Chapter 15

Intravenous Solutions, Equipment, and Calculations
# IV Components

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<th>Abbreviation</th>
<th>Solution Component</th>
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<tr>
<td>D</td>
<td>Dextrose</td>
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<tr>
<td>W</td>
<td>Water</td>
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<tr>
<td>S</td>
<td>Saline</td>
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<tr>
<td>NS</td>
<td>Normal Saline (0.9% NaCl)</td>
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<tr>
<td>NaCl</td>
<td>Sodium Chloride</td>
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<tr>
<td>RL</td>
<td>Ringer’s Lactate</td>
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<tr>
<td>LR</td>
<td>Lactated Ringer’s</td>
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</table>
Normal Serum Osmolarity

• Hypotonic
  – Less than 250 milliosmole (mOsm) per L
  – Used to dilute excess serum electrolytes
    • E.g., 0.45 percent saline
Normal Serum Osmolarity

• Isotonic
  – 250 to 375 mOsm per L
  – Used to expand volume and maintain normal tonicity
    • E.g., 0.9 percent saline, lactated Ringer’s, 5 percent dextrose in water (D₅W)
Normal Serum Osmolarity

• Hypertonic
  – Greater than 375 mOsm per L
  – Used to correct electrolyte imbalances
    • E.g., 5 percent dextrose and 0.9 percent NaCl, 5 percent dextrose and lactated Ringer’s
IV Sites

• Peripheral
  – Rate of infusion should not exceed 200 mL in one hour

• Central line
  – Accommodates larger concentrations and volumes of fluid
Monitoring IVs

• Nursing responsibility
• Check every 30 minutes to one hour:
  – Fluid volume remaining
  – Infusion rate
Monitoring IVs

• Check every 30 minutes to one hour:
  – Signs for complication
    • Phlebitis
    • Infiltration
    • Infection
Standard Straight Gravity Flow IV
IV with Piggyback (IVPB)
IV Flow Rate

• Ordered by physician
• Measured in:
  – mL per hour
  – gtts per minute
• Nurse’s responsibility to regulate, monitor, and maintain
IV Flow Rate: mL per Hour

- Regulate IV volume by electronic infusion pump or controller calibrated in mL per hour
- Calculate using formula:
  \[
  \frac{\text{Total mL ordered}}{\text{Total h ordered}} = \text{mL/h}
  \]
- Calculate using ratio-proportion:
  \[
  \frac{\text{Total mL}}{\text{Total h}} = \frac{X \text{ mL}}{1 \text{ h}}
  \]
Calculating IV Flow Rate

- mL per hour example:
  - Order: D₅W 250 mL IV during next 2 h by infusion pump
Calculating IV Flow Rate

1. Think
   - Pump set by rate of mL per hour
   - If 250 mL is to be infused in two hours, how much will be infused in one hour?
     • 125 mL will be infused in one hour
     • Set pump at 125 mL per hour
Calculating IV Flow Rate

2. Use formula

\[ \frac{250\ mL}{2\ h} = 125\ mL/h \]

- Set pump at 125 mL per hour
Calculating IV Flow Rate

• Can also solve using ratio-proportion

\[
\begin{align*}
\frac{250 \text{ mL}}{2 \text{ h}} &= \frac{X \text{ mL}}{1 \text{ h}} \\
2X &= 250 \\
2X &= \frac{250}{2} \\
X &= 125 \text{ mL/h}
\end{align*}
\]
Calculating IV Flow Rate

- mL per hour with infusion rate of less than one hour example:
  - Use ratio-proportion

\[
\frac{\text{Total mL ordered}}{\text{Total min ordered}} \times \frac{\text{X mL/h}}{\frac{60 \text{ min/h}}{}} = X = \text{mL/h}
\]
Calculating IV Flow Rate

• mL per hour with infusion rate of less than one hour example:
  – Order: Ampicillin 500 mg IV in 50 mL
  – D$_5\frac{1}{2}$ NS in 30 minutes by controller
Calculating IV Flow Rate

1. Think
   - Controller set by rate of mL per hour
   - If 50 mL is to be infused in 30 minutes:
     • 100 mL will be infused in 60 minutes
     • Set rate of controller at 100 mL per hour to infuse 50 mL in 30 minutes
Calculating IV Flow Rate

2. Use ratio-proportion

\[
\frac{50 \text{ mL}}{30 \text{ min}} = \frac{X \text{ mL/h}}{60 \text{ min/h}}
\]

\[
30 \times X = 3,000
\]

\[
\frac{30 \times X}{30} = \frac{3,000}{30}
\]

\[
X = 100 \text{ mL/h}
\]
IV Flow Rate: Drops per Minute

- Formula for IV flow rate for manually-regulated IVs ordered in mL per hour or for minutes

\[
\frac{V}{T} \times C = R
\]

- Volume to be infused (mL)
- Calibration of tubing (drop factor) gtt/mL
- Time required (min)
- Rate of flow in gtt/min
IV Flow Rate: Drops per Minute

- Carry calculations to one decimal
- Round drops per minute to nearest whole number
- Can watch count only whole drops
Calculating Drops per Minute

• Example:
  – Order: D$_5$W IV at 125 mL per hour
  – Infusion set calibrated for drop factor of 10 drops per mL
  – Calculate IV flow rate in drops per minute
Calculating Drops per Minute

\[
\frac{125 \text{ mL}}{60 \text{ min}} \times 10 \text{ gtt/mL} = \frac{125 \text{ mL}}{60 \text{ min}} \times \frac{10 \text{ gtt}}{1 \text{ mL}} = \frac{125 \text{ gtt}}{6 \text{ min}} = 20.8 \text{ or } 21 \text{ gtt/min}
\]

- Notice that mL cancel out
  - Leaving gtt per minute

- Use watch to count drops and adjust roller clamp to deliver 21 drops per minute
Calculating Drops per Minute: Microdrip Drop Factor

• When IV drop factor is 60 drops per mL (microdrip sets):
  – Flow rate in drops per minute is same as volume ordered in mL per hour
Calculating Drops per Minute: Microdrip Drop Factor

• Example:
  – Order: D₅W NS IV at 50 mL per hour
  – Drop factor: 60 drops per mL
  – Notice order is same as flow rate of 50 drops per minute when drop factor is 60 drops per mL

\[
\frac{50 \text{ mL}}{\text{60 min}} \times 60 \text{ gtt/mL} = 50 \text{ gtt/min}
\]
# Drop Factor Constants

<table>
<thead>
<tr>
<th>Drop Factor</th>
<th>Drop Factor Constant</th>
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<tbody>
<tr>
<td>10 drops per mL</td>
<td>( \frac{60}{10} = 6 )</td>
</tr>
<tr>
<td>15 drops per mL</td>
<td>( \frac{60}{15} = 4 )</td>
</tr>
<tr>
<td>20 drops per mL</td>
<td>( \frac{60}{20} = 3 )</td>
</tr>
<tr>
<td>60 drops per mL</td>
<td>( \frac{60}{60} = 1 )</td>
</tr>
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</table>
Drop Factor Constants

- Administer 125 mL per hour IV with 20 drops per mL infusion set

\[
\frac{125 \text{ mL}}{60 \text{ min}} \times 20 \text{ gtt/mL} = \frac{125 \text{ gtt}}{3 \text{ min}} = \]

41.6 or 42 gtt/min
IV Flow Rate Shortcut Method

- Shortcut to calculate IV flow rate:

\[
\frac{\text{mL/hr}}{\text{Drop factor constant}} = \text{gtt/min}
\]
Adjusting IV Flow Rate

• Nurse may not arbitrarily speed up or slow down flow rate to catch up IV

• Check for institutional policy regarding correcting off-schedule IV rates and percentage of variation allowed
  – Should not exceed 25 percent
Adjusting IV Flow Rate

• If adjustment permitted:
  – Use formula to recalculate mL per hour and gtt per minute for time remaining and percentage of variation
Adjusting IV Flow Rate

1. \( \frac{\text{Remaining volume}}{\text{Remaining hours}} = \) Recalculated mL/h

2. \( \frac{V}{T} \times C = \text{gtt/min} \)

3. \( \frac{\text{Adjusted gtt/min} - \text{Ordered gtt/min}}{\text{Ordered gtt/min}} = \% \text{ Variation} \)
Adjusting IV Flow Rate

• Percent variation will be positive (+) if administration is too slow
  – Rate must be increased

• Percent variation will be negative (-) if administration is too fast
  – Rate must be decreased
Calculating IV Flow Rate Adjustment

• Example:
  – Order: 500 mL LR to run over 10 h at 50 mL per hour
  – Drop factor is 60 drops per mL
  – IV is correctly infusing at 50 drops per minute
  – After $2\frac{1}{2}$ hours, 300 mL remaining
    • Almost half of total volume infused in one-quarter the time
Calculating IV Flow Rate Adjustment

- IV infusion ahead of schedule
- Compute new rate of 300 mL to complete IV fluid order in remaining $7 \frac{1}{2}$ hours
- Patient requires close assessment for fluid overload
Calculating IV Flow Rate Adjustment

1. \[
\frac{\text{Remaining volume}}{\text{Remaining hours}} = \frac{300 \text{ mL}}{7.5 \text{ h}} = 40 \text{ mL/h}
\]

2. \[
\frac{V}{T} \times C = \frac{40 \text{ mL}}{60 \text{ min}} \times 60 \text{ gtt/mL} = 40 \text{ gtt/min}
\]

• Adjusted flow rate is 40 gtt per minute
Calculating IV Flow Rate Adjustment

3. \[ \frac{\text{Adjusted gtt/min} - \text{Ordered gtt/min}}{\text{Ordered gtt/min}} = \% \text{ Variation} \]

\[ \frac{40 - 50}{50} = \frac{-10}{50} = -0.2 = -20\% \]

• Variation of negative percent indicates rate will be decreased
Calculating Intermittent IV Infusion Rates for IVPB

• Example:
  – Order: Cefazolin 0.5 g in 100 mL D$_5$W over 30 min
  – Drop factor is 20 gtt per mL
Calculating Intermittent IV Infusion Rates for IVPB

• Calculate flow rate in gtt per minute

\[ \frac{V}{T} \times C = \frac{100 \text{ mL}}{30 \text{ min}} \times 20 \text{ gtt/mL} = \frac{200 \text{ gtt}}{3 \text{ min}} = \]

66.6 or 67 gtt/min
Calculating Intermittent IV Infusion Rates for IVPB

• Calculate infusion rate for same order if infusion pump used

1. Think
   – If 100 mL will be administered in 30 minutes, then 200 mL will be administered in 60 minutes
Calculating Intermittent IV Infusion Rates for IVPB

2. Calculate using ratio-proportion

\[
\frac{100 \text{ mL}}{30 \text{ min}} \times \frac{X \text{ mL/h}}{60 \text{ min/h}} = \frac{30X}{30} = \frac{6,000}{30} = X = 200 \text{ mL/h}
\]
Calculating Intermittent IV Push Rate

• Caution:
  – IV drugs are potent and rapid-acting
  – Never infuse IV push drugs more rapidly than recommended
  – Some drugs require further dilution after reconstitution
  – Read package inserts and drug resources for administration guidelines
Calculating Intermittent IV Push Rate

• Example:
  – Order: Ativan 3 mg IV Push 20 min preoperatively
  – Available: Ativan 4 mg per mL with drug literature guidelines of “IV infusion not to exceed 2 mg/min”
  – How much Ativan should be prepared?
Calculating Intermittent IV Push Rate

1. **Convert**
   - No conversion necessary

2. **Think**
   - Estimate giving less than 1 mL
Calculating Intermittent IV Push Rate

3. Calculate

\[
\frac{\text{Dosage on hand}}{\text{Amount on hand}} = \frac{\text{Dosage desired}}{\text{X Amount desired}}
\]
Calculating Intermittent IV Push Rate

3. Calculate

\[
\frac{4 \text{ mg}}{1 \text{ mL}} \times \frac{3 \text{ mg}}{X \text{ mL}} = \frac{12}{X}
\]

\[
4 \times X = 3
\]

\[
\frac{4 \times X}{4} = \frac{3}{4}
\]

\[
X = 0.75 \text{ mL}
\]
Calculating Intermittent IV Push Rate

• What is a safe infusion time?
  – Use ratio-proportion

\[
\frac{2 \text{ mg}}{1 \text{ min}} \times \frac{3 \text{ mg}}{X \text{ min}} = \frac{2 \times X}{2} = \frac{3}{2} \Rightarrow X = 1 \frac{1}{2} \text{ min}
\]
Calculating Intermittent IV Push Rate

• How much should be infused every 15 seconds?
  – Convert minutes to seconds
    • One minute equals 60 seconds

\[
\frac{1}{2} \text{min} \times 60 \text{ sec/min} = 90 \text{ sec}
\]
Calculating Intermittent IV Push Rate

- How much should be infused every 15 seconds?
  - Use ratio-proportion

\[
\frac{0.75 \text{ mL}}{90 \text{ sec}} \times \frac{X \text{ mL}}{15 \text{ sec}} = \frac{11.25}{90}
\]

\[
90X = 11.25
\]

\[
\frac{90X}{90} = \frac{11.25}{90}
\]

\[
X = 0.125 \text{ or } 0.13 \text{ mL}
\]
Calculating Intermittent IV Push Rate

- Use 1 mL syringe to draw up 0.75 mL of Ativan 4 mg per mL
- Infuse via IV push at rate of 0.13 mL every 15 seconds for total of $1 \frac{1}{2}$ minutes
Calculating Total IV Infusion Time

• Example:
  – D₅W 1,000 mL to infuse at 60 mL per hour
  – If infusion begins at 0600, what time will infusion be complete?
Calculating Total IV Infusion Time

• Use ratio-proportion

\[
\frac{\text{mL}}{\text{h}} = \frac{\text{Total mL}}{\text{X Total h}}
\]
Calculating Total IV Infusion Time

- Use ratio-proportion

\[
\frac{60 \text{ mL}}{1 \text{ h}} = \frac{1,000 \text{ mL}}{X \text{ h}}
\]

\[
60 \times X = 1,000
\]

\[
\frac{60 \times X}{60} = \frac{1,000}{60}
\]

\[
X = 16.6 \text{ or } 16\frac{2}{3} \text{ h} = 16 \text{ h} 40 \text{ min}
\]
Calculating Total IV Infusion Time

• IV will be complete at:

\[
\text{Time started} \quad \text{Time of completion}
\]

\[
0600 + 1640 = 2240 \text{ (or 10:40 PM)}
\]

Time infusion will run
Calculating IV Fluid Volume

- To calculate IV volume:
  - Flow rate (drops per minute), drop factor, and time are known
  - V is unknown

\[
\frac{V}{T} \times C = R
\]
Calculating IV Fluid Volume

• Example:
  – At 7 AM, IV of D$_5$W is infusing at 25 gtt per minute
  – Drop factor is 15 gtt per mL
  – How much should the patient receive in eight hours?
Calculating IV Fluid Volume

- Convert hours to minutes

\[ 8 \text{ h} \times 60 \text{ min/h} = 460 \text{ min} \]
Calculating IV Fluid Volume

• Apply formula

\[
\frac{V \text{ mL}}{480 \text{ min}} \times \frac{15 \text{ gtt}}{1 \text{ mL}} = \frac{25 \text{ gtt}}{1 \text{ min}}
\]

\[
\frac{15 V \text{ gtt}}{480 \text{ min}} = \frac{25 \text{ gtt}}{1 \text{ min}}
\]

\[
\frac{15 V}{480} = 25
\]

\[
\frac{480}{1}
\]
Calculating IV Fluid Volume

• Apply formula

\[
15 \frac{V}{15} = 12,000
\]

\[
\frac{V}{15} = \frac{12,000}{15}
\]

\[
V = 800 \text{ mL to be infused in 8 h}
\]
Calculate IV Fluid Volume

• To calculate IV volume:
  – Flow rate (mL/h) and time (h) are known
  – Calculate using formula:
    \[ \text{Total hours} \times \text{mL/h} = \text{Total volume} \]
  – Calculate using ratio-proportion:
    \[ \frac{\text{mL}}{\text{h}} = \frac{X \text{ Total mL}}{\text{Total h}} \]
Calculate IV Fluid Volume

• Example:
  – IV infusing per infusion pump at 100 mL per hour
  – How much will infuse during the next eight hours?
Calculate IV Fluid Volume

• Apply formula

\[ 8 \text{ h} \times 100 \text{ mL/h} = 800 \text{ mL} \]

• Use ratio-proportion

\[ \frac{100 \text{ mL}}{1 \text{ h}} \times \frac{X \text{ mL}}{8 \text{ h}} = X = 800 \text{ mL} \]