Calculating I.V. drip rates with confidence

By Ira Gene Reynolds, RN, BSN, PCCN, CMC

By using a simplified equation, you can figure out drip rates and titrations faster and with greater self-assurance.

WHILE YOU'RE WORKING your shift on the progressive care unit, the physician phones in an order to start a patient's I.V. dopamine infusion at 5 mcg/kg/minute. As you hang up the phone, your mind starts to race: How fast should I set the infusion pump to deliver 5 mcg/kg/minute? Will I be able to remember the complex drip rate equation I learned in nursing school? Will I have to mix the solution or will it come premixed? Will I have to titrate the drug myself, or will I get a regular physician's order? If I need to titrate it myself, can I do this on my unit?

Many nurses are expected to deliver and titrate I.V. drugs regularly. Such factors as unit protocols, titration policies, and the specific drug ordered determine exactly how you'll deliver and titrate an I.V. drug.

Today, with an emphasis on patient safety, the pharmacy staff customarily mixes the majority of drug solutions and also may calculate infusion pump rates. Many pharmaceutical companies have gotten in on the act, too, providing a drip rate matrix.

Although many I.V. infusion pumps calculate drip rates automatically, these rates must be double-checked to ensure patient safety. So chances are you'll need to calculate I.V. drip rates and titration scales yourself.

If you feel uneasy when performing these critical tasks, you're not alone. To boost your confidence, this article presents simplified equations to help you breeze through selected I.V. drip rate calculations.

Streamlining the basic equation

In nursing school, you probably had to learn a long, tedious equation for calculating I.V. drip rates. For the dopamine order described above, here's how this equation would look for a patient who weighs 73.5 kg:

$$5 \text{ mcg} \times 73.5 \text{ kg} \times \frac{1 \text{ mg}}{1000 \text{ mcg}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{250 \text{ ml}}{800 \text{ mg}} = 6.89 \text{ ml/hour}$$

But many nurses have trouble remembering what goes where—and in what order. Which goes on top—milligrams or micrograms? Hours or minutes? Milliliters or milligrams?

Fortunately, you can strip this equation down to the basics by eliminating some elements. Here's the streamlined equation:

$$\frac{\text{Ordered amount of drug} \times \text{patient's weight (kg)} \times 60}{\text{Drug concentration}} = \text{I.V. infusion rate (in ml/hour)}$$

When applied to the dopamine order, the simplified equation looks like this:

$$\frac{5 \times 73.5 \times 60}{3200} = 6.89 \text{ ml/hour}$$

Here's what each element in the simplified equation represents:

- 5 refers to 5 mcg (the amount of dopamine ordered)
- 73.5 is the patient's weight (in kg)
- 60 refers to 60 minutes/hour (although the order is written in mcg/kg/minute, the pump runs in ml/hour)
- 3200 results from converting 800 mg into 800,000 mcg (1 mg = 1,000 mcg) and dividing by the amount of available solution (in this case, 250 ml) to yield the correct drug concentration.

But first…a preliminary equation

Before using this simplified equation, you must perform a conversion to find the drug concentration when the order is written in micrograms but the drug is available as milligrams in milliliters of solution. Fortunately, this conversion is simple, too. Multiply the available milligrams by 1000 (1 mg = 1,000 mcg) and then divide the result by the amount of solution.

When applied to our dopamine example, this preliminary equation is:

$$\frac{800 \times 1{,}000 = 800{,}000}{250} = 3{,}200 \text{ mcg/ml of solution}$$

Calculating drip rates for drugs ordered as mcg/kg/minute

Some I.V. drugs (such as dopamine, dobutamine, nitroprusside, phenylephrine, cisatracurium, and in some cases epinephrine) are delivered I.V. in mcg/kg/minute. No matter which drug you're giving, if it is ordered as mcg/kg/minute, you can use the same simplified equations to calculate the drip rate.

Suppose the physician orders nitroprusside 0.5 mcg/kg/minute. Here's the equation you'd use:

$$\frac{0.5 \times \text{patient's weight (kg)} \times 60}{\text{Drug concentration}} = \text{Pump rate in ml/hour}$$

If the patient weighs 75 kg and the drug is available as 50 mg as 250 ml, first calculate the drug concentration, as follows:

$$\frac{50 \times 1000}{250} = 200 \text{ mcg/ml}$$

Then calculate the infusion rate:

$$\frac{0.5 \times 75 \times 60}{200} = 11.25 \text{ ml/hour}$$

So you'd start the infusion at 11.25, 11.2, or 11 ml/hour (depending on what type of infusion pump you're using).

Titrating drugs ordered as mcg/kg/minute

Once the infusion is up and running, your titration approach may depend on:

- whether you need an order to titrate I.V. drugs or are permitted to titrate them independently
- desired effect of drug delivery
- whether you'll wean the patient off the drug or keep him on it for a prolonged period
- how quickly you need to achieve the desired result.

In most cases, you'll titrate the drug according to a specific parameter or desired outcome. (See *Understanding titration goals and protocols.*) The closer you get to this parameter or outcome, the smaller the change you should make in the drip rate. If you need to titrate more aggressively, you may do so in larger amounts to begin with. On some units, you may be required to call the physician with each titration to obtain a new order.

To titrate an I.V. drug that's up and running, you can simplify the main equation by using a single unit of ordered medication. That allows you to determine the infusion rate for a single unit of medication—whether it's 1 mcg, 0.1 mcg, or 0.01 mcg. Using the original order for nitroprusside 0.5 mcg/kg/minute for a patient who weighs 75 kg, here's the equation you'd use to identify the infusion rate for a single unit (0.1 mcg) of medication:

$$\frac{0.1 \times 75 \times 60}{200} = 2.25 \text{ ml/hour}$$

Calculate the initial I.V. pump infusion rate by multiplying the infusion rate for a single unit of medication with the ordered amount of drug. The original order was for 0.5 mcg/kg/minute; that equals 5 units of ordered medication. Thus:

$$5 \times 2.25 = 11.25 \text{ ml/hour}$$

Titrate the medication by multiplying the infusion rate for a single unit of medication by the newly desired drug dose, increasing or decreasing the infusion rate as appropriate. For example:

$$3 \times 2.25 = 6.75 \text{ ml/hour (0.3 mcg/kg/minute)}$$
$$4 \times 2.25 = 9 \text{ ml/hour (0.4 mcg/kg/minute)}$$
$$6 \times 2.25 = 13.5 \text{ ml/hour (0.6 mcg/kg/minute)}$$
$$8 \times 2.25 = 18 \text{ ml/hour (0.8 mcg/kg/minute)}$$

...and so on.

For a drug ordered in full mcg/kg/minute, such as dopamine, omit the ordered amount from the original equation and find the amount of a single ordered unit. For instance, say the physician orders dopamine at 3 mcg/kg/minute and you will titrate upward or downward. Here's how the equations would look for a mixture of 800 mg in 250 ml for a patient weighing 74 kg:

$$\frac{800 \times 1000}{250} = 3200$$

$$\frac{74 \times 60}{3200} = 1.3875, \text{ or } 1.4 \text{ ml/hour}$$

You would figure out the initial infusion rate with this equation:

$$3 \times 1.4 = 4.2 \text{ ml/hour (3 mcg/kg/minute)}$$

Here's how you'd figure out the titrations:

$$4 \times 1.4 = 5.6 \text{ ml/hour (4 mcg/kg/minute)}$$
$$5 \times 1.4 = 7 \text{ ml/hour (5 mcg/kg/minute)}$$
$$10 \times 1.4 = 14 \text{ ml/hour (10 mcg/kg/minute)}$$

...and so on.

Calculating drip rates for drugs ordered as mcg/minute

Certain I.V. drugs (such as nitroglycerin, norepinephrine, and sometimes epinephrine) are delivered in mcg/minute. To calculate drip rates for these drugs, use the simplified equations—but without the weight component. For example, if the physician orders nitroglycerin to run at 10 mcg/minute, complete the equations as shown below.

First, calculate the concentration for nitroglycerin 50 mg in 250 ml of solution:

$$\frac{50 \times 1000}{250} = 200 \text{ mcg/ml}$$

Then, calculate the drip rate using the basic equation, but omitting the weight:

Understanding titration goals and protocols

Most medications are titrated according to a hospital protocol based on current evidence-based nursing standards. For an I.V. antihypertensive drug, the usual titration goal is to achieve a target range of systolic, diastolic, or mean blood pressure (most common). Here are some examples of titration goals:

- Dopamine or dobutamine may be titrated upward or downward in increments of 1 to 5 mcg/kg/minute.
- Nitroprusside, with greater toxicity potential, is titrated in smaller increments—typically 0.1 to 0.2 mcg/kg/minute.

In most intensive care units, nurses can titrate upward or downward as needed. In some progressive care and intermediate care units, the physician may order a maximum dosage to which you may titrate these drugs.

Sedative protocols

For sedatives, most healthcare facilities have protocols that specify the method and amount of titration used to achieve and maintain the appropriate sedation level, as well as how often to assess the patient.

$$\frac{10 \text{ (ordered dose)} \times 60 \text{ (minutes/hour)}}{200 \text{ (mcg/ml)}} = 3 \text{ ml/hour (I.V. pump rate)}$$

Titrating drugs ordered as mcg/minute

To titrate a drug ordered as mcg/minute, use the same approach as for a drug ordered as mcg/kg/minute. Again, the goal is to achieve a target parameter or desired outcome. Typically, norepinephrine, epinephrine, and nitroglycerin are titrated to achieve a desired blood pressure; nitroglycerin also may be titrated to help control chest pain.

First, calculate the drip rate for a single unit of ordered medication. Then, determine the infusion pump rate by multiplying that rate by the desired amount of drug that you want to deliver. Using our example of nitroglycerin at 10 mcg/minute, here's how the calculation looks:

$$\frac{1 \times 60}{200} = 0.3 \text{ ml/hour}$$

To make it even simpler, omit the "1" and just divide 60 by 200, to yield 0.3 ml/hour. The calculation for the original infusion of 10 mcg/minute is 10 x 0.3 = 3 ml/hour.

You'd calculate the titrations like this:

$5 \times 0.3 = 1.5$ ml/hour (5 mcg/minute)
$15 \times 0.3 = 4.5$ ml/hour (15 mcg/minute)
$20 \times 0.3 = 6$ ml/hour (20 mcg/minute)

...and so on.

Calculating drip rates for drugs ordered as mg/minute

Some drugs (such as lidocaine and procainamide) are ordered as mg/minute. To calculate the I.V. drip rate, use the basic simplified equations but omit the weight and substitute micrograms for milligrams. Because these drugs usually are mixed as grams in milliliters of solution, the first equation is the same one we've been using, except you must convert grams to milligrams, instead of milligrams to micrograms.

$$\frac{\text{Amount (in g)} \times 1000}{\text{Amount of fluid}} = \text{Drug concentration}$$

For example, for 2 g in 250 ml:

$$\frac{2 \times 1000}{250} = 8 \text{ mg/ml (drug concentration)}$$

The second equation is our basic simplified equation, with weight omitted. Substitute the micrograms for milligrams. If, for instance, the physician orders procainamide 3 mg/minute and the drug is available as 2 g in 250 ml, use this equation:

$$\frac{3 \times 60}{8} = 22.5 \text{ ml/hour}$$

This means you should set the infusion pump at 22.5 ml/hour to deliver 3 mg/minute.

Titrating drugs ordered as mg/minute

Although some drugs are ordered to be delivered at rates faster than 5 mg/minute, this is rare with lidocaine and procainamide. Lidocaine comes premixed as 2 g in 250 ml.

To simplify the drip calculation for any drug ordered as mg/minute, use the same concentration as for procainamide or lidocaine. First, calculate the infusion rate for 1 mg/minute of 2 g in 250 ml solution as shown here:

$$\frac{1 \times 60}{8 \text{ (drug concentration)}} = 7.5 \text{ ml/hour (infusion rate)}$$

Once you've calculated this infusion rate, you can easily determine the titration rates, as shown below:

$2 \times 7.5 = 15$ ml/hour (2 mg/minute)
$3 \times 7.5 = 22.5$ ml/hour (3 mg/minute)
$4 \times 7.5 = 30$ ml/hour (4 mg/minute)
$5 \times 7.5 = 37.5$ ml/hour (5 mg/minute)

...and so on.

Memorizing this simple set of equations means you don't have to complete the calculation again. However, this works only for a solution concentration of 2 g in 250 ml, when the drug is ordered as mg/minute.

Simpler is better

This article covers calculations for just a few of the I.V. drugs you may be called on to deliver and titrate. But if you understand the simplified equations I've presented, you can calculate drip rates and titrations for I.V. drugs ordered as mcg/kg/minute, mcg/minute, and mg/minute. Just remember—using the simplest equation will increase your confidence and comfort when performing these calculations. ★

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$$\frac{5 \times 73.5 \times 60}{3200} = 6.89 \text{ ml/hour}$$

$$\frac{50 \times 1000}{250} = 200 \text{ mcg/ml}$$

$$5 \times 2.25 = 11.25 \text{ ml/hour}$$

$$6 \times 2.25 = 13.5 \text{ ml/hour}$$

(0.6 mcg/kg/minute)