Critical Thinking: Nursing Calculations Part 3

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Acknowledgements

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Purpose and Objectives

The purpose of this course is to help ensure safe IV medication administration by reviewing calculation techniques.

After successful completion of this course, you should be able to:

1. Identify reasons why nurses need to maintain competency in performing nursing calculations.
2. Perform calculations correctly.
3. Determine correct dosages.

Introduction

As a healthcare professional, medication safety is a critical part of your job. Patients' safety and lives depend on receiving the correct dose of medications.

This course offers the healthcare professional the opportunity to practice intravenous (IV) medication dosage calculations most commonly used in clinical situations.

Barriers to Calculation Success

Top ten reasons why healthcare professionals don't think they need to maintain competency in calculations:

1. The computer does it
2. The pharmacy does it
3. The IV infusion pump does it
4. We have charts and tables that do it
5. The drug companies take care of it
6. We use unit dose
7. It's just a nursing school exercise
8. We have a unit-based pharmacist
9. Math is just not one of my strengths
10. It's not a good use of my time

Responsible professionals cannot afford to become complacent with drug calculations as they are accountable for all drugs they administer.

Keys to Calculation Success

To prepare and administer medications safely, healthcare professionals must avoid total dependence on technology to perform calculations.

The safe practitioner maintains a state of risk-awareness; continuously evaluating that the nursing action they are about to perform is correct.

Accountability for Medication Calculations

With the advent of smart technology infusion pumps, unit dose preparations by drug manufacturers and pharmacists counting drops has virtually become a thing of the past. However, occasions may arise when unit dose preparations are not available.

Even when all systems are go – when the technology works well and pharmacy support is optimal – the nurse still remains responsible for safe administration of IV medications directly to patients. To fulfill this responsibility, the nurse must maintain competency in basic medication calculations.

For most drug calculation problems, there is more than one method for arriving at the correct answer. This course demonstrates two commonly used methods. All populations can use these methods. No longer do we need separate calculation methods for pediatrics or NICU.

Calculating Flow Rate (mL/hr)

The nurse needs to be comfortable calculating the number of mL per hour that the patient is to receive. Once the number of mL/hr is determined, the nurse can then adjust the pump to deliver the correct number of mL per hour.

Your patient's IV orders read: **Administer 3000 mL D_5W/24 hours.**

The first factor to determine is how many mL/hr you need the pump to deliver. There are two methods you can use to determine this:

Method #1:

$$\frac{3000\text{ mL}}{24\text{ hours}} = \frac{x\text{ mL}}{1\text{ hour}}$$

$$24x = 3000$$

$$\mathbf{x = 125\text{ mL/hr}}$$

Method #2:

$$\frac{\text{Total volume}}{\text{\# of hours to infuse}} = \text{mL/hour infusion rate}$$

$$\frac{3000}{24} = \text{mL/hr}$$

$$\mathbf{125 = \text{mL/hr}}$$

Practice: Calculating Flow Rate (mL/hr)

Your patient's IV orders read: **Administer 2.5 L of LR/10 hours**

You will adjust the IV infusion pump to deliver _____mL/hr?

Did you get the right answer? Let's check the math.

Method #1

2.5 liters = 2500 mL

$$\frac{2500 \text{ mL}}{10 \text{ hrs}} = \frac{x \text{ mL}}{1 \text{ hr}}$$

$$10x = 2500$$

$$x = \textbf{250 mL/hr}$$

Method #2

2.5 liters = 2500 mL

$$\underline{x \text{ mL/hr}} = \frac{2500 \text{ mL}}{10 \text{ hrs}}$$

x = **250 = mL/hr**

Calculating IV Drip Rates

CAUTION: IV fluids containing medications such as vasoactive drips, TPN, or any other high risk medication should not be given without the use of a smart pump.

In the past, the nurse was responsible for calculating how many drops per minute equated to the correct mL/hour as ordered by the provider. Now days, with smart infusion pump use, this is becoming a lost skill. It is important to retain this skill for those times when you may not have a pump available for use.

Commonly Supplied IV Sets: Drip Factor

The most commonly supplied IV sets have one of the following drip factors:

- 60 gtts/mL minidrip set
- 15 gtts/mL regular drip set
- 10 gtts/mL regular drip set

Note that for each set, if you divide the 60-minute hour by the number of drops per mL, you will obtain a whole number of minutes.

That is:

- **60** gtts/mL minidrip set = Sixty **1**-minute periods
- **15** gtts/mL regular drip set = Fifteen **4**-minute periods
- **10** gtts/mL regular drip set = Ten **6**-minute periods

Time Period per Hour Method

Once you have determined the mL/hour using the formulas on the previous page, divide the number of mL/hr by the appropriate number of minutes per time period.

For example:

The provider order reads: D_5NS to run at 80 mL/hour. To calculate the drops/minutes (gtts/min) you must determine the flow rate of the drip set and divide by the appropriate number.

80 mL/hr via 60 gtts/mL set = 80 /1 = 80 gtts/min

80 mL/hr via 15 gtts/mL set = 80 /4 = 20 gtts/min

80 mL/hr via 10 gtts/mL set = 80 /6 = 13.3 gtts/min, rounded to 13 gtts/min

Test Yourself

You have an order for 1000 mL D_5½ NS IV to be infused over 8 hours. You will use a 15 gtt/mL drip set. How many drops per minute do you need to count in the drip chamber?

Did you get the right answer? Let's check...

Calculation for Method 1:

$$\frac{1000\text{ mL}}{8\text{ hr}} = \frac{x\text{ mL}}{\text{hr}}$$

8 x = 1000 mL

x = 125 mL/hr

$$\frac{125\text{ mL/hr}}{60\text{ min}} = 2.08\text{ mL/min}$$

2.08 mL/min X 15 gtts/mL = 31.2 gtts/min, rounded to **31 gtts/min**

Calculation for Method 2:

$$\text{X gtts/min} = \frac{\text{volume to be infused x drip factor of tubing}}{\text{Time in minutes to be infused}}$$

$$\text{x gtts/min} = \frac{1000\text{ mL x 15 gtts/min}}{8\text{ hrs (480 minutes)}}$$

X gtts/min = 31.2 gtts/min, rounded to **31 gtts/min**

Practice: gtts/min Calculations

Practice these gtts/min calculations. Use both of the methods on at least one problem. How many gtts/min will deliver:

1. 3 L IV fluid over 24 hours, using a 10 gtt/mL set? Answer: **21 gtts/min**
2. 100 mL IVPB over 1 hour, using a 15 gtt/mL set? Answer: **25 gtts/min**
3. 50 mL IVPB over 1 hour, using a 60 gtt/mL set? Answer: **50 gtts/min**
4. 250 mL over 4 hours, using a 60 gtt/mL set? Answer: **63 gtts/min**

Infusion Rate Equation for mcg/min

When you have an order in mcg/min and have a solution that you have received from pharmacy containing a drug measured in mg, you must calculate the concentration and mL/hr in order to program the IV infusion pump correctly.

Your patient has an order for Epinephrine 4 mcg/min IV. Pharmacy has supplied a solution labeled Epinephrine 1 mg in D_5W 500 mL. You will set the infusion pump for how many mL/min?

The first step is to calculate the concentration. Once you know the concentration in mcg/mL, you can work out the mL/min by determining the number of mL needed to deliver 4mcg/min.

Step One: Determine the concentration in mcg/mL

Method #1

1 mg = 1000 mcg

$$\frac{x\ mcg}{1\ mL} = \frac{1000\ mcg}{500\ mL}$$

x mcg = 2 mcg/mL or 0.002 mg/mL

Method #2

$$\frac{x\ mcg}{1\ mL} = \frac{1\ mg}{500\ mL}$$

Note: Units must be the same in both denominators. Therefore; change 1 mg to 1000 mcg.

$$\frac{x\ mcg}{1\ mL} = \frac{1000\ mcg}{500\ mL}$$

1000 = 500 x mcg

$$\frac{1000}{500} = x\ mcg$$

So the concentration is 2 mcg/mL = x Or 0.002 mg/mL = x

Infusion Rate Equation for mcg/min

Step two. Now you need to calculate the rate of infusion for 4 mcg/min:

Method #1:

$$\frac{2\text{ mcg}}{1\text{ mL}} = \frac{4\text{ mcg}}{x\text{ mL}}$$

$$4\text{ mL} = 2x$$

$$\mathbf{x = 2\text{ mL/min}}$$

2mL/min X 60 minutes = 120 mL/hr

Method #2

$$\text{Infusion rate (mL/hr)} = \frac{\text{(target dose in mcg/min) x 60}}{\text{(Concentration in mg/mL) x 1000}}$$

$$\text{X mL/hr} = \frac{\text{(4 mcg/min) x 60}}{\text{(0.002 mg/mL) x 1000}}$$

$$\text{X mL/hr} = \frac{\text{240 mcg/hr}}{\text{2 mcg/mL}}$$

X = 120 mL/hr

As you can see, method two has less steps and may reduce the chance of error when performing unfamiliar calculations. It is important that you find a calculation method that you like and stick with it. Consistency/standardization = safety

Infusion Rate Equation for mcg/kg/min

Since some drugs are ordered in mcg/kg/min (such as Dobutamine and Dopamine), you will need to calculate the infusion rate in mL/hr in order to administer these potent drugs via an IV infusion pump.

You are ordered to administer Dobutamine 5 mcg/kg/min IV. Your patient weighs 152 pounds. You have infusate labeled 250 mg Dobutamine in 500 mL D_5W. You will set the IV infusion pump to deliver how many mL/hr?

Infusion Rate Equation for mcg/kg/min

Method #1:

When medications are ordered in mcg/kg/min and the patient's weight is in pounds, you must first convert the weight into kg.

1 pound = 2.2 kg

$\frac{\text{152 pounds}}{\text{2.2 kg}}$ = x kg

69.09 kg = x round to 69.1 kg

Next, to find the patient's dose:
kg weight x ordered dose = patient's dose

69.1 kg x 5 mcg/kg/min = x
345.5 mcg/min = x

Next find the amount of drug in mcg/mL of infusate:

$\frac{\text{x mg}}{\text{1 mL}} = \frac{\text{250 mg}}{\text{500 mL}}$

500 = 250 x mg

$\frac{500}{250}$ = x

0.5 mg/mL = x

Now calculate how many mcg/mL you will have:

mcg/mL = mg/mL X 1000   500 mcg/mL = 0.5 mg/mL

Now find the number of mL/min needed for the ordered dose:

$\frac{\text{500 mcg}}{\text{1 mL}} = \frac{\text{345.5 mcg}}{\text{x mL}}$

$\frac{345.5}{\text{500 mcg/mL}}$ = x

x = 0.691 mL = x   rounded to 0.69 mL

0.69 mL represents the patient's dose per minute contains the patient's dose per minute: 345.5 mcg

Now find the number of mL per hour needed to deliver the patient's dose:

60 min X the one-minute dose of 0.69 mL = 41.4 mL/hr, rounded to 41 mL/hr

Infusion Rate Equation for mcg/kg/min

Method #2:

$$\text{Infusion Rate (mL/hr)} = \frac{\text{(Weight in kg) (Target Dose in mcg/kg/min) X 60}}{\text{(Infusate concentration in mg/mL) X 1000}}$$

NOTE: In a mathematical operation, when 2 quantities appear in parentheses proximate to one another, this means multiply. So (Weight in kg) (Target Dose in mcg/kg/min) in this formula means the same as (Weight in kg) X (Target Dose in mcg/kg/min).

When medications are ordered in mcg/kg/min and the patient's weight is in pounds, you must first convert the weight into kg.

1 pound = 2.2 kg

$$\frac{\text{152 pounds}}{\text{2.2 kg}} = \text{x kg}$$

69.09 kg = x round to 69.1 kg

Next, find the concentration of the infusate in mg/mL

$$\frac{\text{x mg}}{\text{1 mL}} = \frac{\text{250 mg}}{\text{500 mL}}$$

250 = 500 x

0.5 mg/mL = x

Now, you can enter these values into the formula:

$$\text{Infusion Rate (mL/hr)} = \frac{\text{(69.1 kg) (5 mcg/kg/min) X 60}}{\text{(0.5 mg/mL) X 1000}}$$

$$\text{x mL/hr} = \frac{20730}{500}$$

x = 41.46 rounded to 41

Practice: Infusion Rate Equation for mcg/kg/min

You have an order to administer Intropin (Dopamine) 10 mcg/kg/min IV. Your patient weighs 176 lbs. You have infusate labeled 200 mg in 250 mL D5W. You will set the IV infusion pump to deliver how many mL/hr?

The answer is 60 mL/hr. How well did you do?

Method #1:

When medications are ordered in mcg/kg/min and the patient's weight is in pounds, you must first convert the weight into kg.

1 pound = 2.2 kg

$\frac{176 \text{ pounds}}{2.2 \text{ kg}} = x \text{ kg}$

80 kg = x

Next, to find the patient's dose

kg weight x ordered dose = patient's dose

80 kg x 10 mcg/kg/min = x

800 mcg/min = x

Next find the amount of drug in mcg/mL of infusate:

$\frac{x \text{ mg}}{1 \text{ mL}} = \frac{20 \text{ mg}}{200 \text{ mL}}$

200 = 250 x mg

$\frac{250}{200} = x$

0.8 mg/mL = x

Now calculate how many mcg/mL you will have:

mcg/mL = mg/mL x 1000   800 mcg/mL = 0.8 mg/mL

Now find the number of mL/min needed for the ordered dose:

$\frac{800 \text{ mcg}}{1 \text{ mL}} = \frac{800 \text{ mcg/mL}}{x \text{ mL}}$

1 mL = x   (1 mL represents the patient's dose per minute: 800 mcg)

Now find the number of mL per hour needed to deliver the patient's dose:

60 min x the one-minute dose of 1 mL = 60 mL/hr

Practice: Infusion Rate Equation for mcg/kg/min

NOTE:
In a mathematical operation, when 2 quantities appear in parentheses proximate to one another, this means multiply.

So (Weight in kg) (Target Dose in mcg/kg/min) in this formula means the same as (Weight in kg) X (Target Dose in mcg/kg/min).

Method #2:

$$\text{Infusion Rate (mL/hr)} = \frac{\text{(Weight in kg) (Target Dose in mcg/kg/min) X 60}}{\text{(Infusate concentration in mg/mL) X 1000}}$$

When medications are ordered in mcg/kg/min and the patient's weight is in pounds, you must first convert the weight into kg.

1 pound = 2.2 kg

$$\frac{\text{176 pounds}}{\text{2.2 kg}} = \text{x kg}$$

80 kg = x

Next, find the concentration of the infusate in mg/mL

$$\frac{\text{x mg}}{\text{1 mL}} = \frac{\text{200 mg}}{\text{250 mL}}$$

250 = 200 x

0.8 mg/mL = x

Now, you can enter these values into the formula:

$$\text{Infusion Rate (mL/hr)} = \frac{\text{(80 kg) (10 mcg/kg/min) x 60}}{\text{(0.8 mg/mL) x 1000}}$$

$$\text{x mL/hr} = \frac{48000}{800}$$

x = 60 mL/hr

Checking the Safety / Effectiveness of a Prescribed Dose: Unit/kg of Body Weight

A child who weighs 50 pounds has an order for amoxicillin oral suspension (Amoxil) 250 mg PO Q8H. According to the drug reference on the unit, the recommended pediatric dose is “20 – 50 mg/kg/day in divided doses every 8 hours.” Does the ordered dose fall within the recommended range of dosage?

What questions must you answer before you can answer the question about the safety and effectiveness of the ordered dose?

Step One:

What is the child’s weight in kg?

$\frac{50 \text{ lbs}}{2.2 \text{ kg}}$ = 22.72, rounded to **22.7 kg**

Next, in order to calculate the recommended daily dosage range, multiply the patient’s weight by the recommended dose.

22.7 X 20 mg/day = **454 mg/day lower limit**

22.7 X 50 mg/day = **1135 mg/day upper limit**

Now, calculate the individual dose range by dividing the mg/kg/day dose by the frequency.

How many eight-hour periods are there in a day?
(24 hours per day/8 = 3)

$\frac{454 \text{ mg/day lower limit}}{3}$ = 151.3 mg

$\frac{1135 \text{ mg/day upper limit}}{3}$ = 378.3 mg

151.3 mg/single 8-hour dose lower limit
378.3 mg/single 8-hour dose upper limit

Does the ordered dose lie within or outside of the recommended range?

The dose of 250 mg Q8H lies within the recommended range.

Using kg of Body Weight to Calculate Volume to be Infused for Packed Red Blood Cells

The Recommended Volume Range for Administering Packed RBCs to a Pediatric Patient is 10 – 20 mL/kg.

For a child who weighs 63 pounds, the recommended volume range for administering packed RBCs is ___________.

First find the child's weight in kg: $\frac{63}{2.2} = 28.6$ kg

Low end of range = 10 X 28.6 = 286 mL

High end of range = 20 X 28.6 = 572 mL

Recommended volume range for this child = **286 mL to 572 mL**

Using kg of Body weight to Calculate Maintenance Fluids

Using kg of body weight to calculate fluid maintenance:

Child's Weight in Kg	IV Drip Rate for Fluid Maintenance
0 – 10 kg	4 mL/kg/hr
11 – 20 kg	40 mL/hr + 2 mL/kg/hr
≥ 21 kg	60 mL/hr + 1 mL/kg/hr

For a child who weighs 42 pounds, the correct IV drip rate for fluid maintenance is how many mL/hr?

First, find the child's weight: 42/2.2 = 19.09, rounded to 19 kg

Next, identify the correct formula:

(4 mL X10 kg) + (2mL x 9kg) = hourly rate

40 mL + 18 mL = **58 mL/hr**

Practice Calculations

Your patient is a 4-year-old who weighs 48 pounds. His physician orders a daily maintenance dose of digoxin pediatric elixir 250 mcg PO. The drug is supplied in a 60 mL bottle containing 50 mcg/mL.

Questions:

1. **(a)**. According to your drug reference, the recommended daily maintenance oral dosage for a child age 2 years to age 5 years is 7.5 – 10 mcg/kg. Is the 250 mcg dose a safe dose using recommended mcg/kg?

    No, the 250 mcg is more than the recommend dose range

    The child weighs 21.8 kg

    $$\frac{48 \text{ lb}}{2.2 \text{ kg}} = 21.8 \text{ kg}$$

    21.8 X 7.5 mcg = 163.5 mcg, lower limit recommended

    21.8 X 10 mcg = 218 mcg, upper limit recommended

    (b). The child's doctor writes a new order for digoxin pediatric elixir 200 mcg PO. Is this dose within safe and effective limits for this child?

    Yes, 200 mcg is within the safe and effective range.

    (c). How many mL of digoxin pediatric elixir containing 50 mcg/mL will you prepare to administer a 200 mcg dose?

    $$\frac{200 \text{ mcg} \times 1 \text{ mL}}{50 \text{ mcg}} = 4 \text{ mL}$$

Practice Calculations

2. Use the maintenance IV fluid calculation to determine hourly IV fluid rate for a child who weighs 50 lb.

Answer: 62.7 mL/hr

The child's weight in kg = 22.7 kg.
(4mL x 10 kg) + (2 mL X 10 kg) + (1mL X 2.7 kg) = hourly rate
40 mL + 20 mL + 2.7mL = 62.7 mL/hr

Child's Weight in Kg	IV Drip Rate for Fluid Maintenance
0 – 10 kg	4 mL/kg/hr
11 – 20 kg	2 mL/kg/hr
≥ 20 kg	1 mL/kg/hr for every kg above 20

Tips for Calculation Safety

The absolute safest approach to administering medications, IV fluids and performing other interventions requiring calculation is to AVOID CALCULATION UNLESS ABSOLUTELY NECESSARY.

This is because there is always potential for human error and there is often the potential for distraction while calculating which can lead to error.

Ways to avoid calculation include:

- The use of computer algorithms.
- Completion of most calculations by the pharmacy.
- Posting durable (e.g., laminated) references that give the calculated amounts, rates or other answers for frequently used drugs.

When calculation is unavoidable, the following tips can help assure calculation safety:

- Always use the same method to approach the same type of problem.
- Always have your answer independently verified by an RN/Pharmacist colleague and assure that your colleague actually performs the calculation.
- Assert your need to concentrate by eliminating distractions while performing calculations.
- Before beginning the calculation procedure, identify some of the parameters of a sensible answer – for example, "Should the correct answer be more or less than one mL?" Then, compare the answer you obtain with your common sense parameter.
- Assure that you have taken into account all of the relevant conversion factors – for example, if you have obtained a rate in mL, have you obtained mL per hour or mL per minute?.
- Validate your calculated answer with an appropriate up-to-date drug reference. That is, does your calculated answer fall within recommended guidelines?

Conclusion

This course has offered evidence to support the need for nurses to maintain competency in performing selected calculations. A variety of examples of calculation problems common in nursing practice have been presented and solved.

The course has provided the opportunity for practice with at least two methods for solving particular problems.

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