Dosage Calculations for Nurses

June L. Olsen, Anthony Patrick Giangrasso,
Dolores M. Shrimpton, Patricia M. Dillon
and Sheila Cunningham

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Chapter 4

The metric measurement system

Learning outcomes

After completing this chapter, you will be able to

1. Identify the units of measurement in the metric system.
2. Recognise the abbreviations for the units of measurement.
3. State the equivalents for the units of volume for liquids.
4. State the equivalents for the units of weight for solids.
5. Convert from one unit to another within the metric three system.

The *International System (SI)*, commonly known as the *metric system*, is replacing other imperial systems of measurement. However, other systems are still in use, and in a more prevalent manner than in the United Kingdom (UK), especially in countries such as the United States of America (USA). You should appreciate their existence whilst also understanding that in Europe the SI system of measurement ensures comparability across countries and literature. There are plenty of examples of use of imperial measures in the UK (i.e. distance is measured in miles), but for medication and weights and measures in general the metric system is preferred whilst for trade and business use of the metric system is mandatory and monitored by law (NWML 2008). The metric system uses whole and decimal numbers (i.e. 3.5); at times fractions (i.e. $3\frac{1}{2}$) may be utilised. The purpose of this chapter is to explore and clarify metric measurements and to develop confidence in using and moving between decimals and fractions.

Diagnostic questions

Before commencing this chapter try the following questions to stimulate your appetite. Compare your answers with those in Appendix A.

1. Which is larger 5.17 or 5.38?
2. Which is smaller 2.19 or 2.64?

3. Put these in size order, the largest first:

   75.1 25.7 25.762 0.34 3.44

4. Put these in order, the smallest first:

   0.96 0.547 0.009 1.76 0.19

5. Write three and four tenths as a decimal using digits.

The metric system

The metric system is the most widely used, general system of measurement in the world and is the preferred system for prescribing medications. The fundamental units of measurement in the metric system are the **litre** (for liquid volume), the **gram** (for weight) and the **metre** (for length). Other units are formed by placing prefixes onto these fundamental units. The prefixes commonly used in medical doses are **kilo**, **centi**, **milli** and **micro**. The equivalences illustrated in this section need to be understood in order to work within the metric system.

> **Note**
>
> The abbreviation **mL** should be used instead of the abbreviation cc because 'c' may be confused with 'u' (units) or 'cc' with '00' (double zero). Whilst 'cc' is not generally used for medicine measures it is seen occasionally in relation to volumes and may well be seen in international texts.

Liquid volume measurements

Drugs in liquid form are measured by volume. The volume of a liquid is the amount of space it occupies. In dosage calculations, *litres* and *millilitres* are used to measure liquid volume (see Table 4.1).

Table 4.1 Metric equivalents of liquid volume

1 litre (L) = 1000 millilitres (mL)
1000 microlitres = 1 millilitre (mL)

Originally, units for volume and mass were directly related to each other, with mass defined in terms of a volume of water. Even though that definition is no longer used, the relation is quite close at room temperature. So as a practical matter, one can fill a container with water and weigh it to get the volume. For example:

1000 litres	= 1 cubic metre	≈ 1 tonne of water
1 litre	= 1 cubic decimetre	≈ 1 kilogram of water
1 millilitre	= 1 cubic centimetre	≈ 1 gram of water
1 microlitre	= 1 cubic millimetre	≈ 1 milligram of water

Millilitres are used for smaller amounts of fluids. The prefix milli means $\frac{1}{1000}$, so:

$$1 \text{ litre (L)} = 1000 \text{ millilitres (mL)}$$

Millilitres are equivalent to *cubic centimetres* (cm^3 or cc), so:

$$1 \text{ mL} = 1 \text{ cm}^3 = 1 \text{ cc}$$

Note: This (cc) term is not generally used in the United Kingdom or Europe but, due to the prevalence of American texts and electronic resources, it is always useful to understand the equivalences.

It is straightforward to convert fractions to decimals. The unit fraction has the *given units of measurement on the bottom* (the denominator) and the *desired units of measurement on top* (the numerator), you simply divide the top number by the bottom number, as the following examples show.

Example 4.1

If a patient is prescribed 0.5 L of 5% glucose in water, how many millilitres were ordered?

$$0.5 \text{ L} = ? \text{ mL}$$

Cancel the litres and obtain the equivalent amount in millilitres:

$$0.5 \text{ L} \times \frac{? \text{ mL}}{? \text{ L}} = ? \text{ mL}$$

Because 1000 mL = 1 L, the fraction you want is $\frac{1000 \text{ mL}}{1 \text{ L}}$:

$$0.5 \cancel{\text{L}} \times \frac{1000 \text{ mL}}{1 \cancel{\text{L}}} = 500 \text{ mL}$$

So, the patient is prescribed <u>500 mL</u> of 5% glucose in water.

Stop and think

When reporting or writing volumes such as 0.5 L this is best written as decimals instead of $\frac{5}{10}$ or $\frac{1}{2}$ L in the metric system to avoid confusion.

Practice point

When using decimal points the zero needs to be used in numbers less than 1 (e.g. 0.5). When used with whole numbers above 1 this can cause confusion. For example, 3.0 could be confused as 30 or .1 can be confused as 1. Be cautious with the use of zeros and decimal points – a dose of 2.0 mg of a drug maybe confused for 20 mg of a drug and potentially causes serious harm to a patient.

Example 4.2

Your patient is to receive *1750 mL of 0.9% sodium chloride (NaCl intravenously (IV)) every 12 hours*. What is the same amount in litres?

$$1750 \text{ mL} = ?\text{ L}$$

Cancel the millilitres and obtain the equivalent amount in litres.

$$1750 \text{ mL} \times \frac{?\text{ L}}{?\text{ mL}} = ?\text{ L}$$

Because 1000 mL = 1 L, the fraction you want is $\frac{1\text{ L}}{1000\text{ mL}}$

$$1750\ \cancel{\text{mL}} \times \frac{1\text{ L}}{1000\ \cancel{\text{mL}}} = \frac{1750\text{ L}}{1000} = 1.75\text{ L}$$

So, 1750 mL of 0.9% NaCl is the same amount as 1.75 L of 0.9% NaCl.

Alert

The abbreviation for microgram, mcg, is preferred over the abbreviation µg because µg may be mistaken for the abbreviation for milligram, mg. This error would result in a dose that would be 1000 times greater than the prescribed dose – the heart medication digoxin could be prescribed as 62.5 µg or 0.0625 mg, thus giving 62.5 mg would be 1000 times too much and extremely serious for the patient.

Weight measures

Drugs in dry form are measured by weight in the metric system. In dosage calculations, **kilograms**, **grams**, **milligrams** and **micrograms** (written in order of size) are used to measure weight. *Kilograms* are the largest of these units of measurement and *micrograms* are the smallest (see Table 4.2).

Table 4.2 Metric equivalents of weight

1 kilogram (kg) = 1000 grams (g)
1 gram (g) = 1000 milligrams (mg)
1 milligram (mg) = 1000 micrograms (mcg)

Kilograms are used for heavier weights. The prefix kilo means 1000, so:

1 **kilo**gram (kg) = 1000 *grams* (g)

Milligrams are used for lighter weights, and *micrograms* are used for even lighter weights. The prefix milli means $\frac{1}{1000}$, and micro means $\frac{1}{1\,000\,000}$, so:

1 gram (g) = 1000 **milli**grams (mg)

1 milligram (mg) = 1000 **micro**grams (mcg or µg)

Using the simple conversion information in Table 4.2, you can convert a quantity written in one unit of metric weight to an equivalent quantity in another unit of metric weight. The following examples show you how to do this.

Example 4.3

The prescription states *125 mcg of Lanoxin (digoxin) PO daily*. How many milligrams of this cardiac medication would you administer to the patient?

$$125 \text{ mcg} = ?\text{ mg}$$

Cancel the micrograms and obtain the equivalent amount in milligrams:

$$125 \text{ mcg} \times \frac{?\text{ mg}}{?\text{ mcg}} = ?\text{ mg}$$

Because 1000 mcg = 1 mg, you have

$$125 \cancel{\text{mcg}} \times \frac{1 \text{ mg}}{1000 \cancel{\text{mcg}}} = 0.125 \text{ mg}$$

So, 125 mcg is the same amount as 0.125 mg, and you would administer 0.125 mg of digoxin.

Example 4.4

The prescription states *Glipizide 15 mg PO daily before breakfast*. How many grams of this hypoglycaemic agent would you administer?

$$15 \text{ mg} = ?\text{ g}$$

Cancel the milligrams and obtain the equivalent amount in grams:

$$15 \text{ mg} \times \frac{?\text{ g}}{?\text{ mg}} = ?\text{ g}$$

$$15 \cancel{\text{mg}} \times \frac{1 \text{ g}}{1000 \cancel{\text{mg}}} = \frac{15}{1000} \text{ g} = 0.015 \text{ g}$$

So, 15 mg is the same amount as 0.015 g, and you would administer 0.015 g.

Stop and think

Be aware of the relationship between grams (g), milligrams (mg) and micrograms (mcg). Mistaking 62.5 mcg for 62.5 mg means an overdose of 1000 times the prescribed dose! (Because 62.5 mcg = 0.0625 mg)

Length measures

Centimetres (cm) are used to measure lengths or heights and the centimetre (cm) is the only metric unit of length used in medical dosage calculations. Therefore, no conversions of metric units of length are necessary in medical dosage calculations. You may see metres (m) being used, but this would be for non-drug but related aspects, e.g. height or to calculate body mass index. There are 100 centimetres (cm) in a metre (m) so a person who is 1.8 m tall is also 180 cm tall.

Shortcut for converting units in the metric system

The following chart is useful for a quick method of converting units of measurement within the metric system.

	Kilo-	**Fundamental unit**	**Milli-**	**Micro-**
Weight	**kilo**gram (kg)	gram (g)	**milli**gram (mg)	**micro**gram (mcg)
Volume		litre (L)	**milli**litre (mL)	

Another way of looking at it:

1	**Gram/Litre**
10	Decigram/litres (not generally used in practice)
100	Centigrams/litres (not generally used in practice)
1 000	**Milligrams/litres**
10 000	**Micrograms/litres**
100 000	**Nanograms/litres**

The metric system, like our number system, is a **decimal** system *because it is based on the number 10*. Therefore, measurements given in one metric unit can be converted to another metric unit by *merely moving the decimal place*. Using the preceding chart indicating the fundamental units and equivalencies, to change a quantity measured in units from one column to units in the column to its right, move the decimal point *three places* to the right. To change a quantity measured in units from one column to units in the column to its left, move the decimal point *three places* to the left. In other words, to make a number bigger (even though the amount is smaller) move the decimal point to the right and to make it smaller move the decimal point to the left. Therefore, Examples 4.1 to 4.4 could also have been done this way as shown in the following examples.

Stop and think

When converting 0.5 L to 500 mL, the unit of measurement got smaller (L to mL), whereas the number got larger (0.5 to 500).