300 micrograms</td>
</tr>
<tr>
<td>Adult and adolescent</td>
<td>500 micrograms</td>
</tr>
<tr>
<td><strong>Epipen</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
</tr>
<tr>
<td></td>
<td>(contains 2 mls of which 1.7 mls will be left in auto injector after use)</td>
</tr>
<tr>
<td></td>
<td>Paediatric</td>
</tr>
<tr>
<td><strong>Anapen</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
</tr>
<tr>
<td></td>
<td>Junior</td>
</tr>
</tbody>
</table>

If the patient is unconscious:

- Assess patient as per current resuscitation guidelines
- Call 2222/9999 or get help as per local operational policy
- Commence cardiopulmonary resuscitation (CPR) until help arrives
Time out for reflection

Can you answer or find out about the following:

- Where (how many places) is information documented on the allergy status of the patient, and who documents this?
- What is the dose of adrenaline used in anaphylaxis?
- What do you consider are the initial 5 life saving actions in the treatment of anaphylaxis?
- What access do you have and what equipment and drugs do you have available for the management of an anaphylactic reaction in your clinical area?

Further Reading

Also available from RC (UK) website http://www.resus.org.uk

- Current Resuscitation Guidelines – BLS and ALS for adults and children.
- Anaphylaxis – guidelines, algorithms and frequently asked questions.
- Anaphylaxis section of the Lothian Adult Medical Emergencies Handbook.

Available on Lothian intranet – Healthcare / Clinical Guidance / Clinical policies

- Protocol and Procedure for the Administration of Adrenaline (IM) in Life Threatening Anaphylaxis.


See attached anaphylaxis algorithms.
Anaphylactic reactions – Initial treatment

Anaphylactic reaction?

Airway, Breathing, Circulation, Disability, Exposure

Diagnosis - look for:
- Acute onset of illness
- Life-threatening Airway and/or Breathing and/or Circulation problems
- And usually skin changes

Call for help
- Lie patient flat
- Raise patient’s legs (if breathing not impaired)

Intramuscular Adrenaline

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 Intramuscular Adrenaline
- IM doses of 1:1000 adrenaline (repeat after 5 min if no better)
  - Adult: 500 micrograms IM (0.5 mL)
  - Child more than 12 years: 500 micrograms IM (0.5 mL)
  - Child 6-12 years: 300 micrograms IM (0.3 mL)
  - Child less than 6 years: 150 micrograms IM (0.15 mL)

March 2008

Resuscitation Council (UK)
Anaphylaxis algorithm

Anaphylactic reaction?

Airway, Breathing, Circulation, Disability, Exposure

Diagnosis - look for:
• Acute onset of illness
• Life-threatening Airway and/or Breathing and/or Circulation problems
• And usually skin changes

• Call for help
• Lie patient flat
• Raise patient’s legs

Adrenaline

When skills and equipment available:
• Establish airway
• High flow oxygen
• IV fluid challenge
• Chlorphenamine
• Hydrocortisone

Monitor:
• Pulse oximetry
• ECG
• Blood pressure

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 min if no better)
• Adult: 500 micrograms IM (0.5 mL)
• Child more than 12 years: 500 micrograms IM (0.5 mL)
• Child 6-12 years: 300 micrograms IM (0.3 mL)
• Child less than 6 years: 150 micrograms IM (0.15 mL)

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

3 IV fluid challenge:
Adult: 500 – 1000 mL
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

March 2008
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Web resources
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www.yellowcard.gov.uk date accessed 04/11/11 – reporting adverse drug events
http://nhsdiabetes.healthcareea.co.uk accessed 15/11/11, register for a module on The Safe Use of Intravenous Insulin Infusions