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KEY OBJECTIVES

After reading this chapter, you should be able to:

- outline the procedure for administering an oral medicine
- demonstrate how to fill a syringe in preparation for administration of an injection
- plot the sites for the administration of subcutaneous and intramuscular injections on a blank model
- list the hazards associated with the administration of injections and describe how they may be minimised
- outline the advice you would give to a patient being discharged using glyceryl trinitrate patches for the first time
- be able to interpret the prescription for an oral (or other non-injectable) preparation
- be able to calculate an oral (or other non-injectable) dose
- be able to interpret a standard label for an oral (or other non-injectable) preparation
- be able to interpret and calculate as above for a parenteral dose.

INTRODUCTION

Many conditions are treated systemically using medicines administered either by mouth or by injection. The procedural details are highly relevant.
to all nurses, because by far the majority of medicines are given by these routes. The transdermal route is also included. The advantages and disadvantages of each route are given in Table 4.1. These routes are not specific to any system of the body, and so they have been grouped together in one chapter.

**ADMINISTRATION OF MEDICINES BY MOUTH**

For the majority of patients, the most convenient and acceptable method of receiving medication is by mouth. Most medicines taken by mouth are intended to be swallowed, and are referred to as oral medicines. Others, known as sublingual, are specifically for dissolving under the tongue; some, known as buccal, are for holding against the mucous membranes of the cheek.

**ORAL ADMINISTRATION**

Tablets, capsules and liquid preparations are relatively easy to administer and are suitable delivery systems for drugs that are effective when given orally. If a tablet or capsule sticks in the oesophagus, it can cause irritation to the point of ulceration of the mucosa, especially with drugs such as ferrous salts. Small tablets are generally easy to swallow. Larger uncoated tablets may present problems; torpedo-shaped coated tablets are more patient-friendly. It is important that soluble tablets and effervescent tablets are completely dissolved in water prior to administration. To ensure complete
transit from mouth to stomach, tablets and capsules should be swallowed with a large drink, ideally when
standing. Where this is not possible, the patient should be in the sitting position (Channer 1985).

The disguising of medicines in food and drink without informed consent is a complex issue. Covert
administration of medicines to patients in Norwegian nursing homes was revealed in a study of 243 patients,
of whom 95% had their drugs mixed in food and beverages routinely (Kirkevold and Engedal 2005).

The principles involved are underpinned by the Human Rights Act 1998. Registered nurses need to be
sure that what they are doing is in the best interests of the patient, and are reminded of their accountability
in any decision they make regarding what may be seen as misleading the patient (Nursing and Midwifery
Council 2006, pp. 7–8). The doctor and pharmacist are available to suggest alternatives and to provide
professional support. Any duty of care argument should be supported by good record keeping (Nursing
and Midwifery Council 2006, p. 8).

ADMINISTERING ORAL SOLID DOSAGE FORMS

Patients have their own preferences as to the order in which they take their medicines. For example, they
may take unpleasant-tasting ones first or those that for some reason cause them a problem. Patients who
have difficulty swallowing tablets may be assisted in a number of ways.

- A drink beforehand moistens the mouth and gets the
  swallowing process started.
- When the tablet is large and is scored, it may be
  split in two or even four. A specially designed
  tablet splitter may be helpful. Some tablets are not
  designed to be split, and attempts to do so could
  lead to an inaccurate dose being administered. If for
  any reason the tablet is unsuitable, the pharmacist
  should be asked to advise.
- In certain instances, the tablet may be crushed
  using a mortar and pestle or specially designed
  tablet crusher. Enteric-coated or sustained-release
  formulations must not be split or crushed, because
  this could destroy the properties of the tablet and
  cause gastric irritation or premature release of the
  drug into an incompatible pH. The crushing of
  a tablet or opening of a capsule not specifically
  designed for this purpose renders its use unlicensed
  (Nursing and Midwifery Council 2006, p. 6).
- Some patients find it helpful to place the tablet at the
  back of the tongue, take a draught of water and tilt
  the head back before swallowing. This stimulates the
  back of the tongue and produces a swallowing reflex.
- For those who cannot swallow tablets or capsules,
  a liquid form of the medicine may be available.
- For dysphagic patients, consideration of the viscosity
  of an oral liquid medicine is important. Patients with
  swallowing difficulties may be more able to swallow a
  more viscous preparation than a very mobile liquid.

Whenever possible, patients should put the tablet or capsule into the mouth themselves. By observing
patients attempting to take a tablet and assessing their capabilities generally, the nurse can decide how best
to present further medicines. The methods employed are:

- taking directly from a spoon or medicine measure
- transferring from spoon or measure into the palm of
  the hand
- picking up using the thumb and forefinger.

However, some difficulties are encountered with each of these methods. For example:

- a spoon is not advisable for patients with any degree
  of tremor
- medicine measures are not designed with the size of
  an adult’s nose in mind
- unless the medicine measure is completely dry,
  tablets can adhere to the measure and may be lost
- tablets or capsules may be dropped or may stick to
  the hand if moist
- intention tremor and stiff joints may make picking
  up difficult or impossible.

In general, patients who are elderly, frail, poorly
sighted or confused are helped if the tablets are placed
in a row on the medicine tray, accompanied by a glass
of water or a suitable beverage. In this way, they are
more likely to see what they are to take: the colour of
the tablets and the number. They can then safely pick
each one up themselves and so retain some degree of
independence. Hemiplegic patients find this a helpful
method, especially when more than one tablet has to
be taken. Using the unaffected hand, they require to
break down the process. For example:

- pick up glass, take drink, lay down glass
- pick up first tablet, place in mouth
- pick up glass, take drink, lay down glass
- pick up next tablet ... and so on.

White tablets may be overlooked when they are laid
out on a white tray, and so care must be taken to ensure
that none has been missed. If the tray is used in this
way, it must be washed before and after use.

Care must be taken, particularly when there is facial
paralysis, to ensure that the tablets are swallowed and
not retained in the side of the mouth. Patients who do not want to take their tablets are sometimes known to retain the tablet between the gum and cheek until the staff are out of sight and then reject the tablet, often into the bed.

An adequate volume of fluid, for example at least 100 mL, ensures transport into the gastrointestinal tract. Apart from personal tastes and preferences, the choice and volume of liquid to be used will depend on a number of factors. Clearly, for patients on restricted fluids the volume may be critical. Milk may inhibit the absorption of some drugs, and acidic fruit cordials tend to cause capsules to swell, which may make swallowing more difficult. Improved formulations are a help in disguising the taste of many drugs, but children of all ages may welcome the traditional ‘spoonful of sugar’.

 Severely breathless patients may find swallowing difficult, and very drowsy patients may be unable to cooperate in taking medicines, with a risk of accidental inhalation. In such cases, other routes may have to be used.

If a patient rejects part of a dose or vomits after swallowing a dose of medicine, the doctor should be informed of this along with the time lapse between drug administration and emesis or rejection. Vomitus should be retained for examination of drug content.

ADMINISTERING ORAL LIQUID DOSAGE FORMS

• All liquid medicines should be thoroughly shaken before use and measured at eye level in a good light using a suitably designed measure, i.e. a measure with clear graduations that is convenient to pour into.
• When pouring a liquid medicine, the bottle is held with the label uppermost so that any drips will not deface the label.
• Viscous suspensions, syrups, etc. can be more completely administered if taken from a suitable graduated spoon rather than from a medicine measure. A standard 5-mL spoon should normally be used. However, medicine spoons of different designs are available, the choice depending mainly on acceptability to the patient. Care should be taken not to overfill a medicine spoon when administering a viscous preparation.
• The formulation of liquid medicines presents many problems, not least of which is to achieve an acceptable taste. If particular problems are experienced, the clinical pharmacist should be consulted, as dilution or an alternative formulation may be available.
• It is necessary to ensure that soluble (effervescent) tablets are completely dissolved prior to administration, but an excessive volume should not be used because this could make the resulting solution less acceptable to the patient.
• When the medicine is presented in powder form to be reconstituted (e.g. unstable antibiotics), the date of reconstitution or expiry should be marked on the bottle. The diluent and volume to be used will be specified on the label. If further dilution of the reconstituted medicine is required, this should be undertaken only in the pharmacy.
• Reconstituted medicines will normally require storage in a refrigerator, and it is very important to shake the bottle well prior to administration.
• When liquids are being instilled in the mouth from a dropper, a separate bottle and dropper are used for each patient.
• In some instances, a specially designed oral syringe may be useful, for example for severely disabled people or when specially potent oral liquid medicines are in use. Graduated droppers are supplied for use with high-dose oral morphine preparations.
• The bottle should be wiped clean after use to reduce the build up of bacteria and make for safer handling.

The administration of oral medicines is summarised in Box 4.1.

<table>
<thead>
<tr>
<th>Box 4.1 Administration of oral medicines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Documentation</strong></td>
</tr>
<tr>
<td>• Prescribing and recording sheet</td>
</tr>
<tr>
<td><strong>The medicine</strong></td>
</tr>
<tr>
<td>• Oral solids (tablet, capsule, lozenge, granules)</td>
</tr>
<tr>
<td>• Oral liquids (mixture, suspension, emulsion, linctus)</td>
</tr>
<tr>
<td><strong>The nurse and the patient</strong></td>
</tr>
<tr>
<td>• Identification of patient</td>
</tr>
<tr>
<td>• Explanation given to patient</td>
</tr>
<tr>
<td><strong>Technique</strong></td>
</tr>
<tr>
<td>• The nurse’s hands should be socially clean</td>
</tr>
<tr>
<td>• Whenever possible, the patient should be in an upright position</td>
</tr>
<tr>
<td>• Whenever possible, patients should put the medicine into the mouth themselves</td>
</tr>
<tr>
<td>• The nurse should witness the medicine being taken</td>
</tr>
<tr>
<td>• If required, any fluid taken should be recorded on the patient’s fluid balance chart</td>
</tr>
<tr>
<td>• Any medicines rejected should be retained</td>
</tr>
<tr>
<td><strong>Problems</strong></td>
</tr>
<tr>
<td>• Irritation of gastrointestinal tract</td>
</tr>
<tr>
<td>• Aspiration of the medicine</td>
</tr>
<tr>
<td>• Staining of teeth and lips</td>
</tr>
</tbody>
</table>
SUBLINGUAL ADMINISTRATION

First-pass metabolism is avoided when drugs are given by the sublingual route (i.e. under the tongue), because the drug passes directly into the general blood circulation via the blood vessels on the undersurface of the tongue. Sublingual tablets are uncoated, ready for absorption. Once the tablet has been placed under the tongue, the patient should keep the mouth closed and refrain from swallowing saliva for as long as possible, as this contains the drug that will be absorbed. As absorption through the oral mucosa is rapid, the effects of the drug become apparent within a minute or two.

Tablets to be given by this route must be prescribed as such. The method of administration is simple, requiring no liquid and demanding little effort from the patient. The cooperation of the patient is necessary, however, and a clear explanation of this method of administration should be given. Although no harm will ensue if the tablet is swallowed, the patient will benefit from the drug only if it is taken sublingually.

The ease with which drugs can be given by this route can be used to advantage in pre- and postoperative patients and in those who are terminally ill, in whom swallowing of tablets can be a problem.

The sublingual route is also useful when there is risk of symptoms arising unexpectedly and when a rapid effect is wanted, such as in angina. Patients who are prescribed glyceryl trinitrate tablets for prevention of anginal attacks should be advised to carry with them a small supply of the tablets at all times. The expiry date (8 weeks after opening) should be carefully noted on the label of the container. Once individual patients realise which activities tend to precipitate an attack, they should get into the habit of placing the tablet under the tongue just before embarking on any of these activities. When the tablet is used to alleviate an anginal attack, it should be taken immediately the pain is experienced and retained under the tongue until the pain is relieved, after which any of the tablet remaining is spat out. This may help to prevent headache caused by cerebral vasodilatation, which often follows administration of this drug. Sublingual glyceryl trinitrate may also be administered in the form of an aerosol spray.

BUCCAL ADMINISTRATION

When a tablet is to be held in the mouth against the mucous membranes, the method of administration is described as buccal. This specific route appears on the packaging and on the prescription. It refers to the area high up between the upper lip and the gum where the dosage form is left to dissolve. Tablets for buccal administration are uncoated to facilitate absorption. Glyceryl trinitrate and prochlorperazine maleate are available as buccal tablets. The site chosen should be varied to reduce the risk of dental caries.

MEDICINE ROUNDS

Despite an increase in self-administration, the majority of medicines in hospital are still administered consecutively to groups of patients in the form of a medicine round (Box 4.2). A medicine trolley or an individual medicine cabinet may be used.
ADMINISTRATION OF MEDICINES BY INJECTION

Medicines should be administered by injection only when no other route is suitable, because of their hazardous nature (Clinical Resource and Audit Group of NHS Scotland 2002). When there is no alternative but to use this method, every precaution must be taken to minimise the risks involved (see Table 4.2). In the interests of safety, staff training in the preparation and administration of intravenous injections should be supported by a standard operating procedure (Millar et al. 2006). There are a number of reasons why some medicines require to be administered by this method. For example:

- they may not be absorbed when given by mouth (e.g. gentamicin)
- they may be destroyed in the stomach (e.g. insulin)
- rapid first-pass metabolism may be extensive (e.g. lignocaine [lidocaine])

- a fast onset of action may be required in an emergency
- very precise control over dosage may be needed
- because the patient is unable, for whatever reason, to take the medicine by mouth
- to achieve high drug plasma levels.

Because the routes used for administering injections do not involve the gastrointestinal (enteral) tract, drugs prepared for injection are often described as for parenteral use.

PRESENTATION AND PREPARATION OF SMALL-VOLUME INJECTIONS

Small-volume injections are presented in the form of an ampoule or a rubber-capped vial.

AMPOULES

Ampoules are mostly made of glass (an inert material) of special quality that does not react with the contents. Plastic ampoules are now used for certain products. Sizes range from 0.25–50 mL. Ampoules normally
contain solutions ready for use but may contain a sterile powder for reconstitution.

An ampoule has a body containing the drug, a top, and a narrow constriction in between referred to as the neck (Fig. 4.1). The neck may be marked with a white ring, or the top may have a coloured spot. These indicate where the ampoule is to be snapped off to enable the contents to be accessed. Some ampoules have coloured rings on the neck that help in avoiding mix-ups. These rings must not be used to identify the product.

Ampoule-opening devices of various designs are available (Fig. 4.2). Plastic ampoules are accessed by twisting off a tab on the neck or by direct penetration with a needle at a site indicated on the ampoule. Ampoules whose tops have been removed cannot be resealed and are therefore for single use only. Any unwanted contents must be discarded.

After shaking down any solution that has entered the neck, the neck is wiped with an alcohol swab to remove any surface contamination and the top snapped off using an ampoule sleeve to protect the fingers from glass spicules and/or any sharp edges. Less commonly, it may be necessary to make a scratch on the ampoule using a small file.

**VIALS**

Rubber-capped vials are used for solutions for injection and sterile powders for reconstitution (Fig. 4.3). They are squat glass containers closed with a rubber plug that is held in place by a metal ring. The exposed rubber surface is generally covered with a protective pull-off metal or plastic disc.

Rubber-capped vials are capable of being used as multidose containers, because the rubber plug is self-sealing if correctly used. They should, however, be used as such only if the stability of the contents permits and there is a suitable antimicrobial preservative present in the formulation.

The disc is removed and the exposed surface swabbed with an alcohol swab and allowed to dry, prior to puncturing the centre of the rubber plug with a needle. To facilitate withdrawal of fluid, the plunger of the syringe is first withdrawn and air injected, the volume of air being the same as the volume of fluid to be withdrawn. The required dose is removed or the
required volume of the appropriate reconstitution fluid is added prior to the removal of the dose. Great care is essential in calculating what portion of the total volume is required from multidose vials. It is vitally important to follow the instructions regarding reconstitution and to ensure that the powder is dissolved before withdrawing the dose.

The needle is then changed after drawing up the injection and before injecting the patient, in case particles of rubber are retained inside the needle. Another good reason is that when a needle is inserted through the rubber cap, it may become dulled or the needle coating that helps it glide through the skin may be removed (Beyea and Nicoll 1996). Besides, because of the high risk of needlestick injury when resheathing a needle, the practice of using a new needle for administering the injection to the patient is obligatory (Royal College of Nursing 2006).

**RECONSTITUTION OF MEDICINES FOR INJECTION**

Where there are problems of stability, the drug may be presented in powder form, which requires reconstitution with a diluent. Reconstitution is most often done using water for injections, although in certain instances special diluents may be required. It should be recognised that the addition of 1 mL of diluent to 250 mg of a drug will produce a volume in excess of 1 mL. Normally this is of little consequence, but it may be important if a fraction of the total content of the vial is to be administered. For emaciated patients, the volume of reconstituting fluid should be the minimum compatible with the physical and other properties of the drug such as solubility, and any possible local irritancy should be taken into account. Once the contents of a multidose vial have been reconstituted, the vial must be dated and stored in the refrigerator.

On occasion, it may be desirable to combine two drugs in the same injection. This may present problems such as the physical/chemical incompatibility in the syringe and in the management of any subsequent drug reaction. The prime considerations here should be the safety and comfort of the patient. Comfort of the patient, however, should not be allowed to detract from safety in drug therapy. The advice of the prescriber and clinical pharmacist will often be helpful in resolving these difficult situations.

**ROUTES OF ADMINISTRATION**

The routes most commonly used for administering injections are:

- subcutaneous (SC; into the fatty layer beneath the skin)
- intramuscular (IM; into skeletal muscle)
- intravenous (IV; into a vein).

Intravenous medicines given by direct venepuncture are administered only by a doctor. A nurse who has undertaken specific training and is in possession of authorisation to do so may administer intravenous medication when venous access has already been established (Clinical Resource and Audit Group of NHS Scotland 2002). In clinical practice, there is widespread use of the intravenous route for the administration of drugs such as antibiotics and diuretics. However, some drugs still require to be given by either the subcutaneous or intramuscular route, and therefore nurses must maintain the skills involved.

The subcutaneous route is generally used for administering small doses of non-irritating, water-soluble substances. Drugs commonly given subcutaneously include:

- insulin
- heparin
- hyoscine
- vaccines.

Patients receiving outpatient treatment for certain ongoing conditions are encouraged to self-administer subcutaneous medication when possible. Examples include the administration of insulin, heparin, interferon and granulocyte-colony stimulating factor. Alternatively, a family member may be taught to do this.

The intramuscular route is used for administering formulations such as aqueous solutions, oily solutions and aqueous suspensions. Drugs commonly given intramuscularly include:

- analgesics
- sex hormones
- corticosteroids.

**RATE OF ABSORPTION**

The rates at which drugs are absorbed and take effect after subcutaneous or intramuscular injection depend on two factors. These are the local blood circulation and the nature of the drug solution or suspension. Subcutaneous absorption occurs chiefly through the capillaries and is much faster compared with absorption following oral medication but usually slower than intramuscular absorption because of muscle tissue’s excellent blood supply.

Absorption following intramuscular injection may be speeded up by massaging the area of injection.
However, insulin-dependent diabetics are discouraged from massaging the site vigorously, in an attempt to preserve the state of the capillaries. An inflamed or oedematous site should be avoided when administering subcutaneous or intramuscular injections, so as to prevent a worsening of the inflammation/oedema and consequently a delay in absorption. In states of shock, blood flow to the skin and superficial muscle may be greatly reduced, thus reducing the absorption of drugs from these sites. In this case, intravenous injection should be used.

SYRINGES
A syringe consists of a barrel and a plunger (Fig. 4.4). The barrel is graduated. The plunger has a rubber stopper attached. Syringes are available in various sizes (e.g. 1, 2, 5, 10 and 20 mL). The choice of syringe is made according to the volume of medication to be injected. It should be noted, however, that insulin must always be measured using an insulin syringe. The tip of a syringe can vary, with the concentric Luer tip being the one used for subcutaneous and intramuscular injections. It is also used for introducing medication via an already sited intravenous cannula. For direct intravenous injections, the eccentric Luer tip is used to allow the needle to lie within the vein wall without puncturing the distal wall. The Luer tips of syringes interlock to an international standard with needle hubs.

Disposable syringes are made of a plastic material that is compatible with most substances to be injected. There are one or two exceptions, however. Paraldehyde, for example, should be administered using a glass syringe, because it dissolves plastic and rubber on prolonged contact. Syringes are individually sealed in a sterile pack. Before use, a check should be made that the seal has not been broken. Once a syringe has been removed from its pack, the utmost care is required to prevent contamination of the tip of the syringe.

NEEDLES
A needle consists of a hub and a cannula (Fig. 4.5). The cannula is hollow and is made of strong flexible steel that has been siliconised to assist penetration. For the same reason, the tip of the cannula is bevelled. Different types of needle have a different bevel. A shorter bevel encourages minimal penetration, as is required in an intradermal injection (see p. 63). A longer bevel allows easier deep penetration, as needed for an intramuscular injection (see p. 56). The gauge of the cannula is an indication of its diameter. The higher the gauge, the finer the bore. Higher gauges are used for ‘watery’ solutions and make for less painful injections. Low gauges are essential for injecting viscous (syrupy) solutions.

Needle lengths also vary. Selection of length depends on the route of the injection as well as the patient’s age and physical build. A study by Chan showed that only 32% of patients received the correct dose of intramuscular injection, the reason being that needles could not penetrate the muscle due to excessive fat in patients’ buttocks caused by obesity (Anonymous 2005).

Each needle is enclosed in a removable guard and individually sealed in a sterile pack. Before use, a check should be made to ensure that the pack has not been damaged. Once a guard is removed, the needle should be in one of three places only: in the ampoule or vial containing the medication, in the patient or in the sharps container.

For drawing up any injection from a glass ampoule, it is important to use a needle with a bore that is 21-gauge or smaller to filter out any shards of glass that may have entered the ampoule (Shaw and Lyall 1985).

For administering subcutaneous injections, a short fine-bore needle is used. For adults, this may be \( \frac{1}{2} \) inch
(13 mm) or ½ inch (16 mm), 25-gauge or 26-gauge; ⅝ inch (13 mm), 26-gauge; or ¾ inch (10 mm), 27 gauge.

For administering intramuscular injections, the needle used has to be sufficiently long to reach deep into the muscle so as to increase the speed of effect and to reduce the likelihood of the drug seeping back along the needle track. For adults, a 1 ½-inch (40 mm), 21-gauge (0.8 mm) needle is normally used. In severely emaciated adults, a 1-inch (25 mm), 23-gauge (0.6 mm) needle may be used.

When drawing up and injecting drugs with a known potential to cause sensitivity reactions, disposable gloves should be worn to prevent possible contact with the skin and the development of a sensitivity reaction. The special precautions that require to be taken when handling cytotoxic drugs are given in Chapter 19.

VOLUME
When preparing an injection, the nurse should give consideration to the volume that may be effectively accommodated in one site. Apart from the route to be used, the patient’s age and physical build are factors that will influence the decision. Normally, the following would apply.

- For subcutaneous injections, no more than 2 mL should be injected at one site.
- For intramuscular injections, the volume injected at any one site should normally be no more than 3 mL. When a volume in excess of 3 mL is to be given, two separate sites may have to be used. No more than 1 mL should be given into the deltoid muscle.

SITE
The sites most commonly used for subcutaneous injections (Fig. 4.6) are as follows:

- middle outer aspect of the upper arm
- middle anterior aspect of the thigh
- anterior abdominal wall below the umbilicus.

(The back and lower loin may also be used.)

The sites most commonly used for intramuscular injections are as follows:

- upper outer quadrant of the buttock
- anterolateral aspect of the mid-thigh.

(The deltoid is used for hepatitis B and influenza vaccines.)

It is vital that the intramuscular injection is confined to the upper outer quadrant of the buttock or the anterolateral aspect of the mid-thigh so as to avoid damage to the sciatic nerve (Fig. 4.7) and to avoid penetrating a major blood vessel.

Rotation of the sites used for subcutaneous and intramuscular injections helps to reduce the likelihood of irritation and improves absorption. Rotation within the sites is also important. Patients who, for example, have to repeatedly self-administer subcutaneous injections may be taught to visualise a clock face on the site and systematically work round it. Where nurses are
repeatedly administering injections, the site used on each occasion may be plotted on a diagram held at the bedside. Before administering any type of injection, the skin should be inspected on each occasion. Lesions, such as birthmarks, moles or scars, and inflamed or oedematous sites should be avoided.

SKIN PREPARATION
Despite now quite old research findings, old habits die hard. It is not considered necessary to use an alcohol swab to disinfect the skin prior to the administration of injections. Although there are inconsistencies in practice, the lack of skin preparation does not result in infections (Dann 1969, Koivisto and Felig 1978, Workman 1999). Torrance (1989) cites two studies that prove this point. One describes a series of 1078 injections given by all routes without any skin preparation, which resulted in no case of systemic or local infection. The second was a study of 7000 insulin injections given to a group of diabetic patients without skin cleansing, with no infection noted. Lipids in the epidermis provide an antibacterial barrier, so that removal of the lipids may encourage bacterial colonisation (Torrance 1989).

Clinical evidence suggests that no harm will be caused by pricking the skin so long as it is socially clean. Contaminated skin will need preparation to produce a low bacterial count. In this case, the site should first be made socially clean followed by a 30-s rub using an ‘alcohol swab’ (alcohol swabs contain 70% alcohol and a disinfectant such as chlorhexidine). The skin should then be allowed to dry for a further 30 s before proceeding to ensure that bacteria are rendered inactive (Cullen 2004) and so that the antiseptic does not cause irritation by being injected into the tissues. In immunosuppressed patients, the skin must be cleansed in this way, as this group of patients may become infected by inoculation of a relatively small number of pathogens.

ANGLE
The angles at which the needle is directed for subcutaneous and intramuscular injections are illustrated in Figure 4.8. It is common practice for subcutaneous injections of, for example, heparin or insulin to be given into the abdomen at an angle of 90° using a very short subcutaneous needle. An angle of between 45 and 90° may be used with a longer subcutaneous needle. Where the syringe and needle have been previously prepared in a pack (as for self-administration), the needle is usually very short and an angle of 90° is recommended.
by injections can be reduced in a number of different ways (Box 4.3). First, it is important to try to encourage patients to relax. This may be achieved by explaining to them what they should do. Patients should be positioned so that they are at ease. For example, for subcutaneous injections into the upper arm, the patient should be sitting with the hand resting on the iliac crest; for intramuscular injections, the patient should be lying on a couch or bed.

When the buttock is the chosen site for intramuscular injection, administration may be made less painful by asking the patient to adopt the prone position and to point the feet inwards. Internal rotation of the femur helps to relax the gluteus maximus muscle. Alternatively, the patient may lie on one side with the lower leg extended and the upper leg flexed.

As a general rule, with intramuscular injections the needle should be inserted (and withdrawn) quickly. Subcutaneous injections require the needle to be steadily pushed through the skin into the tissues and then eased out gently on completion of the injection.

Fine-bore needles create less pain on puncturing the skin and necessitate slow injection of the fluid. Pain can result from injecting too large a volume of fluid at one site or injecting the drug too quickly, resulting in improper distribution of the drug. The medication should be injected using slow, steady pressure at a rate of about 10 s/mL (Beyea and Nicoll 1996).

The skin may be cooled using a volatile spray such as ethyl chloride. A further possibility is to use a local anaesthetic agent such as Emla (eutectic mixture of local anaesthetic) cream.

Subcutaneous administration may be carried out by means of a high-pressure jet of liquid, using an injector that delivers an accurate dose without the aid of a needle. This technique may be useful in mass inoculation programmes. There is a reduction in pain to the patient and no risk of needlestick injury. The risk of transmitting blood-borne infections by this method should be carefully considered.

Use of the Z-track technique (see p. 57) may also reduce the discomfort associated with intramuscular injections, because there is less likelihood of the medication leaking into the subcutaneous tissue by this method.

Needle phobia is a very real problem to those who suffer from it. Ten per cent of the population is said to be affected by it. Little is written about it. There have been instances of vasovagal reflex reaction (fainting) even resulting in death. Patients may need courage to admit they suffer from needle phobia, just as they need courage to admit they suffer from a painful condition. Physicians must learn how fearful the problem is to the individual concerned and that many appointments and opportunities are missed because of it, with consequent increase in morbidity. The development of microneedles that are 0.15–0.3 mm long will allow permeability of the skin without reaching pain receptors.

ADMINISTRATION

The process of checking a medicine for injection against the prescription is the same as for the administration of any medicine. This should be done immediately prior to the administration procedure. It
is not acceptable to prepare a substance for injection in advance of its immediate use or to administer a medication drawn into a syringe by another nurse without him or her being present (Nursing and Midwifery Council 2006, p. 5). Hands must be washed thoroughly using chlorhexidine gluconate solution at the start and finish of the procedure. Asepsis must be maintained throughout, because puncturing the integument provides easy access for pathogenic microorganisms. Every effort must be made to encourage the patient to relax and to minimise pain as far as possible. Extra support will be required for patients suffering from needle phobia. Careful disposal of syringes and needles is of great importance.

The procedure for administering a subcutaneous injection is outlined in Box 4.4. Patients may be taught to self-administer medication by this route. The procedure for administering an intramuscular injection is outlined in Box 4.5.

Patients with haematological conditions such as leukaemia, in which the platelet count is likely to be low, must never be given intramuscular injections, because of the high risk of bleeding into muscle tissue (because of its rich blood supply).

ADMINISTRATION OF SUBCUTANEOUS INSULIN

The needle that comes already attached to an insulin syringe is very short (5, 6 or 8 mm) and of fine bore (0.33 mm). It is essential to reach the correct layer of tissue, namely subcutaneous adipose tissue, on every occasion, and not to administer the insulin intramuscularly or by the intradermal route in error. Failure to reach the subcutaneous layer leads to altered rates of absorption and poor diabetic control (Peragallo-Dittko 1997). The recommended method is to pinch up the skin in order to raise the adipose tissue away from the underlying muscle. Using a gentle pushing technique, the insulin is injected at an angle of 90° (Burden 1994). Such advice is thought to be important in thin diabetic patients, especially men, who it has been found may have less depth of subcutaneous fat than the length of the needles in use, resulting in the administration of an intramuscular injection and not a subcutaneous one (Spraul et al. 1988, Peragallo-Dittko 1997).

ADMINISTRATION OF SUBCUTANEOUS DALTEPARIN

In order to reduce the great risk of bruising leading to pain and unsightliness, a modified injection technique is recommended for the administration of subcutaneous low molecular weight heparins (Conaghan 1993). Efforts are directed at minimising the physical trauma that can be caused before, during and after the giving of an injection. Dann (1969) has shown that, in most patients, there is no need to disinfect the skin with an antiseptic. Besides, the
use of an alcohol swab leads to vasodilatation and encourages bleeding. Vigorous rubbing or pinching of the skin may damage capillaries (Koivisto and Felig 1978). The preferred site is the abdomen, because of the greater depth of subcutaneous fat, although abdominal surgery may limit the available area. Brenner et al. (1981) claim that using an angle of 90° leads to fewer bruises. In addition, the amount of movement of the needle throughout the procedure should be kept to a minimum (McGowan and Wood 1989–1990). It is recommended that a roll of tissue be gently lifted before slowly inserting the needle. It is also generally thought that the plunger should not be withdrawn prior to injecting, as this can lead to negative pressure and the formation of a haematoma (Springhouse Corporation 1993). Once the needle has been removed, only light pressure over the injection site using cotton wool is necessary to stop any backflow of blood from the injection site.

### INTRAVENOUS INJECTION

Administering a drug directly into a vein avoids all complications of drug absorption and, as a result, an effective blood level of the drug can be achieved in a matter of seconds. The intravenous route is used:

- in emergency situations such as shock and status asthmaticus
- to administer general anaesthetic agents (e.g. propofol)
- for larger volumes (e.g. 5–20 mL)
- when the preparation has irritant properties (e.g. cytotoxic drugs)
when subcutaneous or intramuscular injections would cause intolerable pain (e.g. aminophylline).

Intravenous injections may, however, be associated with a number of complications, such as:

- a haematoma caused by puncturing through, instead of into, the vein
- necrosis caused by the drug escaping into the surrounding tissues when the needle slips out of the vein and is simply lying in the tissues
- phlebitis at the injection site, resulting from a high concentration of an irritant agent, repeated injections or prolonged administration
- because of rapidity of action, intoxication or death if an error is made when calculating or measuring the dose.

Those drugs recommended for administration intravenously by medical staff only will be made known within each trust.

It is important, however, that nurses understand how the procedure is carried out so that they can, if called on, play a supporting role. The standard approach to prescribing, administering and recording medicines is followed. To reduce the risk of introducing microorganisms into the bloodstream, it is essential that the hands are washed, sterile equipment used and an aseptic technique practised. The patient should be given an explanation of what is to be done and should be in a comfortable position with the site to be used exposed. A vein in the elbow or the back of the hand is normally used. With the help of a tourniquet, the vein is distended to allow access. The standard approach to prescribing, administering and recording medicines is followed. To reduce the risk of introducing microorganisms into the bloodstream, it is essential that the hands are washed, sterile equipment used and an aseptic technique practised. The patient should be given an explanation of what is to be done and should be in a comfortable position with the site to be used exposed. A vein in the elbow or the back of the hand is normally used. With the help of a tourniquet, the vein is distended to allow access. If indicated, the site of injection is swabbed with a suitable antiseptic and allowed to dry. A syringe with an eccentric nozzle and a 1-inch (25 mm) 20-gauge needle with an intravenous bevel are used for giving an intravenous injection. All air bubbles are expelled from the syringe and the needle filled with drug. Holding the syringe in line with the vein, the needle with the bevel up is pushed through the skin into the vein in the direction of the heart (Fig. 4.10). Before injecting, the position of the needle must be verified by gently pulling the plunger. If no blood is aspirated, the needle must then be withdrawn and another attempt made. After releasing the tourniquet and making an initial injection of 0.1 mL, there should be a pause of at least 30 s to observe the response before the remainder is slowly injected (up to 10 min). It is dangerous to give a rapid intravenous injection, as this exposes tissues and organs such as the heart and brain to high concentrations of a drug that has been poorly diluted with blood. A drug solution injected over 2 min will be 60 times more dilute than if injected over 2 s. After completing the injection, a sterile swab should be placed over the injection site, the needle slowly removed and gentle pressure maintained to avoid a haematoma.

Alternatively, intravenous drugs may be administered intermittently via the upper inlet of an indwelling intravenous cannula or into the administration set of an intravenous infusion by means of a three-way stopcock or multiple-inlet device. If there is not a continuous fluid infusion to keep the cannula patent, a dilute heparin solution should be injected before and after the drug is administered to prevent blood from clotting in its lumen.

A summary of common routes for injection is given in Table 4.3.

OTHER ROUTES OF INJECTION

Although parenteral administration is normally accomplished by subcutaneous, intramuscular or intravenous routes, occasionally other routes are used to deliver a drug to a particular tissue or organ.

Intra-arterial injection. This route is sometimes used to inject or infuse drugs into an artery supplying the affected organ if the drugs are rapidly metabolised or systemically toxic. Cytotoxic drugs for the treatment of local neoplasms or radio-opaque substances used in arteriography may be injected in this way.

Intra-articular injection. In inflammatory conditions of the joints, particularly rheumatoid arthritis, corticosteroids are given by intra-articular injection to relieve inflammation and increase joint mobility. Insoluble, long-acting compounds such as triamcinolone hexacetonide are used. Corticosteroids should not be injected into infected joints. Tissues or joints injected with corticosteroids have an increased
<table>
<thead>
<tr>
<th>Table 4.3</th>
<th>Summary of common routes for injections</th>
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<tbody>
<tr>
<td><strong>Subcutaneous</strong></td>
<td><strong>Intramuscular</strong></td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td>Fatty layer beneath the skin</td>
</tr>
<tr>
<td><strong>Indications</strong></td>
<td>Drug would be destroyed in stomach if taken orally</td>
</tr>
<tr>
<td></td>
<td>Self-administration desirable</td>
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<tr>
<td><strong>Contraindications</strong></td>
<td>Shock</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Who may administer</strong></td>
<td>Registered nurse</td>
</tr>
<tr>
<td></td>
<td>Student nurse under supervision of registered nurse</td>
</tr>
<tr>
<td><strong>Relative rate of onset of action</strong></td>
<td>Slow</td>
</tr>
<tr>
<td><strong>Maximum volume at one site</strong></td>
<td>2 mL</td>
</tr>
<tr>
<td><strong>Sites (commonest)</strong></td>
<td>Outer aspect of upper arm</td>
</tr>
<tr>
<td></td>
<td>Anterior aspect of thigh</td>
</tr>
<tr>
<td></td>
<td>Abdominal wall, i.e. below umbilicus</td>
</tr>
<tr>
<td><strong>Needle</strong></td>
<td><strong>Length</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Gauge</strong></td>
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<tr>
<td><strong>Angle</strong></td>
<td>45–90° to the skin</td>
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<tr>
<td><strong>Hazards</strong></td>
<td>Abscess formation</td>
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susceptibility to infections. It is therefore essential to observe full aseptic precautions when making these injections.

**Intradermal (intracutaneous) injection.** Intradermal injections are small-volume injections of the order of 0.02–0.1 mL, given with a tuberculin syringe and a 16-mm, 26-gauge needle. The most common site used is the anterior aspect of the mid-forearm to allow for ease of inspection. The injection is given just under the skin, holding the syringe about parallel (about 10–15°) to the skin and with the bevel facing upwards. The needle is advanced, and while doing so is elevated under the skin. The technique is most commonly used for the administration of certain diagnostic agents such as tuberculin purified protein derivative and skin testing solutions in the diagnosis of allergy. As the potential allergen is slowly injected, a small weal forms. The needle is slowly withdrawn and the site is not massaged, in an effort to reduce interference with the formation of the weal.

In testing for allergy, a distinct benefit in not cleansing the skin beforehand is that there is no risk of causing irritation that could interfere with the interpretation of the result. The local reaction is assessed 24–72 h later by measuring its diameter.

**Intrathecal injection.** It is necessary to administer some drugs intrathecally if they have poor lipid solubility and, as a result, do not pass the blood–brain barrier. In the treatment of meningitis, water-soluble antibiotics are administered by the intrathecal route to achieve adequate concentrations in the cerebrospinal fluid. Drugs administered by this route include penicillins, the choice of which will depend on the results of bacteriological examination of the cerebrospinal fluid. Doses have to be very carefully calculated and are much smaller than would be given by intramuscular or intravenous injection because, in effect, the antibiotic is being introduced into a closed system. An example of an adult dose of an antibiotic given intrathecally is 1 mg daily of gentamicin increasing if necessary to 5 mg daily. However, the use of the intrathecal route for administering antibiotics appears to have diminished, e.g. benzylpenicillin is no longer recommended for intrathecal administration.

Methotrexate is administered intrathecally (15 mg at weekly intervals) to treat meningeal leukaemia. Antifungal agents, opioids, corticosteroids and radio-opaque substances, used in the diagnosis of spinal lesions, are sometimes administered by this route. A product specially prepared for the intrathecal route should be used. In many instances, intrathecal therapy is supported by a course of the drug given by intramuscular or intravenous injection.

**USE OF SYRINGE DRIVERS**

Medication may be administered via a syringe driver either intravenously or subcutaneously (see also Fig. 26.3). The subcutaneous route is the more common of these routes and is typically used for the administration of heparin, insulin and cytotoxic drugs, and in palliative care (for technique, see p. 520).

In palliative care, this route is used when the patient has difficulty in swallowing, is vomiting or may be semi-conscious or unconscious. The use of a syringe driver allows continuous subcutaneous infusion treatment to be delivered and a steady concentration of analgesia to be achieved without the need for repeated injections. Diamorphine can be given by syringe driver to maintain analgesia. Other drugs administered in this way include antiemetics, sedatives and antimuscarinics.

**SUBCUTANEOUS INFUSION**

Patients suffering from dehydration for whatever reason may be treated by the administration of fluids by subcutaneous infusion. The great advantage of this method is that the infusion may be commenced...
SECTION 1  MEDICINES MANAGEMENT

as required by community nursing staff or relatives. An infusion of 3 L should be run over a 12- or 24-h period. The administration of the enzyme hyaluronidase assists in the subcutaneous absorption of the fluid.

**INTRAVENOUS INFUSION**

When large volumes of fluid (50 mL upwards) require to be administered over a prolonged period, the most effective method is intravenous infusion. The indications for intravenous infusion are:

- when a patient cannot take oral medication
- when a rapid response is required
- to maintain or restore blood volume
- when a drug is inactivated in the gastrointestinal tract
- when there is a problem of absorption from the gut
- to supply electrolytes or nutrients
- when it is important to control plasma levels of a drug
- to administer irritant substances (e.g. cytotoxic agents)
- in life-threatening infections, when it is vital to establish high concentrations of antibiotics in the tissues.

Intravenous infusions are normally packed in plastic containers and delivered to the patient via an intravenous administration set (Fig. 4.11) attached to an intravenous cannula (Fig. 4.12) that has been inserted into the patient’s vein. Because of the considerable risk of introducing infection directly into the bloodstream, the infusion fluid, all parts of the administration equipment and any dressings used must be sterile.

Introducing an intravenous cannula and establishing the free flow of the infusion are the doctor’s responsibility. Registered nurses (and midwives) who are appropriately trained are permitted to prepare the prescribed medication and administer it into an already established cannula. The care of the patient before and after the procedure, and the satisfactory maintenance of the intravenous line, rests with the nurse assigned to the patient.

Before assembling an intravenous line, it is important to do the following.

- Read and carefully check the label of the infusion container against the fluid prescription. This should be carried out by a registered nurse or by a student nurse under the supervision of a registered nurse. Local policy may dictate that two members of staff are to be involved at all times.

![Fig. 4.11 Intravenous administration set.](image)

![Fig. 4.12 Intravenous cannula.](image)
that the container is just less than a metre above the intravenous infusion stand that should be adjusted so should be recognised. The container is hung on an contamination through any of the points of entry is connected to an administration set, the risk of until required for use. Once an infusion container is connected to an administration set, the entry port of the container is pierced by the spike of the appropriate administration set, the filter end of the administration set is covered by its sheath from the tubing and the control clamp closed. The free spike of the appropriate administration set, the filter is connected to an administration set, the risk of contamination through any of the points of entry should be recognised. The container is hung on an intravenous infusion stand that should be adjusted so that the container is just less than a metre above the cannula insertion site to achieve the optimum flow rate (Auty 1989). The flow rate is adjusted by means of a roll clamp attached to the tubing. When accurate control of flow rate is essential, an automatic infusion system may be used that pumps solutions at a preset rate. As the fluid runs through the administration set, the container empties and, in so doing, collapses. Adjuncts are sometimes used with this system, for example a calibrated burette may be incorporated in the system into which the infusion drips. One or more drugs can be added to the burette, and this is very useful, particularly in neonatal and intensive care units, for intermittent infusion of potent drugs in precise volumes. Drugs may be slowly injected through an additive port in the administration set or can be added to minibags usually containing either glucose 5% or sodium chloride 0.9% intravenous infusion. The contents of these secondary containers are infused using a Y-administration set, three-way tap or non-return valve. This method may be used to give a higher intermittent blood level of a particular drug than would be achieved if the drug were added to the larger primary container, or to avoid an incompatibility with a drug that may already be present in the primary container.

Drugs commonly given by intravenous infusion include antibiotics, lignocaine (lidocaine), heparin and potassium chloride. Cytotoxic drugs are frequently given by intravenous infusion. The infusion maintains a steady blood level of the drug over a prolonged period of time, and the patient is spared the pain of frequent injections. The addition of drugs to intravenous infusion fluids presents a number of hazards (e.g. resulting from interaction between the drug and the infusion fluid). Drugs should not be added to blood, plasma, lipid emulsions, saturated manitol solutions, sodium bicarbonate solutions, amino acid solutions or dextran solutions, because these infusion fluids are particularly likely to be degraded.

In addition to interactions, the fluid infused can be contaminated by micro-organisms if admixtures are not carried out under strict aseptic conditions. Ideally, these additions should be made by pharmacy staff using laminar air flow cabinets in aseptic rooms and administered within 12–24 h. Complications such as thrombophlebitis (damage to the endothelium as the result of inflammation of the vein accompanied by formation of a blood clot) may arise at, and spread beyond, the site of cannula insertion. This results from physical or chemical irritation often related to the duration of the infusion or the type of fluid infused. Glucose is mildly acidic and, on autoclaving, a small quantity is broken down to hydroxymethylfurfural, and these two factors appear to cause a higher incidence of thrombophlebitis when glucose infusions are given. Blood for transfusion should never be mixed with any drug or solution other than sodium chloride 0.9%, because of the danger of interaction. If a unit of blood is preceded by a solution such as glucose, agglutination may result. To avoid this, the administration set should be flushed with sodium chloride 0.9% solution or changed.

The standard procedure for prescribing, checking and recording the administration of medicines similarly applies to intravenous infusions. The procedure should be explained to the patient in advance and the opportunity given to attend to toilet needs. A change into a garment with wider sleeves may be required to ensure that the infusion flow is unobstructed. If possible, whichever arm/hand will make things easier for the patient should be used. The patient should be comfortable, with the site of introduction of the infusion exposed and well lit. Some pain is usually experienced with the insertion of a needle, especially in the back of the hand, and patients appreciate having support and encouragement at this time.

The commonest sites of introduction are the fore-arm, the back of the hand and the antecubital fossa at the elbow. In an emergency, a vein in the foot or the external jugular vein may have to be used. A large straight vein, preferably at the junction of two veins and not running over a joint, is the one of choice.

The insertion of an intravenous cannula should be regarded as a minor surgical procedure. This, together with the fact that a cannula is to be lying...
in the vein for possibly several days, means that asepsis is an important objective. The prevention of microbial contamination begins with the appropriate handwashing technique. Careful preparation of the skin is important prior to insertion of the cannula. Although clipping extra-long hairs with scissors facilitates the subsequent removal of adhesive tape and is acceptable, shaving the skin is not recommended, because it produces tiny abrasions that may become infected. Any visible dirt is washed from the area with soap and water.

Before completing the preparation of the skin, the venous outflow is blocked and the vein distended by applying pressure above the site. This may be achieved in one of three ways:

- the use of a tourniquet
- the use of a sphygmomanometer cuff inflated to 100 mmHg
- with the help of an assistant, making sure not to apply too great pressure, as this may occlude the arterial supply.

The vein can also be made more prominent in different ways. For example:

- asking the patient to open and close the fist
- gently tapping the vein
- immersing the hand in hot water.

Increased venodilatation can also be achieved using glyceryl trinitrate applied in the form of a cream or transdermal patch (see p. 72) distal to the site of cannulation 20–30 min before venepuncture is performed.

Finally, the site is rubbed firmly for at least 30 s using a 70% alcohol swab and allowed to dry before puncturing the skin. Any further finger contact with the vein should be avoided.

Intravenous cannulae of different gauges are available. A small-gauge cannula (e.g. 19-gauge) is sufficient for the delivery of most therapy and limits both the size of the wound and the incidence of intravascular complications. When viscous fluids are to be administered, a large-gauge cannula (e.g. 18-gauge) is required. If a blood transfusion is likely to be required, the cannula introduced at the start of the infusion must be of large gauge (e.g. 16-gauge).

The cannula is checked to ensure that it is patent and has no obvious defects. With the bevelled edge uppermost, the cannula is firmly entered under the skin a short distance away from the vein, always pointing the cannula proximally towards the heart. It is then gently pushed into the vein, making sure to enter the plastic covering on the needle as well as the needle itself into the vein. Some types of cannula show a flash of blood at the hilt of the needle, indicating that the needle, but not necessarily the plastic cannula, is in the vein. The tourniquet is then removed and simultaneously the needle withdrawn and the plastic cannula gently advanced into the vein. A well-sited cannula should introduce with little or no resistance. The tubing of the administration set is quickly attached. Gentle pressure on the vein proximal to the cannula tip prevents a leakage of blood through the cannula.

When a small vein is used, the tubing may be attached earlier so that the cannula advances, while at the same time infusing fluid through it, thus displacing the walls of the vein. The control clamp is released and the flow rate observed. Subcutaneous swelling around the cannula indicates that it is not in the vein and must be removed.

The cannula is secured using an adhesive dressing designed for the purpose. The adjacent tubing is taped so as to prevent any pull on the cannula. A light conforming bandage promotes the patient’s comfort. A splint may be applied and is essential if the cannula has been positioned over a joint.

On completion of the procedure, the patient should be made comfortable with the arm supported on a pillow, if required. Personal requirements such as a drink, tissues, sickness basin, reading material, etc. should be placed within reach. The call bell should also be to hand and instruction in its use given.

A regimen of fluids to be infused is prescribed by the doctor. The rate of flow required (i.e. the number of drops/min) can be calculated on the basis that, for solutions using a standard administration set, 1 mL equals 20 drops, that is:

\[
\frac{\text{Volume of fluid (mL)}}{\text{Duration (min)}} \times 20 \quad \text{drops/min.}
\]

Thus, for 500 mL of fluid to be run through in 4 h the number of drops/min is:

\[
\frac{500 \times 20}{240} = 41.66 \text{ rep.}
\]

For working purposes, this figure may be regarded as 42.

To transfuse blood or blood components, a blood administration set is used that delivers 15 drops/mL.

Alternative methods of introducing an intravenous line are:

- surgically cutting down on a vein and introducing the cannula under direct vision (e.g. when no veins are visible or patent)
by means of a central venous line (e.g. for prolonged feeding or for central venous pressure measurement).

Both these techniques are specialised procedures that are undertaken by experienced medical staff.

Throughout the ongoing administration of the infusion, the nurse’s responsibilities are as follows.

OBSERVING THE PATIENT
Each time the patient is attended by the nurse, the patient’s colour, respirations and general demeanour should be observed. An elevated temperature is noteworthy. Any apparent abnormality or change in the patient’s condition should be reported to the nurse in charge or doctor.

OBSERVING THE INFUSION
A check is made that the infusion is running at the prescribed rate and that the container still has enough fluid in it. The nurse must anticipate the point when the container requires to be changed and estimate how much time will be required to get the next container checked and ready for use.

If the infusion is not running, a systematic list of checks should be made (Fig. 4.13).

When an infusion pump is in use, an alarm signals that the infusion is complete.

OBSERVING THE CANNULA SITE
The nurse must be alert to any:

- redness
- swelling
- leakage
- complaints from the patient of pain at or radiating from the cannula site.

KEEPING ACCURATE RECORDS
The following records must be maintained:

- fluid prescription sheet
- fluid balance chart
- nursing care plan and progress notes.

PROVIDING NURSING CARE
Even the most able patient requires some assistance when one limb is out of action. Indeed, patients are to be discouraged from trying to be too independent, as this can create movement of the cannula in the vein, especially one that crosses a joint, causing a mechanical phlebitis. Assistance with changing position, toileting, dressing, cutting up food, etc. will often be required.

REPORTING ABNORMALITIES
Although in most cases the infusion is established by doctors, doctors depend on nurses to notify them of any changes in the patient’s condition, of either a localised or a generalised nature, and any difficulties encountered with the infusion. To reduce the risk of infection, it is normally recommended that administration sets be changed after 3 days (Band and Maki 1979, Josephson et al. 1985, Maki and Ringer 1987). However, sets should be changed directly following blood transfusion and, in the case of parenteral nutrition, daily.

The hazards associated with intravenous infusion may be localised or systemic and are potentially very dangerous.

Local hazards are:

- thrombophlebitis
- infection
- extravasation.

Systemic hazards are:

- sepsicaemia
- cardiac embarrassment caused by too rapid rate
- allergic reaction to fluid or drug
- air or particle embolism.

Consequently, checking procedures, asepsis, careful observation and prompt reporting are vitally important.

INFUSION SYSTEMS
Infusion systems are used to deliver fluids (including emulsions), electrolytes and drugs in solution by the intravenous (and subcutaneous) route. They have become increasingly sophisticated and widely used over the past 20 years. This trend will continue in the years ahead. In common with other drug delivery systems, infusion systems have all the key features outlined in Table 4.4.

The indications for the use of an infusion system include the need to maintain or restore blood volume, to deliver electrolytes and/or nutrients, and to administer drugs, especially those agents that are highly irritant and cannot be administered by other, more accessible routes. Infusion systems also provide the capability to control very accurately drug administration (e.g. cytotoxic therapy) over time, especially when a powered device is used.

INFUSION SYSTEMS RELYING ON GRAVITY
These infusion systems rely on gravity alone to provide the infusion pressure. It follows that the infusion container must be placed at a suitable height above
Fig. 4.13  What to do when an intravenous infusion stops.

- 'Drip' stand high enough?
  - Yes ➔ Elevate stand to maximum height
    - Fluid runs in by gravity
  - No ➔ Sufficient fluid in container?
    - Yes ➔ Arrange for next prescription to be checked and administered
      - Try to anticipate changeover
    - No ➔ 'Giving' set needle driven ‘home’?
      - Yes ➔ Push ‘giving’ set needle fully into container
        - Take care not to puncture bag
      - No ➔ Space for fluid to drop within lower chamber?
        - Yes ➔ Control clamp open?
          - Yes ➔ Tubing free of kinks or obstructions?
            - Yes ➔ Bandage too tight?
              - Yes ➔ Bandage dry?
                - Yes ➔ Splint correctly used?
                  - Yes ➔ Venepuncture site free from pain, redness, swelling?
                    - Yes ➔ Patient relaxed with limb resting on pillow?
                      - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Sufficient fluid in container?
  - Yes ➔ ‘Giving’ set needle driven ‘home’?
    - Yes ➔ Space for fluid to drop within lower chamber?
      - Yes ➔ Control clamp open?
        - Yes ➔ Tubing free of kinks or obstructions?
          - Yes ➔ Bandage too tight?
            - Yes ➔ Bandage dry?
              - Yes ➔ Splint correctly used?
                - Yes ➔ Venepuncture site free from pain, redness, swelling?
                  - Yes ➔ Patient relaxed with limb resting on pillow?
                    - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- 'Giving' set needle driven ‘home’?
  - Yes ➔ Space for fluid to drop within lower chamber?
    - Yes ➔ Control clamp open?
      - Yes ➔ Tubing free of kinks or obstructions?
        - Yes ➔ Bandage too tight?
          - Yes ➔ Bandage dry?
            - Yes ➔ Splint correctly used?
              - Yes ➔ Venepuncture site free from pain, redness, swelling?
                - Yes ➔ Patient relaxed with limb resting on pillow?
                  - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Space for fluid to drop within lower chamber?
  - Yes ➔ Control clamp open?
    - Yes ➔ Tubing free of kinks or obstructions?
      - Yes ➔ Bandage too tight?
        - Yes ➔ Bandage dry?
          - Yes ➔ Splint correctly used?
            - Yes ➔ Venepuncture site free from pain, redness, swelling?
              - Yes ➔ Patient relaxed with limb resting on pillow?
                - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Control clamp open?
  - Yes ➔ Tubing free of kinks or obstructions?
    - Yes ➔ Bandage too tight?
      - Yes ➔ Bandage dry?
        - Yes ➔ Splint correctly used?
          - Yes ➔ Venepuncture site free from pain, redness, swelling?
            - Yes ➔ Patient relaxed with limb resting on pillow?
              - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Tubing free of kinks or obstructions?
  - Yes ➔ Bandage too tight?
    - Yes ➔ Bandage dry?
      - Yes ➔ Splint correctly used?
        - Yes ➔ Venepuncture site free from pain, redness, swelling?
          - Yes ➔ Patient relaxed with limb resting on pillow?
            - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Bandage too tight?
  - Yes ➔ Bandage dry?
    - Yes ➔ Splint correctly used?
      - Yes ➔ Venepuncture site free from pain, redness, swelling?
        - Yes ➔ Patient relaxed with limb resting on pillow?
          - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Bandage dry?
  - No ➔ Splint correctly used?
    - Yes ➔ Venepuncture site free from pain, redness, swelling?
      - Yes ➔ Patient relaxed with limb resting on pillow?
        - No ➔ If intravenous infusion still not running, INFORM DOCTOR

- Venepuncture site free from pain, redness, swelling?
  - Yes ➔ Patient relaxed with limb resting on pillow?
    - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- Patient relaxed with limb resting on pillow?
  - Yes ➔ If intravenous infusion still not running, INFORM DOCTOR

- If intravenous infusion still not running, INFORM DOCTOR

Kinks and obstructions can be caused when tubing gets caught in backrest, cot side, splint, etc.

Correct positioning is important

INFORM DOCTOR
the infusion site. Drip rate control is achieved by a simple mechanical clamp on the delivery tube. A drop sensor on the drip chamber monitors the rate of infusion. Such a device does not monitor resistance to infusion (leading to underinfusion), but overinfusion is effectively controlled. Drip rate controllers enable the flow rate to be selected in drops/min and controlled by identically powered valves. Such systems are acceptable in low-risk situations. A number of factors will influence the accuracy of drug delivery. Although the drop counting is accurate, the volume of delivery may not be (see p. 66). The use of volumetric controllers (calibrated in mL/h) avoids the need to carry out calculations on the drip rate.

**POWERED INFUSION PUMPS**

Infusion devices, such as infusion pumps and syringe drivers, are powered items of equipment that are capable of delivering fluids/drugs in a controlled manner in line with clinical requirements. Pumps have a number of advantages over gravity-powered systems. Notably, resistance to flow can be overcome by increasing delivery pressure. Safety mechanisms are normally provided if the entry port becomes blocked or displaced – normally referred to as occluded. Although the use of powered pumps does enable safe and accurate drug delivery to be achieved, the risks of malfunction must be recognised. The range of devices is summarised in Table 4.5.

Unfortunately, although giving great benefit to patients, the use of infusion systems is not without problems. Poor management procedures, lack of training and inadequate documentation have in many cases contributed to significant patient morbidity and mortality. Table 4.6 gives an indication of the range of problems that can arise.

**SAFE MANAGEMENT OF INFUSION SYSTEMS**

In order to achieve safe use of infusion systems, it is necessary to establish procedures that ensure that control is exercised at all stages from procurement of the equipment to use in patient care. A safe system will incorporate the following features.

- The structures and procedures established have the overall aim of reducing hazards to patients.
- Clear responsibilities for the choice of equipment and subsequent procurement are established, along with lines of accountability and responsibility. As few types of pump as possible should be used. They should be of the correct type and there should be adequate supplies of them. Extra sockets and cabling may have to be supplied. Operational manuals should always accompany items of equipment.
- A multidisciplinary committee is designated to oversee all aspects such as procurement, audit and monitoring, clinical/operational procedures and the effective communication of hazard warnings.
- Training needs are identified and met. Policy and procedure manuals should be readily available and kept up to date.
- Strong links are established with the local drug and therapeutics committee and other medicine management arrangements within the health authority. Infusion devices are used within the community, and so policies that recognise this dimension must also be established.

**TECHNICAL SUPPORT**

Technical staff play a vital role in carrying out a regular maintenance programme on all infusion devices. ’Imported’ pumps, for example any that have been donated, should be checked before use. The functioning of all equipment sent for repair should be checked before its return to the clinical area. Technical staff also have an important advisory role in the day-to-day use of such equipment.

**ROLE OF THE NURSE: INFUSION DEVICES**

All clinical staff involved in the treatment of patients with an infusion device have specific responsibilities, but the responsibility for ongoing safety and comfort of the patient most definitely falls to the nurse. The potential for things to go wrong is very considerable, and the nurse’s responsibilities are numerous. Knowledge of the principles involved is vital, and continuing evidence of clinical competence must be demonstrated. Attendance at in-service training sessions, as well as personal updating, is therefore imperative.

**Table 4.4** Key features of a drug delivery system

<table>
<thead>
<tr>
<th>Structure</th>
<th>Containers, tubing, administration set, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy source</td>
<td>Gravity or powered pump system</td>
</tr>
<tr>
<td>Control mechanism</td>
<td>Drip rate controller</td>
</tr>
<tr>
<td>Delivery port</td>
<td>Needle/cannula</td>
</tr>
</tbody>
</table>

9/26/07 12:12:22 PM
Table 4.5  Powered devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drip rate pumps</td>
<td>Flow rate set in drops/min, peristaltic pump powers system. Such devices have few controls. The pressure of fluid in the line is not detected, and occlusion detection is very poor. As a result, these pumps are not recommended for use at present.</td>
</tr>
<tr>
<td>Volumetric pumps</td>
<td>Flow rate set in mL/h. Various safety features are present (e.g. alarm to signal empty infusion container, air in line, occlusion). These pumps are useful for medium and large flow rates and for large-volume infusions. They can employ many different methods for accurate delivery, and nurses must know the details for the pumps they will use.</td>
</tr>
<tr>
<td>Syringe pumps</td>
<td>A syringe containing the drug in solution is placed in a device that drives the plunger of the syringe at a predetermined rate. These devices are useful for low-volume/high-accuracy drug delivery. Syringes may be up to 60 mL. The volume is delivered in mm/h or mm/24h. Heparin, cancer chemotherapy and analgesia are commonly administered by this method. As with all devices, it is important to set up the equipment correctly (e.g. the correct size of syringe must be used and located securely in order to ensure accurate delivery). Miniature syringe pumps accepting syringes from 2 to 10 mL, which are battery-operated, can be used to achieve low rates of delivery (e.g. for insulin and for ambulatory patients).</td>
</tr>
<tr>
<td>Patient-controlled analgesia pumps</td>
<td>These devices provide for patient initiation of doses of a pain-relieving drug. Controls are built in to prevent overuse by the patient. Pumps for ambulatory use are similar but lighter for ease of carrying by the patient. A variety of programming options is available; loading dose, continuous infusion with or without bolus can be achieved. It is important to avoid free flow (siphonage) of solution, especially when patient supervision is minimal.</td>
</tr>
</tbody>
</table>

Other devices
- Pumps for the administration of anaesthetic agents
- Pumps using an elastomeric membrane
  These pumps are designed for the specific purpose of administering anaesthetic agents. These disposable devices are ‘powered’ by an elastomeric membrane that contracts as a result of pressurisation caused by the filling process. They provide a simple method of administration especially suitable for home therapy.

Table 4.6  Examples of problems that can arise with infusion pumps

<table>
<thead>
<tr>
<th>Type of error</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human error</td>
<td>Wrong rate/volume, Failure to allow for priming volume, Altered default settings, Selection of inappropriate/wrong pump, Incorrect loading (leading to occlusion or siphoning), Faulty pump in service, Spillage of fluid (resulting in electric shock)</td>
</tr>
<tr>
<td>Equipment malfunction</td>
<td>Spontaneous failure, Damage to equipment, Flat battery, Defect in set or bag, Frequent alarms (staff start to ignore)</td>
</tr>
<tr>
<td>Other</td>
<td>Infiltration of tissues with fluid, Patient or relative tampers with rate</td>
</tr>
</tbody>
</table>
The responsibilities of the nurse looking after patients with infusion devices may be summarised as follows.

- Being able to choose the most suitable pump by considering the following (Medical Devices Agency 2003).
  - Risk to the patient of:
    - overinfusion
    - underinfusion
    - uneven flow
    - high delivery pressure
    - inadvertent bolus
    - extravascular infusion.
  - Delivery parameters:
    - infusion rate and volume required
    - accuracy required (long and short term)
    - alarms required
    - ability to infuse into site chosen (venous, arterial, subcutaneous)
    - suitability for infusing given drug (viscosity, half-life).
  - Environmental features:
    - ease of operation
    - frequency of observation and adjustment
    - type of patient (e.g. very sick)
    - mobility of patient (battery operation needed?).

- Using the administration set recommended by the pump manufacturer.

- Ensuring that all connections are tight but not overtight.

- Getting solutions, medications, rates and readings checked.

- Avoiding siphonage by positioning the device at the correct height.

- Keeping the alarm (when fitted) on and heeding it when it sounds.

- Ensuring that the medication is being administered.

- Checking the device every hour (in hospital) and on arrival at and departure from a home visit.

- Being observant at all times – of the patient, the infusion, the device and the documentation.

- Remembering that there is a patient attached to the infusion who requires reassurance.

- Keeping lines free from obstruction and, when more than one are in use, taping the lines (at both the pump end and the cannula end).

- Keeping all parts of the equipment clean (removing fluid from pump if spilled).

- Handling equipment carefully so as to avoid damage.

- Reporting abnormalities/discrepancies in rate at once.

- NEVER attempting to ‘catch up’ on the rate.

- Changing all components of the system every 24 h

- Recharging battery-operated devices by connecting to the mains supply.

- Labelling faulty equipment/reporting faults.

- Checking equipment on return from repair before next use.

- Instructing patients in the safe handling of portable equipment.

### DISPOSAL OF SHARPS

Accidental inoculation with infected blood as a result of needlestick injury presents a major risk to the healthcare worker (Royal College of Nursing 2006). Despite the amount written about the prevention and management of sharps injury, many accidents still occur (May and Brewer 2001). Between July 1997 and June 2002, 1550 reports of blood-borne exposures in healthcare workers were reported, of whom 42% were nurses and midwives (Royal College of Nursing 2006). Sharps injuries can give rise to the transmission of HIV, the hepatitis B virus, hepatitis C and other blood-borne diseases. Injuries that do not involve contaminated blood, for example those that arise when drugs are being drawn up, carry with them fewer hazards but are nevertheless considered important because of the possible entry of infection through the punctured skin. Responsibility for safe practice rests with the employee through the Health and Safety at Work Act 1974 and the employer through the Control of Substances Hazardous to Health Regulations 1988.

One particularly important procedure in clinical practice is the disposal of needles. Resheathing of needles must not be attempted, and no attempt should be made to try to detach the needle from the syringe prior to disposal. The combined syringe and unsheathed needle should be carefully placed as a single unit in a rigid plastic sharps bin immediately after use. Needles should not be cut or bent, whether used or unused. It is the personal responsibility of the individual using the sharp to dispose of it safely (Royal College of Nursing 2006). Sharps containers should be sealed when two-thirds full. There should be a sufficient number of them to allow for replacement. In any case, no attempt should be made to press down the contents of a sharps container to create room for more. Sharps containers should be carried by their handles and placed in a secure place away from the public prior to ultimate disposal as medical waste by incineration or other high-temperature system. Although free sterile syringes and needles are available...
to people who abuse drugs, the risks of pilfering from sharps containers should not be overlooked. Access by patients and visitors (especially children) to sharps containers must be prevented. Staff should be aware of local inoculation policy in the event of needlestick injury. The prospect of the availability of retractable syringes is good news.

**TRANSDERMAL ADMINISTRATION**

Although most preparations are applied topically to give a local effect, the topical route can also be used to achieve a systemic effect. This is the transdermal route of administration. Drugs administered in this way avoid first-pass metabolism by the liver (see p. 126). The best known is glyceryl trinitrate, used in the prophylaxis of angina. Where flexibility of dosage is required, this may be achieved with the application of an ointment containing 2% glyceryl trinitrate. Magnitude and duration of effect are directly related to the amount of ointment applied. It is therefore possible by this method to titrate the dosage against the clinical presentation of the patient. To obtain the optimum dosage, 12 mm (0.5 inch) of ointment is applied to the chest, arm or thigh on the first day, followed by 12-mm increments on each successive day until headache occurs; this length is then reduced by 12 mm. A graduated paper scale facilitates measurement of the dose. When applied to the skin, the ointment is covered with a simple dressing. It is not rubbed in. This is a messy procedure and therefore not commonly used.

A more sophisticated transdermal drug delivery system is the transdermal self-adhesive patch. Patches containing a reservoir of glyceryl trinitrate (see Fig. 4.14) are specially designed to achieve a prolonged and constant release of the drug. The main clinical indication for glyceryl trinitrate patches is in the prophylaxis of angina. The patches have also been used in the prophylactic treatment of phlebitis and extravasation, secondary to long-term venous cannulation.

Patches are available from which the average amount absorbed in 24 h is either 5 or 10 mg. One patch is applied every 24 h to a hairless area to ensure that it sticks well. The anterior or lateral chest wall is recommended, although the upper arm or shoulder is another suitable site. The site should have been washed and thoroughly dried, although not powdered, before applying the patch.

The sachet in which the patch is packaged should be torn rather than cut open, otherwise the patch might be damaged. Without touching the sticky surface (which contains some medicament), the backing is removed and the patch applied, pressing firmly for about 5 s to ensure complete contact. The patch is then sealed to keep out air or water, by running the finger round its edge. A different area should be used each day to avoid skin irritation. Patients who are to be self-administering a transdermal drug for the first time should be counselled in its use. Tolerance to glyceryl trinitrate can develop, in which case the patch should be removed at bedtime and a fresh one attached next morning.

Several other drugs may be administered by this route. For example, a hyoscine patch to prevent motion sickness is placed behind the ear 5–6 h before travelling and replaced after 72 h, if necessary, by a patch behind the other ear; estradiol used in hormone replacement therapy is applied to unbroken areas below the waistline (not on or near the breasts or under the waistband) and is replaced after 3–4 days. Nicotine transdermal patches are available for weaning addicted smokers off their nicotine dependence. Fentanyl patches are widely used to relieve pain in palliative care.
The transdermal route of administration offers many advantages to the patient and the nurse, because it is non-invasive and convenient. However, the technology involved in developing and producing transdermal systems results in a relatively high-cost product. While the number of drugs that can be administered transdermally is gradually expanding, there are many problems to be overcome before a clinically effective product can be introduced. Not least of these problems is the efficient barrier to systemic absorption provided by the skin itself.

**CALCULATIONS**

With the development of clinical pharmacy services and the introduction of patient-specific medicines, the overall need for nurses to undertake calculations in connection with the administration of medicines and other pharmaceutical products has declined. Situations still arise, however, when nurses need to perform basic calculations, and these they must be able to do accurately and with confidence. Moreover, there is concern at the lack of numeracy among student nurses due to graduate (Hall 2006).

**SI UNITS**

In order to calculate how to obtain a particular dose for an individual patient, a sound understanding of Système International d’Unités (SI) units of mass (weight) and volume is essential.

The international system of units for mass and volume is as follows.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass:</td>
<td></td>
</tr>
<tr>
<td>1 kilogram (kg)</td>
<td>1000 grams</td>
</tr>
<tr>
<td>1 gram (g)</td>
<td>1000 milligrams</td>
</tr>
<tr>
<td>1 milligram (mg)</td>
<td>1000 micrograms</td>
</tr>
<tr>
<td>1 microgram µg</td>
<td>1000 nanograms µg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume:</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 litre (L)</td>
<td>1000 millilitres</td>
</tr>
<tr>
<td>1 millilitre (mL)</td>
<td>1000 microlitres (µL)</td>
</tr>
</tbody>
</table>

*It should be noted that these denominations must not be abbreviated in prescription writing, because of the possibility of confusion with other abbreviations.*

**UNITS OF ACTIVITY**

The strength of some medicines obtained from natural products is expressed in units of activity per given volume, for example 100 units/1 mL (insulin), 5000 units/mL (heparin), 100 000 units/mL (nystatin). The abbreviation ‘U’ should not be used, because it has been mistaken for a zero, with disastrous consequences. The word ‘units’ must always be written in full.

**PERCENTAGES**

The strength of active ingredient in some pharmaceutical products may be expressed as a percentage, meaning parts per 100 parts. This is expressed in four ways.

- Percentage weight in volume (% w/v). The expression 5% w/v indicates that 5 g of active ingredient is present in 100 mL of product.
- Percentage weight in weight (% w/w). The expression 5% w/w indicates that 5 g of active ingredient is present in 100 g of product.
- Percentage volume in volume (% v/v). The expression 5% v/v indicates that 5 mL of active ingredient is present in 100 mL of product.
- Percentage volume in weight (% v/w). The expression 5% v/w indicates that 5 mL of active ingredient is contained in 100 g of product.

**THE MOLE AND THE MILLIMOLE**

The strength of a pharmaceutical preparation used in electrolyte replacement therapy is normally expressed in mmol/tablet or mmol/given volume of solution. In addition, the strength of a solution will be expressed as a percentage.

A mmol is one-thousandth of a mole, which is the molecular weight of a substance expressed in g. Nurses will not normally be expected to calculate mmol from first principles but may have to calculate how much of a given solution to measure to obtain a particular dose.

**ARITHMETIC REQUIRED FOR CALCULATING MEDICINE DOSES**

A prerequisite of safe practice is the need to abide by the principles of basic arithmetic. An understanding of fractions, decimals and proportion is essential. For a variety of reasons, the subject of arithmetic has not always been understood or favoured by nurses (Wright 2006) prior to entering the profession, and so it is incumbent on those who lack confidence in their ability to do basic arithmetic or have simply forgotten the skills involved to seek help urgently. The use of a calculator to determine the quantity or volume of medication to be given should not act as a substitute for arithmetical knowledge and skill (Nursing and Midwifery Council 2004, p. 7).

As a note of encouragement, the need to carry out complex calculations has been greatly reduced. Indeed, in many instances there is no need to make a calculation at all. The difficulties encountered are...
now being recognised, and help is available. What cannot be achieved, other than by the individual, is an acceptance that practice is needed in this area of study.

**EXPRESSING THE STRENGTH OF ACTIVE INGREDIENT(S)**

**SOLID ORAL DOSE FORMS**

In most cases, the strength of the active ingredient(s) present in each tablet or capsule will be expressed on the label of the product in g, mg or micrograms, for example amoxicillin 250 mg. Quantities of less than 1 g should always be expressed in mg, thus the expression 500 mg is used and not 0.5 g. Similarly, quantities of less than 1 mg should always be expressed in micrograms. This approach should always be followed when prescribing, recording the administration of and ordering or dispensing medicines. This reduces the need to use the decimal point, which, if incorrectly placed, can lead to massive errors in drug administration. The need for the decimal point to be used remains when doses such as 37.5 mg are required.

Products used for electrolyte replacement therapy, in addition to a strength of active ingredient being given in g or mg, will also have the strength quoted in mmol.

On some occasions, it is necessary to convert fractions of a mg into micrograms. This should rarely be required, because, for quantities less than 1 mg, the prescriber should use micrograms in writing the prescription and the label on the container should bear the strength of the product expressed in micrograms. Unfortunately, situations may arise when the dose is expressed in micrograms and the product available is labelled in mg or vice versa.

Calculations involving solid dose forms will generally cause few problems, but as with all calculations the need for accuracy cannot be overstated. Sometimes, there will be no alternative but to subdivide a tablet (using a tablet splitter) or to give a number of tablets to obtain the prescribed dose. The medicine is transported to the patient on a medicine spoon or in a medicine measure.

An example of an oral solid calculation is given on p.75.

**LIQUID ORAL DOSAGE FORMS**

The amount of active ingredient per given volume is given for the strength of preparations such as antibiotic syrups. An ampicillin syrup will bear a label stating that the product contains 250 mg in 5 mL. It is in connection with the administration of liquids (oral and parenteral) that calculations are often required.

A medicine measure, oral syringe or dropper will be used to measure and administer the medicine as appropriate.

Doses of liquid medicines (oral and parenteral) are calculated using the same principles.

**LIQUID PARENTERAL DOSAGE FORMS**

**Small-volume injections**

Two main approaches will be encountered, depending on the volume of the product.

- Small-volume injections will normally bear a label expressing the strength of the product in a manner similar to that used for oral liquids. For example, an injection will be shown to contain 25 mg per 1 mL, but care should be taken to note the volume contained in each ampoule because, if the ampoule contains 2 mL, the amount of active ingredient in 2 mL is 50 mg.
- The strength of injections of local anaesthetics such as lignocaine (lidocaine) is commonly expressed as a percentage w/v.

On the label of parenteral products for electrolyte replacement therapy (large or small volume), the strength is frequently expressed as a percentage, mass per given volume, and mmol per given volume.

The strength of adrenaline (epinephrine) injections is still frequently expressed as 1 in 1000. This indicates that 1 g of active ingredient is contained in 1000 mL of product. Of more value to the nurse is the fact that 1 mL of the injection contains 1 mg of adrenaline.

When a product is supplied in an ampoule or rubber-capped vial as a dry powder for reconstitution before use, the label will give the amount of dry powder contained in it. When reconstituting such products prior to injection, the total volume produced by adding the diluent to the powder must be known if part of the total dose contained in the ampoule or vial is to be administered.

The method used for calculating small-volume parenteral products is exactly the same as for oral dosage forms. Parenteral doses are measured using an appropriate size of syringe. Insulin must always be administered using a special syringe specifically calibrated for insulin units. Some products are prepacked in a syringe ready for use.

An example is given on p.76.

**Large-volume parenteral products**

Labels on containers of large-volume infusion solutions will generally give information on the strength of the product in percentage terms. For example, solutions of sodium chloride may contain 0.9% w/v;
or a glucose infusion may contain 5% w/v. Solutions for electrolyte replacement therapy will also contain information on the number of mmol of given electrolytes per given volume.

Other pharmaceutical products
The strengths of products such as lotions, sterile topical solutions, ointments and antiseptic solutions will generally be expressed as a percentage, i.e. liquid preparations as a percentage w/v, solid or semisolid preparations as a percentage w/w. When very dilute antiseptic solutions are in use, the strength may be expressed as the number of parts of active ingredient in a given volume of solution (e.g. 1 in 5000, 1 in 2000). In the first example, 1 g of the active ingredient is contained in 5000 mL of product; in the second, 1 g is contained in 2000 mL of product.

MAKING A CALCULATION
Four steps are involved in making a calculation.

1. Check the validity of the prescription (see p. 34).
2. Check the details on the label or packaging (see p. 35).
3. Compare the details on the label with those of the prescription.
4. Provided that everything is in order, and only then, a calculation may be made.

Individuals have preferences in the way they make a calculation, but this does not matter as long as the correct answer is reached on every occasion. Two possible approaches are suggested here.

- **Using first principles.** This method is based on using the information available and can often be done mentally. It is frequently used for calculating oral medicines when the units in the prescription and on the label are the same. For example:
  - the patient is prescribed 10 mg of an oral drug
  - the label states that each tablet contains 5 mg of the drug
  - the patient should therefore receive two tablets.

- **Using a simple formula.** This method is based on simple proportion and is useful when calculating liquid doses and when the units in the prescription and on the label are different. Until experienced, the nurse may wish to make the calculation on paper. The formula is:

\[
\text{dose required} = \left( \frac{\text{dose prescribed}}{\text{dose available}} \right) \times \text{volume containing available dose}
\]

Put simply, and easier to remember, this reads as:

\[
\left( \frac{\text{want}}{\text{got}} \right) \times \text{volume}
\]

For example:
- the patient is prescribed 500 mg of a suspension
- the suspension is available as 250 mg of drug in 5 mL

- applying the formula,

\[
= \left( \frac{500 \text{ mg}}{250 \text{ mg}} \right) \times 5 \text{ mL}
\]

\[
= 2 \times 5 \text{ mL}
\]

\[
= 10 \text{ mL}.
\]

CALCULATIONS INVOLVING RECONSTITUTION OF INJECTIONS
When an injection has to be reconstituted from a powder before use, it should be noted that the resulting volume is in excess of the volume of diluent added, owing to the displacement effect of the powder. This must be taken into account if a dose less than that contained in the vial is required. An example follows.

- A vial contains 500 mg, but the dose required is 200 mg.
- The addition of 5 mL of diluent yields a volume of 5.25 mL when drawn into the syringe. This must be taken into account when using the formula.

DOSSAGE CALCULATIONS INVOLVING BODY SURFACE AREA
In certain specialised forms of therapy (e.g. cytotoxic drug therapy), drug dosage is based on body surface area. The patient’s body surface area is determined from a table (nomogram) using the patient’s body weight and height.

CALCULATING DOSES SAFELY
Several key points should be uppermost in the mind of the nurse when making a calculation. These can be summarised as follows.

- Take great care when dealing with very small quantities (e.g. micrograms) and very large quantities (e.g. multiple tablets).
- Take great care with fractions of a mg. It is quite in order to ask the prescriber to change, for example, 0.25 mg to 250 micrograms.
SECTION 1  ■  MEDICINES MANAGEMENT

Regular medicines – non-injectable

<table>
<thead>
<tr>
<th>Date</th>
<th>MEDICINE [Block letter]</th>
<th>DOSE</th>
<th>ROUTE OF ADMIN</th>
<th>TIMES OF ADMINISTRATION</th>
<th>SIGNATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DILTIAZEM</td>
<td>360 mg</td>
<td>ORAL</td>
<td>0800 hrs</td>
<td>1200 hrs</td>
</tr>
</tbody>
</table>

Label

Once Daily
Diltiazem® XL 180mg
Prolonged-release Hard Capsules

for oral use
Take as directed by the physician
Do not suck or chew capsules

Commentary

• A straightforward calculation
• Both prescription and label are in the same units

Workings

The prescribed dose is more than the amount contained in one capsule.

Dose required

\[
\text{Strength available} = \frac{360 \text{ mg}}{180 \text{ mg}}
\]

\[
= \frac{360 \text{ mg}}{180 \text{ mg}}
\]

\[
= \frac{36}{18}
\]

\[
= \frac{6}{3}
\]

\[
= 2
\]

The patient will be given:
2 capsules

Fig. 4.15  Example of calculation for a regular, non-injectable medicine. (From Downie G, Mackenzie J, Williams A 2006 Calculating drug doses safely: a handbook for nurses and midwives. Churchill Livingstone, Edinburgh. With permission of Elsevier.)

• Remember that you are comparing the label with the prescription.
• When two persons are calculating a dose, it is advisable to do so independently to increase accuracy.
• If in any doubt, do not proceed.
• If unsure about the dose, ask for clarification from the prescriber.
• Before administering a medicine, consider whether the quantity is reasonable.
• To ascertain availability of different strengths of a medicine, ask the pharmacist.

The examples in Figures 4.15 and 4.16 are included for demonstration purposes. More examples to practise may be found in the self-assessment exercises at the end of this chapter. For more detailed guidance on calculating drug doses and for up to date clinical examples to practise, refer to Calculating drug doses safely by Downie et al., published in 2006 by Churchill Livingstone.

INTENSIVE CARE

Intensive care is appropriate for patients requiring or likely to require advanced respiratory support, support of two or more organ systems or, in those with chronic impairment of one or more organ systems, additional support for an acute reversible failure of another organ.
Early referral is extremely important. Patients should be admitted to the intensive care unit (or intensive therapy unit, ITU) before their condition reaches a point from which recovery is impossible. Early referral improves the chances of recovery, reduces the potential for organ dysfunction, may reduce length of stay in the intensive care unit and hospital, and may subsequently reduce the costs of intensive care.

Admission criteria:
- severity of illness
- diagnosis
- age
- past medical history
- prognosis
- availability of suitable treatment
- recent cardiac event
- quality of life
- patient’s wishes.
ORGAN SYSTEM MONITORING AND SUPPORT WITHIN THE ITU ENVIRONMENT

- Advanced respiratory support:
  - mechanical ventilation
  - possibility of a sudden deterioration in respiratory function requiring immediate endotracheal intubation and ventilation.
- Circulatory support:
  - need for vasoactive drugs to support arterial pressure or cardiac output
  - support for circulatory instability due to hypovolaemia
  - post cardiac arrest when intensive care is considered clinically appropriate
  - intra-aortic balloon pumping.
- Neurological support:
  - central nervous depression sufficient to prejudice the airway and reflexes
  - invasive neurological monitoring.
- Renal support:
  - haemodialysis, haemofiltration or haemodiafiltration.

FREQUENTLY SEEN CONDITIONS WITHIN THE ITU SETTING

SEPTIC SHOCK
Sepsis is the systemic response to an insult of proven or high likelihood of infection, compared with an infection that can be applied to a localised phenomenon. Sepsis can initiate a systemic inflammatory response syndrome and can affect other organs.

Criteria for systemic inflammatory response syndrome are:
- heart rate > 90 beats/min
- respiratory rate > 20 breaths/min
- temperature > 38°C or below 36°C
- leucocytes > 12 000 cells/mm² or < 4000.

The early twentieth century mortality rate from sepsis of 41% remains virtually unchanged today.

As inflammation becomes systemic, inflammatory responses throughout the body cause:
- body vasodilation
- increased intravascular space
- increased capillary permeability
- oedema
- hypovolaemia
- hypoperfusion with tissue hypoxia.

Treatment includes:
- empirical antibiotic therapy depending on the severity of the illness
- fluid resuscitation
- inotropes.

Cardiogenic, neurogenic and hypovolaemic shock, and toxic shock syndrome are also seen within the ITU setting.

NEUROLOGICAL INSULT
Neurological failure may occur after head injury, poisoning, cerebral vascular accident, cardiac arrest, metabolic encephalopathy (e.g. liver failure) or infections of the nervous system (meningitis or encephalitis). Loss of consciousness can lead to obstruction of airways and loss of protective airway reflexes that require mechanical ventilation.

Sustained high intracranial pressure can cause ischaemic brain damage and is usually fatal. Progressive cellular damage can cause:
- intracellular oedema and cell death
- hyperkalaemia
- capillary vasodilation
- seizures
- thermoregulatory issues.

Treatment for increased intracranial pressure while ventilated includes:
- bed 30° head-up tilt
- minimal endotracheal suction
- sedation, analgesia and possibly thiopentone
- titrating ventilation
- corticosteroids
- mannitol.

MAJOR TRAUMA
Such patients are admitted to the ITU for close observation and rigorous medical management. As well as experiencing multiple fractures, they may have suffered chest or heart injuries including diaphragmatic rupture; injuries to the aorta, pericardium, lungs and airways; and damage to other organs.

Treatment includes:
- restoration of adequate tissue perfusion and gas exchange
- analgesia
- correction of coagulopathy
- prompt attention to complications
- close monitoring
- adequate nutrition.
Spinal injuries, near drownings and burns are also seen in the ITU environment.

**MULTIORGAN FAILURE**

Multiorgan failure involves dysfunction of two or more organs and is one of the main causes of mortality in the ITU. Multiorgan failure can be used to describe two organ failure but is more often used when all organs are failing. However caused, multiorgan failure represents a vicious downward spiral of gross ischaemia causing hypoxaemia and failure of most or all organs.

Treatment objectives include:
- oxygen saturations of 90–95%
- maintenance of cardiac output/oxygen delivery and blood pressure with adequate organ perfusion
- adequate metabolic and fluid homeostasis with intravascular filling, diuretics, vasoactive agents and/or renal replacement therapy
- haemoglobin at > 9–10 g/dL
- careful infection control and antibiotics
- early nutrition (enteral or parenteral).

**DRUGS USED IN THE ITU**

**SEDATION**

Sedation is necessary for most ITU patients. It is used to ensure comfort for the critically ill, to help prevent patients ‘fighting’ the ventilator, and to help remove much psychological trauma that is associated with ITU admissions. However, most sedative drugs have severe respiratory and cardiovascular side effects as well as being cumulative.

Propofol is a commonly used sedative in the ITU environment. Advantages of propofol include a rapid onset of action and a rapid recovery even after prolonged infusion. It is administered as an emulsion in 10% Intralipid, and infusion volumes may contribute to the calorie load of the patient. This must be taken into account when enteral/parenteral feed is prescribed.

**Dose**. For continuous infusion: 4 mg/kg per h. It should be titrated to the required sedation level.

Benzodiazepines (diazepam and midazolam) are also used.

**PARALYSING AGENTS**

Paralysing agents, which are also known as muscle relaxants, are used in the ITU to help control acutely raised intracranial pressure and help to prevent surges in intracranial pressure in response to stimuli such as physiotherapy and endotracheal suctioning. They can also be used to facilitate ventilation.

Paralysing agents cannot cross the blood–brain barrier and therefore have no sedative or analgesic effects. For this reason, it is essential to accompany paralysing drugs with sedative/analgesic drugs in order to avoid the intolerable situation of a patient who is aware, often in pain, but unable to move.

Atracurium is the most popular paralysing agent used in the ITU environment. It is non-cumulative but can cause bradycardia and hypotension.

**Dose**. For continuous infusion: 200–400 micrograms/kg per h.

**ANALGESICS**

Causes of acute pain in ITU patients can be obvious (e.g. surgery), but patients may also suffer from pre-existing chronic pain. Nursing and medical interventions can also cause pain (e.g. intubation, chest drain insertion/ removal, endotracheal suctioning, dressing wounds and line insertion). Assessing pain, perceptions and needs can be difficult with ITU patients because of sedation, intubation and/or impaired psychomotor skills. However, comfort and pain relief are fundamental to nursing.

Alfentanil is 30 times more potent than morphine and of shorter duration than fentanyl, and is the usual drug of choice for a continuous analgesic infusion. Side effects include bradycardia, respiratory depression and urinary retention.

**Dose**. This is 1–5 mg/h (up to 1 microgram/kg per min).

Morphine, diclofenac, tramadol and paracetamol are also used.

**INOTROPES**

Conditions requiring the careful administration of inotropes include septic shock, cardiogenic shock and other low cardiac output states. Catecholamine inotropes (e.g. adrenaline [epinephrine], noradrenaline [norepinephrine] and dobutamine) are commonly used in the ITU setting. They increase the force of myocardial contraction and are usually given by a continuous infusion.

All inotropes should be titrated to the patient’s weight. However, most critically ill patients need to be quickly commenced on a ‘standard dose’ until such time as the patient can be weighed.

Side effects include arrhythmias and myocardial ischaemia. Overdoses can cause life-threatening hypertension, necessitating careful titration and close monitoring with an arterial line, either invasive or non-invasive cardiac output monitoring and continuous electrocardiogram. Inotropes must NOT be attached to the central venous pressure monitoring line port,
to prevent a surge of the drug being administered when flushing the line. They must also always be administered centrally, never peripherally, in order to prevent extravasation.

**Dose.** Standard starting concentration for adrenaline and noradrenaline: 30 micrograms/kg. For 70 kg: $30 \text{ micrograms} \times 70 = 2.1 \text{ mg}$ of adrenaline or noradrenaline, usually made up to 50 mL of dextrose 5% to prevent oxidation.

However, the rate and concentration that may be doubled or tripled will depend on the patient’s blood pressure. Isoprenaline and dopamine are also used.

**ROUTES OF ADMINISTRATION**

Intravenous drugs are usually administered centrally. Peripheral blood flow may be absent due to the patient’s condition (e.g. shock or peripheral blood flow provides insufficient dilution).

Centrally administered drugs act more rapidly, and the patient must be closely monitored during and after administration. Residual particles of drugs in the lines may precipitate with subsequent drugs. Nurses must observe the lines during administration and flush them with sodium chloride 0.9% solution afterwards and between drugs.

Central lines may have single, double, triple or quadruple lumens and are commonly inserted into the internal jugular, femoral or subclavian vein. They allow continuous monitoring of the central venous pressure and the administration of multiple continuous infusions and boluses. Central line insertion can cause an air embolism, venous thrombosis, pneumothorax, infection, arrhythmias and arterial puncture.

- Intravenous drugs are the most common route for the critically ill. Total parenteral nutrition is often administered to the critically ill via a central line.
- Intramuscular drugs are seldom used, because of the increased risk of coagulopathy and unpredictable absorption due to varying cardiac output and blood flow.
- Subcutaneous heparin is commonly administered. However, absorption is variable.
- Oral administration includes nasogastric, nasoduodenal and nasojejunal feeding tubes. Surgical jejunostomy tubes are occasionally required. Drugs given by these routes should be in liquid form or finely crushed and dissolved in water. Varying splanchnic blood flow, inconsistent hepatic function and altered intestinal transit times make this an unreliable form of drug administration in the critically ill.
- Rectal absorption is also unpredictable.

**CRITICAL CARE NURSING**

Critically ill patients require close nursing supervision on a one-to-one basis. However, many patients are severely ill, requiring multiple interventions and have a dependency greater than one to one.

To be an effective critical care nurse, there is a need to meet the physical, psychological, spiritual and social needs of the patient as well as being a competent technician. While coping with the critical care environment, there is a risk of dehumanising patients.

Critical care nurses often work in stressful situations in which there are conflicting demands on their time from the patient, their significant others and the technology. Through training, education, experience and support, critical care nurses will learn how to meet all these demands while delivering the optimum level of care.

These specialist nurses need to maintain the safety, dignity and humanity of the patient while ensuring that the technology is functioning correctly. When critical care nurses become experts in their field, they are able to combine all the aforementioned functions while minimising the adverse effects of the technology.

**SELF-ASSESSMENT QUESTIONS**

**SECTION A**

All nurses and midwives, both pre- and postregistration, should be able to answer the following questions.

1. Apart from the patient’s biographical details, what information must appear on every prescription?
2. What methods may be used to identify a hospital patient prior to the administration of a medicine?
3. How may a patient be assisted in taking an oral medicine?
4. How should you pour an oral liquid medicine?
5. Under what circumstances should a tablet be divided?
6. How should a tablet be divided?
7. What should you do with a medicine container whose contents are time-expired?
8. What should you do with a medicine container whose contents are time-expired?
9. What sources of reference are normally available to the nurse administering medicines?
10. What should you do?
SECTION B
Using the British National Formulary if necessary, complete the above table.

SECTION C
1. Why must oral glyceryl trinitrate be given by the sublingual route?
2. Why must insulin be given by injection?
3. Why is the intravenous route used to administer drugs in an emergency?
4. Why should you never transfuse blood immediately following a glucose infusion?
5. Why should infusions containing potassium be administered and controlled via an infusion pump?
6. Why should the skin not be rubbed after injecting heparin?
7. Why is it crucial that intravenous drugs are never given by the intrathecal route?
8. Why should tablets or capsules be swallowed with a drink?
9. Why is the skin not cleansed when testing for allergens?
10. Why are intramuscular injections never prescribed for leukaemic patients?

SECTION D
1. Intramuscular injections are administered into the upper outer quadrant of the buttock so as to avoid:
   a. the vastus lateralis
   b. the gluteus maximus
   c. the sacroiliac joint
   d. the sciatic nerve.
2. After cleaning the top of a rubber-capped vial with an alcohol swab, you should wait:
   a. 10 s
   b. 30 s
   c. 60 s
   d. 15 s.
3. Place the following in order of speed of action from fastest to slowest:
   a. intramuscular
   b. oral
   c. transdermal
   d. subcutaneous
   e. intravenous.
4. The administration of medicines by injection is known as:
   a. paternal
   b. parenteral
   c. parental
   d. peritoneal.
5. The size of needle normally used for an adult receiving intramuscular injections is:
   a. 19-gauge
   b. 25-gauge
   c. 21-gauge
   d. 23-gauge.

SECTION E
Who would you inform if the following occurred?
1. Extravasation of a drug.
2. Faulty infusion pump.
3. Patient unable to swallow tablets.
4. Patient receiving intravenous infusion becomes breathless.
5. Patient has difficulty picking up tablets.
6. Pharmacy has supplied a change of formulation of a prescribed medicine.

<table>
<thead>
<tr>
<th>Paracetamol</th>
<th>Prednisolone</th>
<th>Diamorphine</th>
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<tbody>
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<td>Class of drug</td>
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<td>Storage</td>
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<td></td>
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<td>Formulations available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indications for use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contraindications</td>
<td></td>
<td></td>
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<tr>
<td>Normal dose range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common side effects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION F
1. Where are the gluteal muscles situated?
2. Where in the body is an intrathecal injection given?
3. Where is a buccal tablet placed?
4. Where can subcutaneous injections be given?
5. Where in the body are intravenous injections commonly given?
6. Where should reconstituted antibiotics normally be stored?
7. Where can you apply a transdermal patch?
8. Where on the body is allergy testing done?
9. Where should infusions with additives be prepared?
10. Where are drug prescription and recording sheets stored after a patient is discharged?

SECTION G
In the following examples, calculate what you would give to the patient.
1. See Figure 4.17.
2. See Figure 4.18.
3. See Figure 4.19.

SECTION H
In the examples on page 84, calculate what you would give to the patient.

Regular medicines – non-injectable

<table>
<thead>
<tr>
<th>Date</th>
<th>MEDICINE (Block letters)</th>
<th>DOSE</th>
<th>ROUTE OF ADMIN</th>
<th>TIMES OF ADMINISTRATION</th>
<th>SIGNATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PROMAZINE</td>
<td>200 mg</td>
<td>ORAL</td>
<td>0800 hrs</td>
<td>1200 hrs</td>
</tr>
</tbody>
</table>

Label

PROMAZINE
SYRUP
50mg/5ml

Caution: This may cause drowsiness. Do not drive or operate machinery. Avoid alcoholic drink

ROSENTHAL

150ml

Fig. 4.17 Calculation of a regular medicine: non-injectable. (From Downie G, Mackenzie J, Williams A 2006 Calculating drug doses safely: a handbook for nurses and midwives. Churchill Livingstone, Edinburgh. With permission of Elsevier.)
### Regular medicines - non-injectable

<table>
<thead>
<tr>
<th>Date</th>
<th>MEDICINE (Block Letters)</th>
<th>DOSE</th>
<th>ROUTE OF ADMIN</th>
<th>TIMES OF ADMINISTRATION</th>
<th>SIGNATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OSELTAMIVIR</td>
<td>75 mg</td>
<td>ORAL</td>
<td>0800 hrs</td>
<td>2000</td>
</tr>
</tbody>
</table>

#### Label

![Tamiflu 12 mg/ml](image)

**Tamiflu® 12 mg/ml**

powder for oral suspension

Oseltamivir

For oral administration after constitution

Shake bottle well before use

Also contains sorbitol and sodium benzoate

Keep out of the reach and sight of children

Read the enclosed leaflet before use and also for the method of preparation

Do not store above 30°C

After reconstitution, store the suspension at 2°C - 8°C (in a refrigerator)

Roche Registration Limited

6 Falcon Way

Shire Park

Welwyn Garden City

AL7 1TW

United Kingdom

10075922 GB (EG) 1111

**EXP Batch**

---

#### Fig. 4.18 Calculation of a regular medicine: non-injectable. (From Downie G, Mackenzie J, Williams A 2006 Calculating drug doses safely: a handbook for nurses and midwives. Churchill Livingstone, Edinburgh. With permission of Elsevier.)

### Once-only medicines

<table>
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<tr>
<th>Date</th>
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<th>SIGNATURE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>FUROSEMIDE</td>
<td>2 mg</td>
<td>IV</td>
<td>2150 hrs</td>
<td>A. Prescriber</td>
</tr>
</tbody>
</table>

#### Label

![Furosemide](image)

**Furosemide**

20 mg in 2 ml

Antigen Pharmaceuticals

---

#### Fig. 4.19 Calculation of a once-only medicine. (From Downie G, Mackenzie J, Williams A 2006 Calculating drug doses safely: a handbook for nurses and midwives. Churchill Livingstone, Edinburgh. With permission of Elsevier.)
## MEDICINES MANAGEMENT

<table>
<thead>
<tr>
<th>Dose prescribed</th>
<th>Dose available</th>
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<tbody>
<tr>
<td>1.5 g</td>
<td>300 mg/5 mL</td>
<td>mL</td>
</tr>
<tr>
<td>75 mg</td>
<td>25 mg/mL</td>
<td>mL</td>
</tr>
<tr>
<td>0.1 mg</td>
<td>0.05 mg</td>
<td>tablets</td>
</tr>
<tr>
<td>500 000 units</td>
<td>300 000 units/mL</td>
<td>mL</td>
</tr>
<tr>
<td>12 mg</td>
<td>4 mg</td>
<td>tablets</td>
</tr>
<tr>
<td>1 g</td>
<td>500 mg</td>
<td>tablets</td>
</tr>
<tr>
<td>60 mg</td>
<td>5 mg</td>
<td>tablets</td>
</tr>
<tr>
<td>15 mg</td>
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<td>tablets</td>
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<tr>
<td>24 mg</td>
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<tr>
<td>125 micrograms</td>
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<tr>
<td>100 mg</td>
<td>50 mg/mL</td>
<td>mL</td>
</tr>
<tr>
<td>0.5 g</td>
<td>250 mg/mL</td>
<td>tablets</td>
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<tr>
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<td>25 mg/mL</td>
<td>mL</td>
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<td>0.4 mg</td>
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<td>62.5 mg</td>
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<tr>
<td>175 micrograms</td>
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<td>100 micrograms/mL</td>
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<tr>
<td>40 mg</td>
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<tr>
<td>2.5 mg</td>
<td>10 mg/2 mL</td>
<td>mL</td>
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</tbody>
</table>
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