Common Drug Calculations

Medication administration is a core competency for nurses in every clinical setting. The ability to perform accurate dosage calculations is a key skill required to safely dispense drugs. New technologies such as bar coding medication and smart infusion pumps have helped to reduce medication errors. However, nurses cannot rely completely on these advances. Two dosage calculation techniques are presented below: *traditional formulas* and *dimensional analysis*. Nurses should select one formula and practice to become proficient in that method.

Universal Formula (Toney-Butler, 2023)

All dosage calculations have these 2 components:

- Medication *dosage* prescribed by the healthcare provider
- Medication *concentration* supplied by the pharmacy

Universal Formula

$$\frac{\text{D (desired amount)}}{\text{H (dose on hand)}} \times \text{V (volume)} = \text{Dose}$$

In the universal formula, the *desired amount (D)* is the dose prescribed by the provider. The *amount on hand (H)* is the dose on the container label. *The volume (V)* is the form and amount in which the drug is supplied (e.g., tablet, capsule, liquid). To use this formula, divide the desired amount by the amount on hand and multiply by the volume.

Example 1:

Administer digoxin 0.5 mg IV daily. The drug concentration available from the pharmacy is digoxin 0.25 mg/mL. How many mL will you need to administer a 0.5 mg dose?

D/H x V = Dose
0.5/0.25 x 1 = 2 mL

Intravenous (IV) Medications

Continuous IV drip calculations are more complex. Use the universal formula, recognizing that some conversions are usually necessary. First, determine the drug concentration. Then, consider the unit in which your drug is measured (units/hour, mg/hour, mg/min, mcg/min, or mcg/kg/minute). Depending on how the drug is ordered, use one of the formulas below.

<u>To find mcg/min:</u>

If your amount on hand is in milligrams (mg), convert mg to micrograms (mcg) by multiplying by 1,000. Also, convert hours to minutes.

To find mcg/min:

$$\frac{\text{mg}}{\text{mL}} \times \frac{\text{1000 mcg}}{\text{1 mg}} \times \frac{\text{mL}}{\text{hr}} \times \frac{\text{1 hr}}{\text{60 min}} = \frac{\text{mcg}}{\text{min}}$$

Example 2:
A patient is on a nitroglycerin drip. The IV pump is running at 8 mL/hour. The label on the bottle reads 50 mg in 500 mL 0.9% sodium chloride solution. What dose of nitroglycerin (mcg/min) is the patient receiving?

50 mg/500 mL x 1000 mcg/1 mg x 8 mL/1 hr x 1 hr/60 min
Answer: 13.3 mcg/min

Most institutions utilize infusion pumps that can be programmed to the tenth or hundredth decimal place. If your institution does not have infusion pumps with this capability, you may need to round to the nearest whole number.

To find mcg/kg/min:
Use the formula for mcg/min and divide by patient's weight (kg).

To find mcg/kg/min:

$$\frac{mg}{mL} \times \frac{1000\ mcg}{1\ mg} \times \frac{mL}{hr} \times \frac{1\ hr}{60\ min} \div \text{weight (kg)}$$

Example 3:
Administer dopamine at 10 mcg/kg/min. The pharmacy provides dopamine 800 mg in 250 mL of D_5W. What is the hourly IV pump rate? The patient weighs 85.3 kg.

In this example, solve for mL/hr.

800 mg/250 mL x 1000 mcg/mg x mL/hr x 1 hr/60 min ÷ 85.3 kg = 10 mcg/kg/min
800,000 mcg/250 mL x mL/hr x 1 hr/60 min ÷ 85.3 kg = 10 mcg/kg/min
3,200 mcg/mL x mL/hr x 1 hr/60 min ÷ 85.3 kg = 10 mcg/kg/min
3,200 mcg/mL x mL/hr x 1 hr/60 min = 853 mcg/min
mL/hr = 853 mcg/min x 1 mL/3,200 mcg x 60 min/hr
mL/hr = 16 mL/hr

To find units/hour:
First, determine the concentration of the amount on hand. Then, use the universal formula to calculate the rate.

Example 4:
Administer heparin 500 units per hour I.V. The pharmacy supplies the heparin infusion as 20,000 units in 500 mL D_5W.

Find the concentration:
20,000 units/500 mL = 40 units/mL

Use the universal formula:
D/H x V = Dose
500 units/hr ÷ 40 units/mL = 12.5 mL/hour

Dimensional Analysis

Dimensional Analysis (DA) or factor-label method: uses a series of conversion factors of equivalency from one system of measurement to another but doesn't require memorizing specific formulas. This method reduces errors and can be used for all dosage calculations.

1. Start with the labels needed in the answer to determine what unit of measure is needed to begin setting up the calculation.
2. Build the calculation by placing information with the same label as the preceding denominator into the equation in the numerator to cancel out the unwanted labels. Repeat until all units of measure not needed in the answer are cancelled out.
3. Calculate to determine the correctly labeled numeric answer. Don't round any numbers in the equation until you have the final answer.

Using the same examples above, let's use the dimensional analysis method.

Example 1:
Administer digoxin 0.5 mg IV daily. The drug concentration available from the pharmacy is digoxin 0.25 mg/mL. How many mL will you need to administer a 0.5 mg dose?

Step 1: What unit of measure (label) is needed? Place this on the left side of the equation.

$$\text{mL?} =$$

Step 2: On the right side, place the information given with the same label needed in the numerator.

$$\text{mL?} = \frac{\text{mL}}{0.25\ \text{mg}}$$

Step 3: Place information with the same label as the preceding denominator into the equation in the numerator to cancel out the unwanted labels. Repeat this step sequentially until all unwanted labels are canceled out.

$$\text{mL?} = \frac{\text{mL}}{0.25\ \cancel{\text{mg}}} \times 0.5\ \cancel{\text{mg}}$$

Step 4. Multiply numbers across the numerator, then multiply all the numbers across the denominator. Divide the numerator by the denominator for the final answer with the correct label.

$$\text{mL?} = \frac{\text{mL}}{0.25\ \cancel{\text{mg}}} \times 0.5\ \cancel{\text{mg}} = \frac{0.5\ \text{mL}}{0.25} = 2\ \text{mL}$$

Example 2:
A patient is on a nitroglycerin drip. The pump is running at 8 mL/hour. The label on the bottle reads 50 mg in 500 mL 0.9% sodium chloride solution. What dose of nitroglycerin (mcg/min) is the patient receiving?

Step 1: $\frac{?\ \text{mcg}}{\text{min}}$

Step 2: *Convert 50 mg to 50,000 mcg.

$$\frac{?\text{ mcg}}{\text{min}} = \frac{50{,}0\cancel{00}\text{ mcg}}{5\cancel{00}\text{ mL}} = \frac{100\text{ mcg}}{\text{mL}}$$

Step 3: $\frac{?\text{ mcg}}{\text{min}} = \frac{100\text{ mcg}}{\cancel{\text{mL}}} \times \frac{8\ \cancel{\text{mL}}}{\cancel{\text{hour}}} \times \frac{1\ \cancel{\text{hour}}}{60\text{ min}}$

Step 4: $\frac{?\text{ mcg}}{\text{min}} = \frac{100\text{ mcg}}{\cancel{\text{mL}}} \times \frac{8\ \cancel{\text{mL}}}{\cancel{\text{hour}}} \times \frac{1\ \cancel{\text{hour}}}{60\text{ min}} = \frac{800\text{ mcg}}{60\text{ min}} = 13.3\text{ mcg/min}$

Example 3:

Administer dopamine at 10 mcg/kg/min. The pharmacy provides dopamine 800 mg in 250 mL of D5W. What is the hourly IV pump rate? The patient weighs 85.3 kg.

Step 1: $\frac{?\text{ mL}}{\text{hr}}$

Step 2: $\frac{?\text{ mL}}{\text{hr}} = \frac{250\text{ mL}}{800\text{ mg}}$

Step 3: $\frac{?\text{ mL}}{\text{hr}} = \frac{250\text{ mL}}{800\ \cancel{\text{mg}}} \times \frac{1\ \cancel{\text{mg}}}{1{,}000\ \cancel{\text{mcg}}} \times \frac{10\ \cancel{\text{mcg}}}{\cancel{\text{kg/min}}} \times 85.3\ \cancel{\text{kg}} \times \frac{60\ \cancel{\text{min}}}{1\text{ hr}}$

Step 4: $\frac{?\text{ mL}}{\text{hr}} = \frac{250\text{ mL}}{800\ \cancel{\text{mg}}} \times \frac{1\ \cancel{\text{mg}}}{1{,}000\ \cancel{\text{mcg}}} \times \frac{10\ \cancel{\text{mcg}}}{\cancel{\text{kg/min}}} \times 85.3\ \cancel{\text{kg}} \times \frac{60\ \cancel{\text{min}}}{1\text{ hr}} = \frac{12{,}795{,}000}{800{,}000} = 16\text{ mL/hr}$

Example 4:

Administer heparin 500 units per hour I.V. The pharmacy supplies the heparin infusion as 20,000 units in 500 mL D5W.

Step 1: $\frac{?\text{ mL}}{\text{hr}}$

Step 2: $\frac{?\text{ mL}}{\text{hr}} = \frac{1\text{ mL}}{40\text{ units}}$

Step 3: $\frac{?\text{ mL}}{\text{hr}} = \frac{1\text{ mL}}{40\ \cancel{\text{units}}} \times \frac{500\ \cancel{\text{units}}}{\text{hr}}$

Step 4: $\frac{?\text{ mL}}{\text{hr}} = \frac{500\text{ mL}}{40\text{ hr}} = 12.5\text{ mL/hr}$

Calculating Drops Per Minute

Continuous IV infusions are delivered via infusion pumps however, there may be times when an electronic pump isn't available. This requires calculating the number of drops per minute, as administered through basic IV tubing.

It is important to note that there are two types of IV tubing that will deliver fluid at a specific flow rate, known as the drip factor: macrodrip and microdrip. The drip factor, which can be found printed on the IV tubing package, is the number of drops (gtts) in one mililiter (mL) of solution delivered by gravity. The rate is measured by counting the number of drops that fall into the drip chamber each minute.

- Macrodrip tubing is wider, producing larger drops, and is available in three sizes: 10, 15, or 20 drops per mL (gtt/mL). Macrodrip tubing is typically used to infuse fluids at a rapid rate.
- Microdrip tubing is narrower, producing smaller drops with a drip factor of 60 gtts/mL. It is often used to infuse fluids to pediatric and neonatal patients or medications requiring a precise flow rate.

Example:

Administer lactated ringer's solution IV at 75 mL/hour. The drip factor is 10 drops/mL. How many drops per minute will you run the infusion?

Using the DA method:

Step 1: $\frac{?\ \text{drops}}{\text{min}}$

Step 2: $\frac{?\ \text{drop}}{\text{min}} = \frac{10\ \text{drops}}{\text{mL}}$

Step 3: $\frac{?\ \text{drops}}{\text{min}} = \frac{10\ \text{drops}}{\text{mL}} \times \frac{75\ \text{mL}}{\text{hr}} \times \frac{1\ \text{hr}}{60\ \text{min}}$

Step 4: $\frac{?\ \text{drops}}{\text{Mn}} = \frac{10\ \text{drops}}{\cancel{\text{mL}}} \times \frac{75\ \cancel{\text{mL}}}{\cancel{\text{hr}}} \times \frac{1\ \cancel{\text{hr}}}{60\ \text{min}} = \frac{750\ \text{drops}}{60\ \text{min}}$ = 12.5 or 13 drops/min

To simplify, take the infusion rate and divide by the following based on the size of the tubing set.

Macrodrip

- 10 gtt/mL - divide the infusion rate by 6
- 15 gtt/mL - divide the infusion rate by 4
- 20 gtt/mL - divide the infusion rate by 3

Microdrip

- 60 gtt/mL divided by 60 is 1.

Therefore, the drip rate is the same as the flow rate (drip rate = flow rate).

General Calculation Tips:

- Verify that your answer makes sense clinically.
- Double-check your work.
- Have a colleague or pharmacist check your work.
- Know general therapeutic drug dose ranges for common medications.
- Memorize common metric and household equivalents to perform drug calculations and convert quantities easily (see tables below).

Dosage Calculation Conversions

Common Metric Conversions in Medication Calculations	
Metric Measurement	Common Conversions
1 kilogram (kg)	1 kg = 2.2 pounds = 1000 grams
1 liter	1000 mL = 1000 cc
1 gram	1000 mg
1 miligram (mg)	1000 mcg

Common Standard Conversions in Medication Calculations	
Standard Measurement	Common Conversions
1 teaspoon (tsp)	5 mL
1 tablespoon (Tbsp)	15 mL
1 ounce (oz)	30 mL

References:

Toney-Butler, T.J., Nicolas S., Wilcox L. (2023) Dose Calculation Desired over have formula method. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK493162/