UNIT X Calculating Medication Doses

PROCEDURE 135

# Calculating Doses, Flow Rates, and Administration of Continuous Intravenous Infusions

PURPOSE: The critical care nurse calculates dosages and flow rates for continuous intravenous (IV) infusions to ensure delivery of the correct amount of medication. Many of the medications delivered by continuous IV infusion have narrow margins of safety; therefore, accuracy in calculating and administering these agents is imperative.

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## PREREQUISITE NURSING KNOWLEDGE

- Knowledge of aseptic technique is important.
- Many different types of medications are delivered as continuous IV infusions in critical care. These are potent medications including, but not limited to, vasoactive, inotropic, and antidysrhythmic agents. The critical care nurse must possess knowledge about the actions, indications, desired patient response, dosage, and adverse effects of the medication being administered.
- Hemodynamic assessment and electrocardiographic (ECG) monitoring are frequently necessary to evaluate the patient response to the infusion. The critical care nurse must be familiar with monitoring equipment such as noninvasive blood pressure cuffs, cardiac monitors, arterial lines, and pulmonary artery catheters.
- Titration is adjustment of the dose, either increasing or decreasing, to attain the desired patient response. Weaning is a gradual decrease of the dose when the medication is being discontinued.
- Volume-controlled infusion devices are required to precisely deliver and titrate continuous infusions. Alterations or interruptions of the flow rate can significantly affect the dose of medication being delivered and adversely affect the patient.
- There are three factors involved in the calculations for continuous IV infusions:
  - ❖ The concentration is the amount of medication diluted in a given volume of IV solution (eg, 400 mg dopamine diluted in 250 mL normal saline (NS), or 2 g lidocaine diluted in 500 mL 5% dextrose in water [$D_5W$]).
  - ❖ The dose of the medication is the amount of medication to be administered over a certain length of time (eg, dopamine 5 μg/kg/min, or lidocaine 2 mg/min). The units of measure for the dose will differ for various medications. The length of time is 1 minute or 1 hour. If the medication is weight based, the dose of the medication is per kilogram of patient weight.
  - ❖ The flow rate is the rate of delivery of the IV fluid solution (eg, 20 mL/hr). The units of measure of the flow rate are always mL/hr.
- All units of measure in the formula must be the same. It frequently is necessary to perform some conversions on the concentration prior to entering it into the formula. The units of measure of the concentration must be converted to the same units of measure of the dose (eg, the

concentration of dopamine is measured in mg, but the dose of dopamine is measured in µg). Additionally, the mathematical calculations are simplified if the concentration is expressed per milliliter of fluid, rather than the total volume of the IV container.

- The mathematical formula for continuous IV infusions contains the three factors involved in continuous infusions (Table 135–1). When two factors are known, the third can be calculated by using the basic formula. Therefore, when the concentration of the solution and the prescribed dose are known, the flow rate can be determined. When the concentration of the solution and the flow rate are known, the dose can be determined. The two known factors are entered into the formula, and the mathematical computations are solved to determine the third factor. Variations on the basic formula are used to allow for medications delivered per hour or per minute, and for medications that are weight based (Tables 135–2 and 135–3).

## EQUIPMENT

- Prepared IV solution with medication to be administered
- IV tubing
- IV infusion device
- Nonsterile gloves
- Alcohol pads
- Calculator (optional)

## PATIENT AND FAMILY EDUCATION

- Explain the indications and expected response to the pharmacologic therapy. ➤➤***Rationale:*** Patients and families need explanations of the plan of care and interventions.
- Instruct the patient to report adverse symptoms, as indicated. Reportable symptoms include, but are not limited to pain, burning, itching, or swelling at the IV site, dizziness, shortness of breath, palpitations, and chest pain. ➤➤***Rationale:*** Assists the nurse to evaluate response to the pharmacologic therapy and to identify adverse reactions.

*Table 135–1* **Basic Formula**

To determine an unknown flow rate

$$\frac{\text{Dose (mg/hr or } \mu\text{/hr)}}{\text{Concentration (mg/mL or } \mu\text{/mL)}} = \text{Flow rate (mL/hr)}$$

To determine an unknown dose

$$\text{Flow rate (mL/hr)} \times \text{Concentration (mg/mL or } \mu\text{/mL)} = \text{Dose (mg/hr or } \mu\text{/hr)}$$

Example when flow rate is unknown: diltiazem 125 mg/125 mL D5W to be administered at 10 mg/hr.

A. Calculate concentration of drug in 1 mL of fluid:

$$\frac{125\text{ mg}}{125\text{ mL}} = \frac{1\text{ mg}}{1\text{ mL}}$$

B. Enter known factors into the formula and solve:

$$\frac{10\text{ mg/hr}}{1\text{ mg/mL}} = 10\text{ mL/hr}$$

Example when dose is unknown: diltiazem 125 mg/125 mL D5W is infusing at 15 mL/hr.

A. Calculate concentration of drug in 1 mL of fluid:

$$\frac{125\text{ mg}}{125\text{ mL}} = \frac{1\text{ mg}}{1\text{ mL}}$$

B. Enter known factors into the formula and solve:

$$15\text{ mL/hr} \times 1\text{ mg/mL} = 15\text{ mg/hr}$$

*Table 135–2* **Variation for Medication Doses Measured per Minute (mg/min or µg/min)***

To determine unknown flow rate

$$\frac{\text{Dose (mg/min or } \mu\text{g/min} \times 60\text{ min/hr}}{\text{Concentration (mg/mL or } \mu\text{g/mL)}} = \text{Flow rate (mL/hr)}$$

To determine unknown dose

$$\frac{\text{Flow rate (mL/hr)} \times \text{Concentration (mg/mL or } \mu\text{g/mL)}}{60\text{ min/hr}} = \text{Dose (mg/min or } \mu\text{g/min)}$$

Example when flow rate is unknown: nitroglycerin 50 mg/250 mL D5W to be administered at 30 µg/min.

a. Convert the concentration to like units of measure:

$$\frac{50\text{ mg}}{250\text{ mL}} \times \frac{1000\ \mu\text{g}}{1\text{ mg}} = \frac{50{,}000\ \mu\text{g}}{250\text{ mL}}$$

b. Calculate concentration of drug in 1 mL of fluid:

$$\frac{50{,}000\ \mu\text{g}}{250\text{ mL}} = \frac{200\ \mu\text{g}}{1\text{ mL}}$$

c. Enter known factors into the formula and solve:

$$\frac{30\ \mu\text{g/min} \times 60\text{ min/hr}}{200\ \mu\text{g/mL}} = 9\text{ mL/hr}$$

Example when dose is unknown: lidocaine 2 g/500 mL D5W is infusing at 30 mL/hr.

a. Convert the concentration to like units of measure:

$$\frac{2\text{ g}}{500\text{ mL}} \times \frac{1000\text{ mg}}{1\text{ g}} = \frac{2000\text{ mg}}{500\text{ mL}}$$

b. Calculate concentration of drug in 1 mL of fluid:

$$\frac{2000\text{ mg}}{500\text{ mL}} = \frac{4\text{ mg}}{1\text{ mL}}$$

c. Enter known factors into formula and solve:

$$\frac{30\text{ mL/hr} \times 4\text{ mg/mL}}{60\text{ min/hr}} = 2\text{ mg/min}$$

*The time factor of 60 min/hr must be added to the basic formula.

## PATIENT ASSESSMENT AND PREPARATION

### Patient Assessment

- Assess medication allergies. ➤➤***Rationale:*** Identification and prevention of allergic reactions.
- Obtain vital signs and hemodynamic parameters. ➤➤***Rationale:*** Provides baseline data and the need for vasoactive agents.
- Assess the ECG. ➤➤***Rationale:*** Provides baseline data and the need for antidysrhythmic therapy.

### Patient Preparation

- Ensure that the patient and family understand preprocedural teaching. Answer questions as they arise and reinforce information as needed. ➤➤***Rationale:*** Evaluates and reinforces understanding of previously taught information.

*Table 135–3* **Variation for Weight-Based Medication Doses Measured per Minute (μg/kg/min)***

To determine unknown flow rate

$$\frac{\text{Dose } (\mu g/kg/min) \times 60 \text{ min/hr} \times \text{pt. weight (kg)}}{\text{Concentration } (\mu g/mL)} = \text{Flow rate (mL/hr)}$$

To determine unknown dose

$$\frac{\text{Flow rate (mL/hr)} \times \text{Concentration } (\mu g/mL)}{60 \text{ min/hr} \times \text{Patient weight (kg)}} = \text{Dose } (\mu g/kg/min)$$

Example when flow rate is unknown:

Dopamine 400 mg/250 mL D5W to infuse at 5 μg/kg/min.
Patient weighs 100 kg.

a. Convert the concentration to like units of measure

$$\frac{400 \text{ mg}}{250 \text{ mL}} \times \frac{1000 \ \mu g}{1 \text{ mg}} = \frac{400{,}000 \ \mu g}{250 \text{ mL}}$$

b. Calculate concentration of drug in 1 mL of fluid

$$\frac{400{,}000 \ \mu g}{250 \text{ mL}} = \frac{1600 \ \mu g}{1 \text{ mL}}$$

c. Enter known factors into the formula and solve

$$\frac{5 \ \mu g/kg/min \times 60 \text{ min/hr} \times 100 \text{ kg}}{1600 \ \mu g/mL} = 18.75 \text{ mL/hr}$$

Example when dose is unknown: dobutamine 500 mg/250 mL D5W is infusing at 15 mL/hr. Patient weighs 70 kg.

a. Convert the concentration to like units of measure:

$$\frac{500 \text{ mg}}{250 \text{ mL}} \times \frac{1000 \ \mu g}{1 \text{ mg}} = \frac{500{,}000 \ \mu g}{250 \text{ mL}}$$

b. Calculate concentration of drug in 1 mL of fluid

$$\frac{500{,}000 \ \mu g}{250 \text{ mL}} = \frac{2000 \ \mu g}{1 \text{ mL}}$$

c. Enter known factors into the formula and solve

$$\frac{15 \text{ mL/hr} \times 2000 \ \mu g/mL}{60 \text{ min/hr} \times 70 \text{ kg}} = 7.14 \ \mu g/kg/min$$

*The patient's weight in kilograms and the time factor of 60 min/hr must be added to the basic formula.

- Weigh the patient, if the medication is weight based. ➸***Rationale:*** Permits calculation of the correct dose based on patient weight.
- Verify patency or obtain patent, appropriate IV access. ➸***Rationale:*** Ensures delivery of the medication into the IV space. Some continuous infusion medications require central line access to prevent irritation or damage to smaller peripheral veins.

## Procedure for Calculating Doses, Flow Rates, and Administration of Continuous IV Infusions

| Steps | Rationale | Special Considerations |
|---|---|---|
| 1. Verify the physician or the advanced practice nurse prescription. | Prevents errors in medication administration. | The prescription should include the medication, dose, concentration of the solution, type of solution diluted in, and the prescribed parameters for titration of the dose. |
| 2. Wash hands, and don gloves. | Reduces transmission of microorganisms; standard precautions. | |
| 3. Connect and flush the IV solution (with prescribed medication) through the tubing system. | Prepares the infusion system. | |
| 4. Place the IV infusion in the infusion device. | The infusion device controls the consistent and accurate delivery of the flow rate. | Infusion devices are electrical equipment and may malfunction. Monitor the infusion for accuracy in flow rate. |
| 5. Connect the infusion system to the intended IV line or catheter. | Prepares the infusion. | Alcohol is used to cleanse the IV port before connecting the infusion, or the infusion system may be connected into a stopcock port. |
| 6. Convert the concentration of the solution to the same units of measure as the dose. | All units of measure must be the same to perform the mathematical functions. | |
| 7. Calculate the concentration of the medication per mL of fluid. | Necessary for medication calculation. | |
| 8. Enter the concentration and the dose into the formula and solve for the flow rate. | Necessary for medication calculation. | Use alternate formulas if medication dose is per minute or is weight based. |
| 9. Double-check the calculations. | Prevents mathematical errors. | |
| 10. Set the flow rate on the infusion pump, and initiate the infusion. | Initiates therapy. | |
| 11. Discard used supplies, and wash hands. | Reduces transmission of microorganisms; standard precautions. | |

### Expected Outcomes

- Desired patient response is achieved.
- Correct dose of medication is administered.
- Dose is titrated to desired patient response.

### Unexpected Outcomes

- Adverse reactions to the medication occur.
- Incorrect dose of medication is administered.
- Desired patient response is not achieved.
- Infiltration or extravasation of medication occurs.

## Patient Monitoring and Care

| Patient Monitoring and Care | Rationale | Reportable Conditions |
| --- | --- | --- |
| | | *These conditions should be reported if they persist despite nursing interventions.* |
| 1. Evaluate patient response by monitoring the indicated parameters for the medication being infused. | Medications given as continuous infusions often have potent effects and potentially serious adverse effects. Most medications given as continuous infusions have a quick onset of action. Frequent monitoring of parameters is necessary during initiation of the infusion. | • Adverse reactions, hemodynamic instability, and cardiac dysrhythmias |
| 2. If the patient response is inadequate, titrate the infusion as prescribed until the prescribed parameters are met. | Patient response to many continuous infusions is dose dependent. To achieve the desired response, titration of the dose is necessary. | • Desired response not achieved within an acceptable dosage |
| 3. Asssess IV access for placement and patency every 1 to 4 hours and as needed. | Ensures delivery of the medication into the venous system. Prevents interruptions in delivery of the medication. | |

## Documentation

Documentation should include the following:

- Patient and family education
- Name of the medication and the type of solution diluted in, concentration of the solution, dose, flow rate, and administration times
- Assessment of the IV access and site
- Parameters monitored and patient response
- Adverse reactions and interventions to treat the reaction
- Titration

## Additional Readings


Burns C, Crawford M. A method for rapidly calculating intravenous drip rates. *Focus Crit Care.* 1988;15:46–48.

Curren A, Munday L. Critical care IV calculations. In: *Math for Meds: A Programmed Text of Dosages and Solutions.* San Diego, Ca: Wallcur, Inc., 1988.

Guiliano K, Richards N, Kaye W. A new strategy for calculating medication infusion rates. *Crit Care Nurs.* 1993;13:77–82.

Robison J, Coleman R. A pocket guide for critical care drug dosing. *Crit Care Nurs* 1991;11:90–96.