Disclosure

Debbi Child is an employee of Smiths Medical
Learning objectives:

- Recognize the impact of syringe size and selection related to flow dynamics, flow continuity and infusion rates.
- Describe the appropriate use of accessory devices and syringe infusion pumps.
- Evaluate the importance of priming the pump and tubing when starting an infusion or changing a syringe.
- Discuss how syringe pump height and location can adversely impact continuous infusions.
- Consider tubing occlusions and the role they play in flow continuity.
- Identify resources for clinician education on syringe infusion pump best practices.
Scenario

Full term 2.5 kg NICU patient with meconium aspiration. Transferring to PICU for ECMO. Patient receiving multiple medications including vasopressors and sedation infusions.

What should be evaluated when setting up and programming the syringe infusion pumps for this patient?

a. Sizes of syringes used for medications
b. Tubing and accessories
c. Pump placement relative to the patient
d. All of the above
FDA safety communication

- Issued August 25, 2016

- Audience:
  - Health care professionals who use or who train users on programmable syringe pumps
  - Health care professionals responsible for maintaining programmable syringe pumps
  - Health care professionals who are responsible for how drugs are mixed for use in programmable syringe pumps
FDA Definition: Syringe infusion pumps

- Used to deliver medications, fluids, enteral feedings, and blood products
- Infusions can be continuous, intermittent and bolus type
- Infusion rates vary depending upon need (e.g. 0.01 mL/hr – 1130 mL/hr)
- Frequent adjustment for intensive care patients
FDA Purpose: Focused on flow

- Safety Communication focuses on slow flowing continuous type infusions
  - Infusion rates < 5 mL/hr = low flow
  - Special focus on flow rates < 0.5 mL/hr
- Lack of flow continuity
  - Delay of therapy
  - Over/under infusion
  - Unintended bolus
- All syringe pumps could be affected
- Benefits of pump use outweigh risk
FDA Recommendations

1. Syringe Size and Selection
2. Use of Accessory Devices
3. Starting an Infusion or Changing a Syringe
4. Height and Location of the Syringe Pump system
5. Occlusion Considerations
Syringe Size and Selection

- Verify syringe model/size is pump compatible
- Syringe size can impact flow dynamics by increasing system compliance
  - Larger syringes at low flow rates can affect pump performance
  - Increased friction and plunger tip compliance
- Select smallest appropriate syringe size
Syringe compliance comparison

**COMPLIANCE EXAMPLE - 60mL SYRINGES**

Generally have a much higher level of compliance than other syringe sizes.

60mL syringes may be 4 to 7 times as compliant.

Particularly susceptible to the limitations of high compliance.

- Longer start-up delays
- Increased time to trigger an occlusion alarm
- Larger post-occlusion boluses

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Medfusion® Data Review: DOPamine

DOPamine # Records by Weight Range

<table>
<thead>
<tr>
<th>Weight Range</th>
<th>Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5 kg</td>
<td>6,923</td>
</tr>
<tr>
<td>5.1 - 10 kg</td>
<td>1,212</td>
</tr>
<tr>
<td>10.1 - 20 kg</td>
<td>856</td>
</tr>
<tr>
<td>20.1 - 30 kg</td>
<td>238</td>
</tr>
<tr>
<td>30.1 - 40 kg</td>
<td>169</td>
</tr>
<tr>
<td>&gt; 40.1 kg</td>
<td>503</td>
</tr>
<tr>
<td>Grand Total</td>
<td>9,901</td>
</tr>
</tbody>
</table>

DOPamine Concentrations

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Records</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600 mcg/mL</td>
<td>4,433</td>
<td>45%</td>
</tr>
<tr>
<td>3200 mcg/mL</td>
<td>2,212</td>
<td>22%</td>
</tr>
<tr>
<td>800 mcg/mL</td>
<td>2,035</td>
<td>21%</td>
</tr>
<tr>
<td>Other</td>
<td>1,221</td>
<td>12%</td>
</tr>
</tbody>
</table>

DOPamine Concentrations, 0-5 kg

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Records</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600 mcg/mL</td>
<td>3,458</td>
<td>50%</td>
</tr>
<tr>
<td>800 mcg/mL</td>
<td>1,515</td>
<td>22%</td>
</tr>
<tr>
<td>3200 mcg/mL</td>
<td>1,335</td>
<td>19%</td>
</tr>
<tr>
<td>Other</td>
<td>615</td>
<td>9%</td>
</tr>
</tbody>
</table>

Other: 400 mcg/mL, 600 mcg/mL, 1000 mcg/mL, 4000 mcg/mL, 6000 mcg/mL, 6400 mcg/mL, 10 mg/mL, 40 mg/mL
DOPamine 1600 mcg/mL, Weight 0-5 kg

DOPamine 1.6 mg/mL, 0-5 kg, Rate < 0.51 mL/hr

<table>
<thead>
<tr>
<th>Syringe Size</th>
<th># Records</th>
<th># Titrations</th>
<th>Min. Titrations</th>
<th>Max. Titrations</th>
<th>Median Titrations</th>
<th>Mean Titrations</th>
<th>Std. dev. Titrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 mL</td>
<td>710</td>
<td>6,216</td>
<td>1</td>
<td>104</td>
<td>8.8</td>
<td>9.4</td>
<td>±12.3</td>
</tr>
<tr>
<td>20 mL</td>
<td>281</td>
<td>2,630</td>
<td>1</td>
<td>94</td>
<td>5</td>
<td>9.4</td>
<td>±11.9</td>
</tr>
</tbody>
</table>
DOPamine 3200 mcg/mL, Weight 0-5 kg

### Rate Range

<table>
<thead>
<tr>
<th>Rate Range</th>
<th>Records</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.05 mL/hr</td>
<td>25</td>
<td>1.87%</td>
</tr>
<tr>
<td>0.05 - 0.5 mL/hr</td>
<td>896</td>
<td>67.12%</td>
</tr>
<tr>
<td>0.51 - 1 mL/hr</td>
<td>340</td>
<td>25.47%</td>
</tr>
<tr>
<td>1.01 - 5 mL/hr</td>
<td>74</td>
<td>5.54%</td>
</tr>
</tbody>
</table>

**Sum:** 1,335

### Syringe Sizes for Rates < 0.51 mL/hr

<table>
<thead>
<tr>
<th>Syringe Size</th>
<th>Records</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 mL</td>
<td>253</td>
<td>27.47%</td>
</tr>
<tr>
<td>50/35 mL</td>
<td>111</td>
<td>12.05%</td>
</tr>
<tr>
<td>20 mL</td>
<td>259</td>
<td>28.12%</td>
</tr>
<tr>
<td>10/12 mL</td>
<td>158</td>
<td>17.16%</td>
</tr>
<tr>
<td>5/6 mL</td>
<td>113</td>
<td>12.27%</td>
</tr>
<tr>
<td>3 mL</td>
<td>27</td>
<td>2.99%</td>
</tr>
</tbody>
</table>

DOPamine 3.2 mg/mL, 0-5 kg, Rate < 0.51 mL/hr

<table>
<thead>
<tr>
<th>Syringe Size</th>
<th># Records</th>
<th># Titrations</th>
<th>Min. Titrations</th>
<th>Max. Titrations</th>
<th>Median Titrations</th>
<th>Mean Titrations</th>
<th>Std. dev. Titrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 mL</td>
<td>253</td>
<td>4,069</td>
<td>1</td>
<td>240</td>
<td>7</td>
<td>16.1</td>
<td>±25.6</td>
</tr>
<tr>
<td>20 mL</td>
<td>259</td>
<td>2,567</td>
<td>1</td>
<td>315</td>
<td>5</td>
<td>9.9</td>
<td>±21.3</td>
</tr>
</tbody>
</table>
Use of Accessory Devices

- Syringes, tubing, stopcocks, manifolds, filters, etc.
- Target smallest internal volume or dead space
  - Low infusion rates = small or micro bore tubing
  - Avoid high pressure port valves
  - Limit y-sites and attachments
- Connect nearest to patient as possible
- Collaborate with other clinicians for best practices
Starting an Infusion or Changing a Syringe

- Verify syringe size and model during pump programming
- Manual prime versus priming on the pump
- Pump priming feature
  - Engages pumping mechanism to remove mechanical slack
  - Reduces syringe friction and stiffness
Mechanical slack

- Motor engagement with syringe driver
- Plunger overcoming force
- Overcoming the gap

MINIMIZING SLACK

Be mindful for the presence of a gap

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Priming the pump

Graphics used with permission from https://lms.phscpd.org/Frameset/Frameset.aspx?View=2&AttemptId=35259&ProductID=25271&attemptStatus=1
Using Data to review practices

<table>
<thead>
<tr>
<th>Drug Program</th>
<th>Conc Units</th>
<th>Profile</th>
<th>Category</th>
<th>Infusion Type</th>
<th>Weight/BSA</th>
<th>Dose</th>
<th>Rate (mL/hr)</th>
<th>Primed Amount (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propofol 10 mg/ml (BD 60ml)</td>
<td>10</td>
<td>mg/mL</td>
<td>Anesthesia</td>
<td>Quick Library</td>
<td>75 kg</td>
<td>75</td>
<td>33.8</td>
<td>0.088</td>
</tr>
</tbody>
</table>
Scenario

PICU has safely received the patient. Upon shift change, the new nurse adjusts the pump set up such that the medications will be in alphabetical order from top to bottom on the IV pole, making it is easier for her to chart.

Is this an appropriate way to determine pump placement?
Syringe Height and Location

- Best practice: pump level with distal end of catheter
- Vertical displacement
- Bed height adjustment
- Minimize changes to placement
Vertical displacement activity

Patient

Pump Raised
Temporary increase in delivery (bolus)

Pump level with patient
Ideal for flow continuity

Pump lowered
Temporary decrease or stop in delivery (aspiration)
Occlusions and flow continuity

Goal is to decrease time to occlusion alarm
- Occlusion limit settings
- Syringe size selection
- Priming
- Decrease accessory device use
Occlusion pressure setting

Programmed Pressure Limit
- 250 mmHg (~5psi)
- 500 mmHg (~10psi)
- 775 mmHg (~15psi)

Time to Occlusion Alarm - Pump Infusing at ~1mL/h

Graph is intended to be an example of the typical patterns observed, based on mathematical modeling of known properties of syringes. It is not representative of a particular pump or all devices.

Use the smallest syringe size that is practical for your specific clinical purpose

Optimize the pressure limit setting on the pump

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Resolving occlusions

- Stop/prevent flow to patient
  - Evaluate options and risk
- Reduce post occlusion bolus
  - Consider syringe size relative to bolus
  - Automatic bolus reduction
Using Data to Review Practices

### Alarm Count Table

<table>
<thead>
<tr>
<th>Alarm Type</th>
<th>Alarm Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>syringe volume near empty</td>
<td>650</td>
</tr>
<tr>
<td>infusion complete</td>
<td>606</td>
</tr>
<tr>
<td>syringe near empty</td>
<td>265</td>
</tr>
<tr>
<td>syringe empty</td>
<td>196</td>
</tr>
<tr>
<td>occlusion - check infusion line</td>
<td>79</td>
</tr>
<tr>
<td>pressure increasing - check infusion line</td>
<td>51</td>
</tr>
<tr>
<td>invalid syringe size</td>
<td>33</td>
</tr>
<tr>
<td>outside range limit - silence alarm to continue</td>
<td>9</td>
</tr>
<tr>
<td>restricted flow - rate reduced</td>
<td>5</td>
</tr>
<tr>
<td>calculated rate out of range</td>
<td>1</td>
</tr>
<tr>
<td>invalid infusion parameter combination</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,886</strong></td>
</tr>
</tbody>
</table>

### Drug Administration Details

<table>
<thead>
<tr>
<th>Profile</th>
<th>Category</th>
<th>Drug Program</th>
<th>Conc Units</th>
<th>Infusion Type</th>
<th>Last Delivery Rate (mL/hr)</th>
<th>Syringe Model</th>
<th>Syringe Size</th>
<th>Date &amp; Time Silenced</th>
<th>Time Interval Alarm Active (HH:MM:SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia</td>
<td>Anesthesia A-Z</td>
<td>propofol 10 mg/mL</td>
<td>10 mg/mL</td>
<td>dose/kg/min</td>
<td>22.5</td>
<td>B-D</td>
<td>60 mL</td>
<td>10:37:16</td>
<td>00:00:38</td>
</tr>
<tr>
<td>General Peds/Surgery A-B</td>
<td>Gen Peds/Surg C</td>
<td>acyclovir 5 mg/mL</td>
<td>5 mg/mL</td>
<td>dose/kg/time</td>
<td>13</td>
<td>B-D</td>
<td>20 mL</td>
<td>16:03:08</td>
<td>00:00:20</td>
</tr>
<tr>
<td>General Peds/Surgery C</td>
<td>Gen Peds/Surg C</td>
<td>ceFAZolin 100 mg/mL</td>
<td>100 mg/mL</td>
<td>dose/kg/time</td>
<td>7</td>
<td>B-D</td>
<td>5 mL</td>
<td>18:15:22</td>
<td>00:04:19</td>
</tr>
</tbody>
</table>
Education and resources

- FDA website lists several resources and articles
- FDA’s Infusion Pump Reduction Strategies for Clinicians
  - [https://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/GeneralHospitalDevicesandSupplies/InfusionPumps/ucm202498.htm](https://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/GeneralHospitalDevicesandSupplies/InfusionPumps/ucm202498.htm)
- Partners Healthcare Education Modules: syringeinfusionsafety.org

- Syringe pump manual and education
- Publications
- Colleagues
Summary

- Understand syringe infusion pumps
- Know best practices for infusion safety and flow continuity
- Collaborate with internal team to develop policies and procedures
- Utilize vendor knowledge to form best practices
Additional References


