Drug Calculation Tutorial

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Basic Math Review

- One **<u>MUST</u>** know this acronym: **<u>P</u>**lease **<u>E</u>**xcuse **<u>M</u>**y **<u>D</u>**ear **<u>A</u>**unt **<u>S</u>**ally PEMDAS - This acronym stands for the order of operation in which math calculations must be solved (Parentheses, Exponents, Multiplication, Division, Addition, and then Subtraction) If not performed in this order, the answer will be wrong.

- Fractions can be converted into a whole number (with or without decimals) by dividing the numerator (top #) by the denominator (bottom #).

- To multiply fractions, first multiply all the numerators, then multiply all the denominators. The final step is to reduce the final fraction down the lowest number which is done by dividing the numerator by the denominator. (Keep in mind you are staying on the top of the line all of the way across and on the bottom of the line all of the way across)

- Percentages refer to parts per 100. For example, 3% is equal to 3 parts out of 100. It can be written as a fraction which in turn can be converted into a decimal or whole number by dividing by 100.
  For example:
  3% = 3 parts out of 100 = $\frac{3}{100}$ = 0.03

- Ratios are proportions or fractions just written in a different format. In a ratio, the first number is the numerator, and the second number is the denominator. Instead of using a line with the numerator on the top and the denominator on the bottom, the numerator and the denominator are separated by a colon (:).
  For example,
  1 : 2 = 1 part per 2 parts = $\frac{1}{2}$
  which can then be turned into a fraction by dividing 1 by 2 = 0.5 and then into a percentage by moving the decimal point two places to the right = 50%.

- A decimal can be converted to a fraction by dividing by 1.

- A decimal can be converted to a percentage by multiplying by 100.

(Source: Nasrawi & Allender, 1999)

Drug Calculations 101

- Rule #1 in drug calculations - **STICK TO ONE FORMULA!**

- Remember, drug calculation problems are simply story problems. You have to develop a mathematical problem from the information that is provided. Reading comprehension is crucial in order to be successful at dosage calculations. When reading the "story problem," one must consider what they have read and ask themselves several questions. These should include:
  - What is being asked of me?
  - What do I need to solve for?
  - What units does my answer need to be expressed in?
  - What units do I need in my problem and what units to I need to get rid of?
  - Are there units in the problem that I need to convert in order to set up my problem? (we always want to work with similar units whenever possible)
  - What information in the problem do I need, and what information do I not need?
  - How do I set up my problem to leave only the desired units in the answer?
  - **Does my answer make sense? (very important)**

- From the information that is provided in the problem to be solved, certain words or phrases can provide the reader with clues as to how to set up the problem. For example:

  The "Desire" or "Need" (what is ordered) in the problem is generally written as follows:
  - "You have an order to give"
  - "The doctor's order reads, give…"
  - "The order reads"
  - "You have an order for"
  - "You are to give"
  - "Your patient has an order for"
  - "Amoxicillin 500 mg is ordered"

- "Gentamycin 50mg/kg is ordered" (must figure this calculation out to determine what the need or desire is)
- "The recommended dose of drug A is 200-400mg/kg/day" (must figure out the range of the recommended dose)

The "Have" (what you physically have in your hand) in the problem is generally written as follows:
- "On hand is…"
- "Available is…"
- "The medication is supplied as"
- "The vial reads"
- "Amoxicillin is available in…"
- "Your patient is receiving"
- "You have available"
- "The bottle reads"
- "Drug A comes in"

The "Vehicle" (form the medication is supplied in) in the problem is generally written as follows:
- tablets, capsules, mL, etc.

The "Give" is what you will actually give to the patient

- Remember, many drug calculations require a multi-step approach to solving. You may have to perform several conversions before you can actually set up the final problem to obtain the answer you are seeking.

    Example: Weight Based Problems
    "Gentamycin 50mg/kg is ordered" (Note: The / slash actually means per; **this is not a division problem, it is a multiplication problem**; this means that we are to give 50 mg of a drug for every 1 kg of body weight)
    - We know by critically reading this part of the problem, that this is our "need" or "desire"
    - We also know that we must figure out what the ordered dose is based on this information
    - If our patient weighs 10 kg, then we can determine the amount of the ordered dose by doing the following calculation:

50 mg X 10 kg = 500 mg (our order is for 500 mg of Gentamycin)
- **Note:** weight may be given in lbs, not kg, and therefore we would need to convert lbs to kg before we could proceed in solving for the ordered dose)

Critical Point! When converting weight given in lbs and oz (**Note: 8 lbs, 6 oz is not 8.6 lbs**) to kg, one must **first** convert oz to lbs, and then the total lbs to kg.

Example: If an infant weighs 8 lbs, 6 oz, how many kg does this infant weigh?
Convert oz to lb:

$$6\text{ oz} \times \frac{1\text{ lb}}{16\text{ oz}} = 0.375 \text{ or } 0.4\text{ lb}$$

(Note: oz cancel one another out and we are left with lb-the units we want)

Therefore, we now know the infant weighs 8.4 lbs (not 8.6 lbs - a common error made in these types of problems)
Now convert lbs to kg:

$$8.4\text{ lb} \times \frac{1\text{ kg}}{2.2\text{ lb}} = 3.8\text{ kg}$$

(Note: lb cancel one another out and we are left with kg - the units we want)

Note: The example above was calculated using Dimensional Analysis (“chemistry math”), which is explained later in this tutorial.

Example: Dosage Range Problems
“The recommended dose of drug A is 200-400mg/kg/day.”
- Many of these types of questions are requiring the reader to determine if the ordered dose is in “the safe range”
If we are given the weight in lbs, we know that we have to first convert lbs to kg
- Next, we know that we must determine the 200mg/kg dose and then determine what the 400mg/kg dose is
- If our patient weighs 10 kg, we can determine the safe 24 hour range for this patient by performing the following calculations:
200 mg X 10 kg = 2000 mg
400 mg X 10 kg = 4000 mg
Therefore, the safe 24 range for this patient is 2000-4000 mg

If you can read a problem and determine what represents the “desire” or “need,” and what represents the “have,” (or the “vehicle,” and the “give” - for some formulas) you are half way there! All that is left to do is to determine what units your answer should be represented in and set up your problem to eliminate unwanted units so that you are left with the units you wanted units.

- **Critical Point!** Do the following examples mean the same thing?

$$\frac{50 \text{ mg}}{100 \text{ mL}} = \frac{100 \text{ mL}}{50 \text{ mg}}$$

1. $\frac{50 \text{ mg}}{100 \text{ mL}}$ means that there are 50 mg in 100 mL
2. $\frac{100 \text{ mL}}{50 \text{ mg}}$ means that 100 mL contains 50 mg

Answer: Yes, these examples mean, or are saying the same thing. We have not changed the amount of solute or solvent in these examples, we have simply inverted them. One can invert fractions such as these in order to manipulate units so that unwanted units may be cancelled or eliminated. This is an important concept to understand in dosage calculations.

More Examples:

$$\frac{1 \text{ mL}}{15 \text{ gtt}} = \frac{15 \text{ gtt}}{1 \text{ mL}} \qquad \frac{10 \text{ mg}}{1 \text{ tablet}} = \frac{1 \text{ tablet}}{10 \text{ mg}} \qquad \frac{1 \text{ tsp}}{20 \text{ mg}} = \frac{20 \text{ mg}}{1 \text{ tsp}}$$

Respectively, these examples are stating the following:
- 1 mL contains 15 gtt or there are 15 gtt in 1 mL
- there are 10 mg in 1 tablet or 1 tablet contains 10 mg
- 1 tsp contains 20 mg or there are 20 mg in 1 tsp

- **Critical Point!** A fraction can be a problem in itself. This concept will be useful for some drug calculations.

Example: $\frac{1}{6}$ grain (gr) $= 1 \div 6 = 0.17$ gr

Rationale: It is easier to work with whole numbers or decimals than it is to work with fractions.

Example: $\frac{1000\text{ mL}}{8\text{ hours}} = 1000 \div 8 = \frac{125\text{ mL}}{\text{hr}}$

The above example is stating that if we have an order to infuse 1000 mL of fluid into a patient over 8 hours, we would set our IV pump for $\frac{125\text{ mL}}{\text{hr}}$ or 125 mL/hr.

(Source: Major-Harris, 2007)

Drug Calculation Terms

- Unit Equivalencies - the value of equivalencies between two units.

For Example: 1 kg = 2.2 lbs, 5 mL = 1 tsp, 30 mL = 1 ounce, 1 gram = 1000 mg, 60 minutes = 1 hour, 15 gtt = 1 mL, 1 grain = 60 mg (see handout which provides you with basic unit equivalencies - **MUST MEMORIZE THIS!**)

- Unit - a dimension that is given to a number.

For Example - If you are to give 50, you would ask, 50 what? This could be mg, mL, tablets, teaspoons, etc. (mg, mL, tablets, tsp. are the units)

- Conversion Factor - it is a unit equivalency written as a fraction.

$\frac{60\text{ mg}}{1\text{ grain}}$ or $\frac{1\text{ grain}}{60\text{ mg}}$

(The above is simply stating that 60 mg is equal to 1 grain or 1 grain is equal to 60 mg….both mean the same thing regardless of how they are set up) Conversion factors are derived from information provided to you in the dosage problem.

- Remember, in any drug calculation, if you do not include the proper unit in your answer, your answer will be **WRONG!**

Example: 5 mL, not 5………2 tsp, not 2………1 tablet, not 1

- Remember: If you do not show your work in dosage calculation, your answer will be considered wrong!

(Source: Nasrawi & Allender, 1999)

Drug Calculation Formulas

- <u>Dimensional Analysis</u> ("chemistry math") - a process of manipulating units, which are actually descriptions of numbers, to solve mathematical equations. This method of mathematic problem solving is used in chemistry with great success. The goal of this approach to drug calculation problem solving is to:

CANCEL OUT UNWANTED UNITS LEAVING ONLY THOSE UNITS YOU WANT YOUR ANSWER TO BE EXPRESSED AS!

- Think of Unit Equivalence as a link that will help you get the desired units you are solving for.

For example:
Covert 50 lb to kg
The Unit Equivalence (link) is: 2.2 lb = 1 kg
Note: $\frac{2.2 \text{ lb}}{1 \text{ kg}}$ is another way of saying that 2.2 lb = 1 kg
The desired units we are seeking are kg in this example.

Using Dimensional Analysis in the above example, we set the problem up in the following format:
Problem: Covert 50 lb to kg

$$50 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} = 22.7 \text{ kg}$$

Another way of stating this problem is: How many kg are there in 50 lb? or 50 lb is equal to how many kg?
In this example, the units of lbs cancel each other out, leaving behind kg (the units we want our answer to be in). We then use our acronym PEMDAS, and multiply 50 X 1 = 50 ÷ 2.2 = 22.7 kg

We have eliminated the units we don't want and are left with the units we do want.

Note: In Dimensional Analysis we simply multiply straight across first (on both sides of the horizontal line if applicable) and then divide. There is no cross multiplication or algebra involved in this method of problem solving.

- Remember, drug calculation problems are simply story problems. You have to develop a mathematical problem from the information that is provided. Using the Dimensional Analysis approach, this can be accomplished in a few simple steps:
    - Determine what it is that is being asked
    - Determine what units your answer must be represented in (desired units)
    - Determine what the unwanted units are
    - Determine what the link (unit equivalence) is (there may be more than one link per problem, and these conversions may have to be made before the final problem can be set up))
    - Set up your problem so that you can eliminate unwanted units to end up with desired units

    Apply this method to the problem above: Covert 50 lb to kg
    - Determine what it is that is being asked - How many kg are there in 50 lb? or 50 lb is equal to how many kg?
    - Determine what units your answer must be represented in (desired units) - kg is what we are solving for
    - Determine what the unwanted units are - We want to eliminate lb
    - Determine what the link is - 2.2 lb = 1 kg
    - Set up your problem so that you can eliminate unwanted units to end up with desired units

Problem: Covert 50 lb to kg

$$50 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} = 22.7 \text{ kg}$$

lb cancel each other out and you are left with kg (the units we want)

Example: A nurse must infuse 1000 mL of IV fluids over 8 hours. The tubing drip factor is 10 gtts/mL. How many gtts per minute will there be?

- Determine what it is that is being asked - How many gtts/min?
- Determine what units your answer must be represented in (desired units) - gtts/min is what we are solving for
- Determine what the unwanted units are - We want to eliminate hours and mL
- Determine what the link is - 60 min = 1 hour

- Set up your problem so that you can eliminate unwanted units to end up with desired units

$$\frac{1000\text{ mL}}{480\text{ min}} \times \frac{10\text{ gtt}}{\text{mL}} = \frac{10{,}000\text{ gtt}}{480\text{ min}} = 20.8\ \frac{\text{gtt}}{\text{min}} \text{ or } 21\ \frac{\text{gtt}}{\text{min}}$$

We converted hours to minutes before setting up the final problem, and then mL cancelled each other out and we are left with gtt/min (the units we want)

(Sources: Major-Harris, 2007 & Nasrawi & Allender, 1999)

- "Desired Over Have Times Vehicle" Drug Formula - This formula is useful when solving problems that involve oral and injectable drugs. One must have the following information in the "story problem" in order to use this formula:
  - Dose Required = Desired
  - Dose on Hand = Have
  - Vehicle = How Drug is Supplied
  - Give = What We Will Actually Give To Our Patient
  - $\frac{D}{H} \times V = G$

  Example: A nurse must administer 25 mg of a medication. The dose on hand is 50 mg per tablet. How many tablets would the nurse administer?
  Desired = 25 mg
  Have = 50 mg
  Vehicle = tablet
  We set up the problem as follows:
  $$\frac{25\text{ mg}}{50\text{ mg}} \times 1 \text{ tablet} = 0.5 \text{ tablet or } \tfrac{1}{2} \text{ tablet}$$

  Example: A nurse must administer 50 mg of a medication intramuscularly. The drug is available as 100 mg/2 mL. How much will the nurse administer?
  Desired = 50 mg
  Have = 100 mg
  Vehicle = 2 mL
  We set up the problem as follows:
  $$\frac{50\text{ mg}}{100\text{ mg}} \times 2\text{ mL} = \frac{100}{100} = 1\text{ mL}$$
  (Source: Major-Harris, 2007)

- Ratios - A ratio expresses the numerical relationship between two quantities. Example: If a given drug contained 50 mg (solute) of the drug for every 2 mL of liquid (solvent), the ratio of drug to liquid could be expressed as 50:2.

- A ratio is the result of the division of two numbers that can be expressed as a fraction. The first number of the ratio becomes the numerator, and the second number of the ratio becomes the denominator. The colon (:) represents the division sign. After writing the ratio as a fraction, the fraction can then be reduced to its lowest terms.
  Example: 50:2 = $\frac{50}{2} = \frac{25}{1}$ mg of drug per every 1 mL of liquid

- Once a ratio is converted to a fraction, the fraction can be converted to a decimal, and the decimal can be converted to a percent.
  Example: 50:2 = $\frac{50}{2} = \frac{25}{1}$ = 25 = 2500%

- Proportions - A proportion is an equation that contains two ratios of equal value. The proportion (equation) uses an equal sign or double colon to demonstrate that the ratios on both sides of the equal sign (double colon) are equal.
  We can use apply desire, have, vehicle, and give to proportions as follows:
  Example: H : V =(::) D : G or $\frac{H}{V} = \frac{D}{G}$
  Example: 4 : 12 =(::) 8 : 24, or $\frac{4}{12}$ =(::) $\frac{8}{24}$

  When these fractions are reduced to their lowest terms, they are equal:
  $\frac{4}{12} = \frac{1}{3}$ $\frac{8}{24} = \frac{1}{3}$

- In a proportion, the outer most numbers are called the extremes, and middle two numbers are called the means.
  Example: 4 : 12 = 8 : 24
  In order for a proportion to be a true proportion, the product of the means is always equal to the product of the extremes.
  Example: 4 X 24 (extremes) = 96 & 12 X 8 (means) = 96 A true proportion!
  (Source: Nasrawi & Allender, 1999)

Remember, when using proportions for drug calculations,
Dose on Hand = Dose Needed

Set up the example from above as a proportion: A nurse must administer 50 mg of a medication intramuscularly. The drug is available as 100 mg/2 mL. How much will the nurse administer?

100 mg : 2 mL = 50 mg : X = (100)(X) = (50)(2) = 100X = 100

Therefore: $X = \frac{100}{100}$ = X = 1 mL

Example: A nurse must administer 25 mg of a medication. The dose on hand is 50 mg per tablet. How many tablets would the nurse administer?

50 mg : 1 tablet = 25 mg : X = (50)(X) = (1)(25) = 50X = 25

Therefore: $X = \frac{25}{50}$ = X = 0.5 tablet or ½ tablet

We can set this problem up using $\frac{H}{V} = \frac{D}{G}$ where H = 50 mg, V = tablet, D = 25 mg, and G = X

Therefore we get:

$\frac{50\text{ mg}}{\text{tab}} = \frac{25\text{ mg}}{X}$ = (50 mg)(X) = (25 mg)(tab) = $X = \frac{(25\text{ mg})(\text{tab})}{50\text{mg}}$

mg cancel one another out, 25 ÷ 50 = 0.5 tabs or ½ tab

(Source: Jackson, 2006, Major-Harris, 2007)

NOTE TO ALL NURSING STUDENTS

You are all very intelligent individuals, and you can be successful at dosage calculations. Try to relax, critically think about the question, and then set up the problem using one of the formulas that you have been shown here.

YOU CAN DO THIS!

☺

References

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