

IV and Drug Calculations for Busy Paramedics

By Kent R. Spitler, MSED, RN, NREMT-P
EMS Educator
Charlotte, North Carolina

Introduction

Medication calculations can cause frustration for EMS providers. Math and pharmacology can make it difficult to succeed on course exams, in the clinical setting, and in the field. There is a solution to make medication calculations easier. The answer to this problem is simple by showing students how to perform calculations using a simple process.

While there are plenty of good drug and solution textbooks, study guides, and presentations available showing the methods of medication calculations, It seems that it much of it causes mathematical confusion often called “math mental blocks” for many EMS providers.

There are only a few drug calculations necessary in the prehospital setting. These calculations include IV drip rates, IV piggyback infusion, IM and Subcutaneous injection. A good review of the metric system is in order here since medicine is based on this measurement system. It is necessary to *practice* drug calculations on a regular basis to gain a comfort level with the methods. The best way to achieve this comfort level is to practice medication calculations 30 minutes a day for six months and it will come natural after while.

Common abbreviations are used in medication administration for all medical fields. Below is a list of some abbreviations that are found in drug calculations used in the prehospital setting:

| | | |
|------------------------------|------------------------|--|
| Gram = Mass | 5 cc = 1 tsp | gtts/ml = Drops per milliliter |
| Meter = Length | 15 cc = 1 TBS or 3 tsp | gtts/min = Drops per minute |
| Liter = Volume | 30 cc = 1 ounce | Conversion |
| Gm = Grams | 30 cc = 2 TBS | Convert grams to milligrams: multiply |
| Gtts = Drops | 60 mg = 1 Grain | X 1000 |
| Hr = Hour | 1 Gram = 15 Grains | Convert liters to milliliters: multiply X |
| IVPB = Intravenous Piggyback | X = Multiply | 1000 |
| Mcg = Micrograms | x = Unknown | Convert milligrams to grams: divide by |
| | answer | 1000 |
| Min = Minute | / = Per or Each | Convert milliliters to liters: multiply X |
| Mg = Milligrams | — = Divide | 1000 |
| MI = Milliliters | - = Minus | <i>Don't forget where to place the decimal</i> |

Table 1

It is assumed that the reader has an understanding of general mathematics. It also assumed that the reader has a general understanding of the metric system as it relates to medicine and drug calculations.

IV Drip Rate Calculations

IV calculations are easier than they appear. There are four common drip sets in two categories: minidrip set which includes microdrip or pediatric set, and regular drip set which include macrodrip or adult sets. The various drip sets are as follows:

| | |
|-------------------|---|
| 60 gtts/ml | minidrip drip set |
| 10 gtts/ml | regular drip set |
| 15 gtts/ml | regular drip set |
| 20 gtts/ml | regular drip set (this set is sometimes used, but it's not as popular) |

Next, think about where these numbers came from for use in medicine. Since there are 60 minutes in one hour and 60 seconds in one minute, it appears natural to calculate drip rates based on the clock.

- There is one (1) 60 minute period in one hour**
- There are six (6) 10 minute periods in one hour**
- There are four (4) 15 minute periods in one hour**
- There are three (3) 20 minute periods in one hour**

It makes sense doesn't it? When calculating IV drip rates all that needs to be done is divide the amount to be infused over one (1) hour by how many time periods the drip set has in one (1) hour based on the clock.

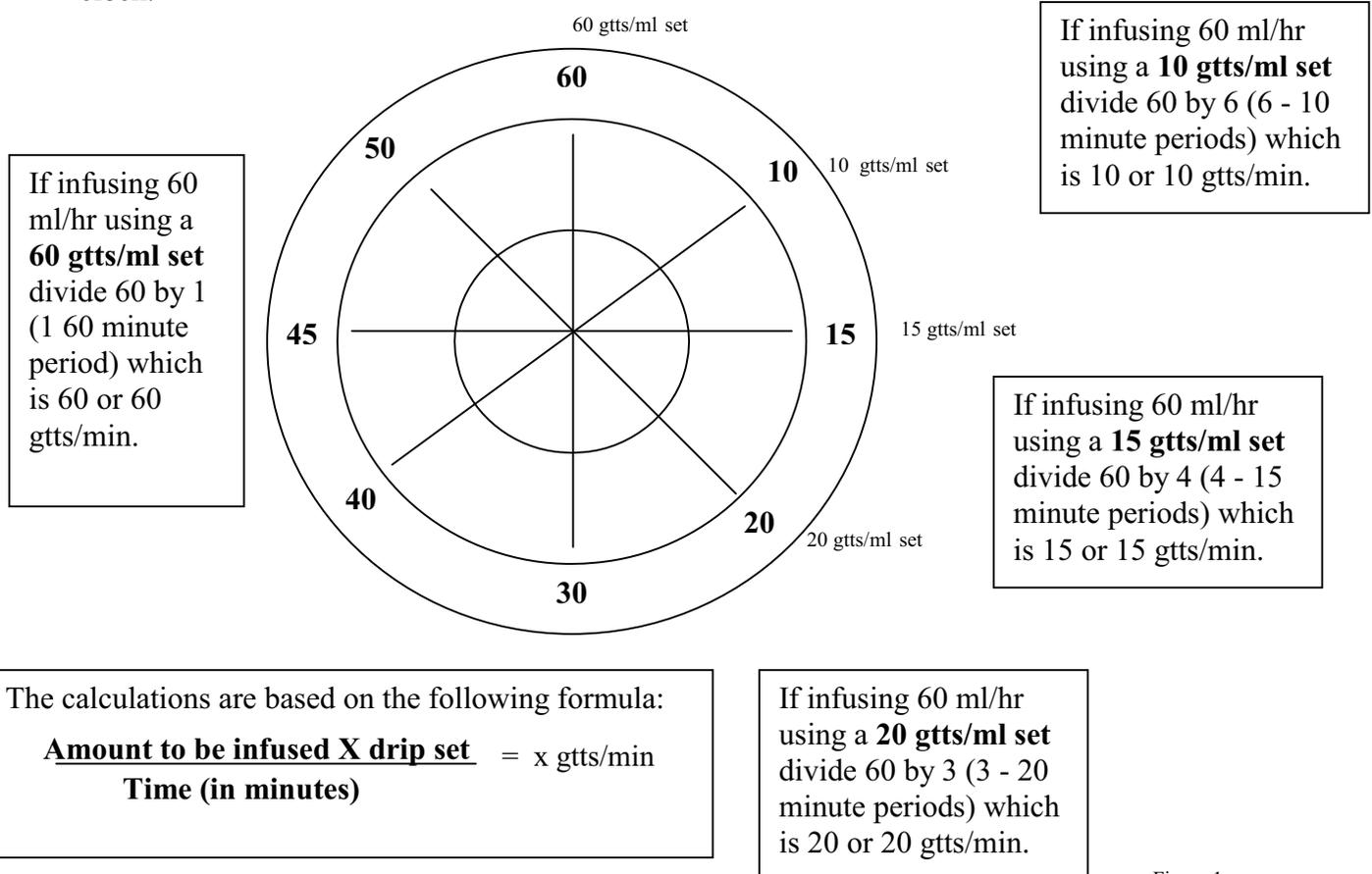


Figure 1

Minidrip (Pediatric or Microdrip) Set - 60 drops per milliliter

How do we arrive at the correct answer? Let's look at the other methods and see if it makes sense. Think about the 60 drop per milliliter set (60 gtts/ml.) Now think about the answer you want which drops per minute. A protocol or medical control will give you fluid amounts to administer most commonly in ml/hr. You already have the amount and the time to be infused. All you do now is choose the appropriate drip set, using a simple formula you can come up with a quick answer:

$$\frac{\text{Amount of Solution (in ml) X drip set}}{\text{(gtts/ml)}} = x \text{ drops/min (gtts/min)}$$

Looking at an example, your medical control states you need to establish an IV on a cardiac patient complaining of chest pressure at a rate of 80 ml/hr using a 500 ml bag of Normal Saline solution. The drip set you choose is a 60 gtts/ml minidrip set. The formula is as follows:

$$\frac{80 \text{ ml (amount) X 60 gtts/ml (drip set)}}{60 \text{ (divided my time in minutes – over 1 hour)}} = \frac{\overset{\text{Divide 60 into 4800}}{4800}}{60} = 80 \text{ gtts/min}$$

When calculating IV drip rates remember that you can reduce to the lowest common denominator by dividing the same number into both the numerator and the denominator to make your calculations much easier. All samples shown from now on demonstrate this throughout. Simply remember that the numbers are consistent with the 60 minute clock and you will catch on rather quickly. The sample problems will show you by dividing the same number into the drip set and the time.

As you see the answer is 80 or 80 gtts/min. 60 goes into 60 once (1). Divide 60 into 60 on the top and bottom. Let's look at the problem again and see how simple it really is:

$$\frac{80 \text{ ml X } \cancel{60} \text{ 1 gtts/ml set}}{\cancel{60} \text{ 1 min}}$$

The only thing necessary is to do is cancel out the 60 on the top line and the bottom line. This leaves you with 1.

$$\frac{80 \text{ X } 1}{1} = \frac{80}{1} = 80 \text{ or } 80 \text{ gtts/min}$$

Thinking this way will make it easier for you any time a 60 gtts/ml drip set is used. Just divide the amount of solution per hour by 1 and the number that is left is your answer in drops per minute. All you need to do is plug in the amount to be given over an hour.

REGULAR DRIP SET – 10 DROPS PER MILLILITER

Taking a look at the 10 gtts/ml regular drip set we need to think, how many 10 minute periods are in one hour? The answer is 6. (see page 2.) The objective here is that there are larger drops leading to less drops per minute. In the problem below, 10 goes into 10 once and 10 goes into 60 six times. Using the same formula as we did with the 60 gtts/ml set the problem is as follows:

$$\frac{80 \text{ ml (amount) X 10 gtts/ml (drip set)}}{60 \text{ (divided my time in minutes – over 1 hour)}} = \frac{80 \text{ X } \cancel{10} \text{ 1}}{\cancel{60} \text{ 6}} = \frac{80 \text{ X } 1}{6} = \frac{80}{6} = 13.3 \text{ or } 13 \text{ gtts/min}$$

80 divided by 6 is 13.3 or 13 gtts/min. Now to it even simpler, every time you use a 10 gtts/ml regular drip set just divide the amount by 6 since they're six 10 minute time periods in one hour. All you need to do is plug in the amount of fluid per hour.

$$\frac{80}{6} = 13.3 \text{ or } 13 \text{ gtts/min}$$

The two remaining regular drip sets are the 15 gtts/ml set and the 20 gtts/ml set. Remember, all you need to do is figure out how many time periods the drip set has in one hour (don't forget the clock.)

The 15 gtts/ml drip set is related to four 15 minute time periods in one hour which means we divide the amount per hour by 4. 15 goes into 15 once and 15 goes into 60 four times resulting as 80/4 leaving us with the answer of 20. Observe the example below:

$$\frac{80 \text{ ml (amount)} \times 15 \text{ gtts/ml (drip set)}}{60 \text{ (divided my time in minutes – over 1 hour)}} = \frac{80 \times \cancel{15} \ 1}{\cancel{60} \ 4} = \frac{80 \times 1}{4} = \frac{80}{4} = 20 \text{ gtts/min}$$

So any time you use a 15 gtts/ml drip set just divide the amount of solution per hour by 4.

$$\frac{80}{4} = 20 \text{ gtts/min}$$

The 20 gtts/ml drip set is calculated the same way except you divide by 3 since there are three 20 minute periods in one hour. 20 goes into 20 once and 20 goes into 60 three times. Observe the example below:

$$\frac{80 \text{ ml (amount)} \times 20 \text{ gtts/ml (drip set)}}{60 \text{ (divided my time in minutes – over 1 hour)}} = \frac{80 \times \cancel{20} \ 1}{\cancel{60} \ 3} = \frac{80 \times 1}{3} = \frac{80}{3} = 26.6$$

The answer is 26.6 or rounded off to 27 gtts/minute.

This means all you need to do is divide the amount of solution per hour by 3 to get the gtts/min.

Summary

- Drip sets used in medicine are based on the 60 minute clock for timing and calculations. All you need to do is divide the amount to be infused each hour by how many time periods the drip set has in one hour which is based on the clock.
- The drip sets include the minidrip set, 60 gtts/ml, and three regular drip sets which include the 10 gtts/ml set, 15 gtt/ml set, and the 20 gtts/ml set.
- There is one (1) 60 minute period in one hour, six (6) 10 minute periods in one hour, four (4) 15 minute periods in one hour, and three (3) 20 minute periods in one hour.
- When reducing fractions to allow easier calculations remember to divide the same number into both the numerator and the denominator to arrive at the lowest common denominator. Thinking about the problems presented you must divide the same number into the drops per milliliter and the time (in minutes.)

$$\underline{60 \text{ goes into } 60 = 1} \quad \underline{10 \text{ goes into } 10 = 1} \quad \underline{15 \text{ goes into } 15 = 1} \quad \underline{20 \text{ goes into } 20 = 1}$$

$$60 \text{ goes into } 60 = 1 \quad 10 \text{ goes into } 60 = 6 \quad 15 \text{ goes into } 60 = 4 \quad 20 \text{ goes into } 60 = 3$$

Looking at these examples you notice that there is a pattern that stays the same. Since there are only four (4) different IV drip sets available, all you have to do is just insert the amount of solution to be delivered over one (1) hour. When setting up each problem remember all you have to do is divide the number of periods each drip set has in the 60 minute clock and divide that number into the amount of solution to be delivered in one (1) hour. It's simple as that!

Problems

You have an order to start an IV of NS How many drops per minute do you want to set the IV drip rate for the following?

1. 150 ml/hr using a 10 drop per milliliter set.
2. 75 ml/hr using a 60 drop per milliliter set
3. 100 ml/hr using a 15 drop per milliliter set
4. 200 ml/hr using a 20 drop per milliliter set

IV Infusion/Piggyback Medications

Medication administration in field can become complicated in the field when you need an the drug dose in a hurry. The medications we give are usually limited to IV push medications, SL medications, IM and Subcutaneous medications. It seems like paramedic students struggle with drug calculations, but do not get the opportunity to do many calculations in the clinical setting and the skill is limited in the field.

The amount of medication to give is usually the answer we want. Medication comes in ampules, vials, prefilled syringes, and premixed IV bags. Piggyback infusions are given frequently in the field, but when they are there is no room for error. The goal here is to use a simple method of calculating medication drip rates effectively spending the least amount of time doing so.

There are two basic issues that we need to think about for piggyback infusions. The first is calculating drip rates for medication in milligrams (mg), e.g., lidocaine, Procainamide, and Bretylium, which are common medications used in ACLS and in the field. The second issue is calculating IV infusion rates in micrograms (mcg). Medication dosing may include the patient's weight as well which needs to be figured into the problem to assure the patient receives the correct amount of medication. There are several methods used in calculating medication doses for IV infusion. We will start with lidocaine as an example because it is one of the most common IV infusions drug in the field.

Let's start with the following information:

Lidocaine

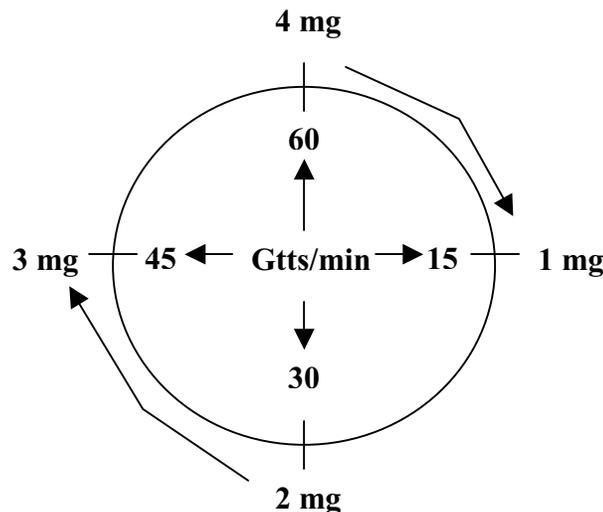
| | |
|---|---|
| Drug ordered: | 2 mg/min IVPB |
| Drug on hand: | 2 Grams Lidocaine 20% in 5 ml (the 5 ml is irrelevant in our calculations) |
| IV Solution: | 500 ml of Normal Saline |
| Drug Concentration in the IV Solution: | 4 mg/ml (this is achieved by dividing the amount of IV solution into the drug. But first you must convert grams to milligrams to properly calculate the problem) |
| IV Drip Set: | 60 drops per milliliter |
| Want to Know: | Gtts/min to be administered to the patient |

Using the "Rule of Fours" Method

Some think the "rule of fours" method is easier than other methods, but this is up to the EMS provider which method is best. This method is sometimes called the Lidocaine clock method. The three simple steps used here are: Compare, Prepare, and Observe.

Using the information above for our problem we can conclude that there is 4 mg of lidocaine for each milliliter of IV solution (That is by putting 2 grams or 2000 mg of lidocaine into 500 ml of NS and dividing 2000 mg by 500 ml = 4 mg/ml) This means that there is 4 mg = 1 ml which means we will have 4mg for every 60 drops of solution because the drip set is a 60 gtts/ml IV set.

The Rule of Fours Method (Lidocaine Clock Method)



Look at the drug order and compare to the clock in the circle. 2 mg = 30 gtts/min is observed and is the answer to the problem.

There is another method that is popular among people with a chemistry and math education, but anyone can use it. Find out the concentration of medication you have. Remember, the drug order is 2 mg of Lidocaine 20% and a bag of 500 ml Normal Saline. First convert the 2 Gms of Lidocaine into mgs which equals 2000 mg. This needs to be done because the order is in milligrams per minute.

We always divide the amount of solution into the amount of drug. Divide 500 ml into 2000 mg Lidocaine 2 Gm = 2000 mg. The answer you get is 4 mg/ml.

The formula is now set up as follows:

$$\frac{\text{IV Bag Amount (ml)} \times \text{dose ordered (mg/min)} \times \text{drip set (gtts/ml)}}{\text{Drug on hand (mg)}} = 30 \text{ drops per minute}$$

Another method found useful is the following:

Reduce fraction

$$\frac{\text{Drug order (2 mg/min)} \times \text{IV drip set (60 gtts/ml)}}{\text{Drug Concentration 4mg/ml} \times \text{1 minute}} = \frac{120}{4} = 30 \text{ gtts/min}$$

You can use these methods with any drugs in the field when giving drugs in milligrams, such as. Bretyllium and Procainamide..

IV infusion drugs in Micrograms

Now we need to consider drugs given in micrograms. This group of drugs includes dopamine, epinephrine, dobutamine, and Isoproterenol. When calculating a drug, such as dopamine, using the micrograms can be a little tricky, but remember it's just a way to measure medicine in smaller amounts (units.) What this really means is dopamine is potent stuff and we need to keep the math as simple as possible (you know, the KISS method)

Dopamine and other complicated Medications can be challenging to calculate, but there is a simple formula method that will make it easier for you. The first formula will include the patient's weight. Of course, it is assumed you already know how to convert pounds (lbs.) to kilograms (kgs.) But if you are not sure let's review. All you need to know is that 2.2 lbs. = 1 kg. And 1 kg. = 2.2 lbs. This means if you want to convert pounds to kilograms just divide the weight (in lbs.) by 2.2. Now to convert kilograms to pounds just multiply the weight (in kgs) X 2.2. Look at the example below:

A 50 year old cardiac patient weighs 150 pounds. You need to convert this patients weight to kilograms because medication based on weight is almost always given in kilograms.

$$150 \text{ divided by } 2.2: \quad \frac{150}{2.2} \text{ or } 2.2 \overline{)150.}$$

it should look like this: $22 \overline{)1500.}$ The answer is: 68.1 or 68 kgs. (rounded off)

Note:

Remember to move the decimal to the right (we don't want to deal with decimals any more than we have to) When you move the decimal to the right you must also move it the same amount of spaces to the right in the for the number you are dividing.

We'll set up a dopamine drip based on the patient's weight (most IV infusion drugs are based on the patient's weight.) This is probably as hard as it's going to get for EMS providers. Take a look and see if you find this fairly easy:

Dopamine

Information

| | |
|-------------------------|---|
| Drug order – | 7 mcg/kg/min |
| Concentration on hand - | 800 mg (it may come in a premixed IV bag or in 200 mg vials) We know this has to be converted to mcg because that's the drug order, right? |
| Drip Set - | 60 gtts/ml |
| Time - | We already know it's per <u>minute</u> |
| Patient's Weight - | 220 lbs. |
| IV Bag - | 500 ml Normal Saline |

First convert the patients weight from lbs. to kilograms: Divide 220 by 2.2 = 100 kgs.

Second convert the concentration on hand, 800 mg to micrograms. How do we do that? Multiply 800 X 1000 (review your metric conversions if you don't understand.) The answer is 800,000 mcg. Remember, to convert mg to mcg just multiply X 1000. Anyway we don't want to messing with decimals when we don't have to. 800 mg X 1000 = 800,000 mcg

Third, all you have to know now is how many mcg are in each ml of the IV bag we are using (500 ml.) Divide the solution into the drug to find out:

$$500 \text{ ml} \left| \begin{array}{l} 1600 \text{ mcg/ml} \\ \hline 800,000 \text{ mcg} \end{array} \right. \text{ This is you concentration on hand}$$

Fourth, set up the formula (this is probably the easiest way to do it without using a drug chart):

$$\frac{\text{Mcg/kg} \times \text{weight (kg)} \times \text{drip set}}{\text{Concentration on hand} \times \text{time}} = \text{Gtts/min}$$

With the numbers now:

$$\frac{7 \text{ mcg/kg} \times 100 \text{ kgs} \times 60 \text{ gtts/ml}}{1600 \text{ mcg/ml} \times 1 \text{ min}} = \frac{7 \times 100 = 700 \quad 700 \times 60 = 4200}{1600 \times 1 = 1600} \frac{4200}{1600} = 26 \text{ gtts/min}$$

actually the answer is 26.2 but we rounded it off

It may not seem easy at first, but remember all you have to do is plug in the right numbers and the simple math. That's all!

Practice - Practice - Practice

IVP, IM, SQ Parenteral Medication Calculation

The key to finding the answer for the right dose is organizing the right information. Doing well in drug calculations is practice-practice-practice. Earlier, we mentioned to practice 30 minutes each day for six months and you will remember how to do it.

When calculating parenteral medication doses there are only three things to remember, drug order, concentration on hand, and the amount you want to give. Using Lasix, for example:

Drug order: 40 mg
 Concentration on hand: 100 mg
 Volume of solution 10 ml
 Amount you want to give: X is the answer you want in ml.

Two methods easy to use (you decide which one) for calculating drug doses are ratio and proportion (also known as cross multiplication) method and the formula method. Both methods require setting up the problem and the rest is fairly easy.

What you want to do is keep it simple (you know, the KISS method) so let's look at the ratio and proportion method first. What needs to be done is put the same form of measurement on the top lines and the bottom lines.

$$\frac{\text{Drug ordered (mg)}}{\text{Amount to give (ml)}} = \frac{\text{Concentration on hand (mg)}}{\text{Volume of solution (ml)}}$$

As you can see we put the mg on the top and the ml on the bottom. It is better to do it this way to keep things straight. Once you set up the formula it necessary to cross multiply to arrive at the correct answer. Using our example, Lasix, we will set up the problem now with the information provided above:

| | |
|--|--|
| Drug ordered | Concentration on hand |
| $\frac{40 \text{ mg}}{X \text{ ml}}$ | $= \frac{100 \text{ mg}}{10 \text{ ml}}$ |
| X = amount to give in ml This the answer we want | Volume of solution |

Next, cross multiply the numbers as shown below:

$$\frac{40 \text{ mg}}{X \text{ ml}} \begin{matrix} \nearrow \searrow \\ \nwarrow \nearrow \end{matrix} \frac{100 \text{ mg}}{10 \text{ ml}} \quad 40 \times 10 = 400 \quad 100 \times X = 100 X$$

Now it will look like this: $400 = 100 X$

Since X is the answer we want, which is the amount of drug to give, X needs to be by itself. The way to do this is move the number with the X underneath the number on the other side. This is how it looks:

$$\frac{400}{100} = 100X \quad \frac{400}{100} = X$$

To arrive at the correct answer, all we need to do is divide 400 by 100 which equals 4. This means X = 4 or 4 ml. The only left to do is draw up the drug into a syringe and give the Lasix to the patient.

Tips:

- Set the ratio and proportion the same each time.
- Put like measurements on the same line $\frac{\text{mg}}{\text{ml}} = \frac{\text{mg}}{\text{ml}}$
- Use X as the symbol for the answer you want
- Always move the number with X underneath the other side leaving X by itself
- Divide leaving you the answer which is the amount to give in ml

The formula method takes a different approach which some practitioners like. It is set up like this:

$$\text{Volume to be given (X ml)} = \frac{\text{Volume of solution X Drug order}}{\text{Concentration on hand}}$$

We will use Lasix again:

Drug order: 40 mg
 Concentration on hand: 100 mg
 Volume of solution 10 ml
 Amount you want to give: X is the answer you want in ml.

$$\text{Volume to be given X ml} = \frac{\text{Volume of Solution } 10 \text{ ml} \times \text{Drug Order } 40 \text{ mg}}{\text{Concentration on hand } 100 \text{ mg}}$$

As you can see, we need to multiply 10 X 40 and divide the answer by 100.

It will look like this: $\frac{10 \text{ ml} \times 40 \text{ mg}}{100 \text{ mg}} = \frac{400}{100} = 4$

X ml is the amount we want to give so just replace x with 4 and we have our answer of 4 ml.

Both the ratio and proportion method and the formula method can be used with tablets, IV push, IM, and SQ medication administration. Now isn't that simple? If you are having trouble it is a good idea to read back through the material and work through the practice problems. Remember, practice-practice-practice!

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