Smart-pumps in the neonatal and pediatric intensive care unit: drug incompatibilities and occlusion alarms

C. Fonzo-Christe PhD1, A. Kiener MSc1, N. Bochaton Nurse2, P. Regard Engineer3, P. Rimensberger MD2, P. Bonnabry PhD1
1Pharmacy, 2Neonatal (NICU) and pediatric (PICU) intensive care unit, 3Biomedical service, Geneva University Hospitals (HUG), Switzerland

Introduction
IV drugs are often infused simultaneously in ICU and drug incompatibilities are frequent1. Incompatibilities may lead to precipitates occluding catheters. Occlusion alarms should alert nurses of an overpressure in the catheter to prevent clinical consequences such as bolus release, over-infusion or extravasations.

Methods

**Objectives**

**Test A:** to evaluate experimentally the occurrence of occlusion alarms when incompatible drugs are infused simultaneously.

**Test B:** to determine the incidence of occlusion alarms in NICU and PICU

**Materials**
- Smart pumps (Module DPS/MVP, Orchestra workstation base intensive Fresenius Kabi)
- Syringes 20 and 50 ml BD Plastipak®, Connectub PE BBraun
- Stopcock BD Multiflo® + BD Connecta®
- In-line filters 0.2 µm Posidyne® Neo PALL / IV Star 10-set CODAN (test A only)
- Central venous catheter (CVC) (Deltec 27G, 20cm)
- Syringes 20 and 50 ml BD Plastipak®, Connectub PE BBraun
- Smart pumps (Module DPS/MVP, Orchestra workstation base intensive Frse nius Kabi ),
- C. Fonzo-Christe PhD1, A. Kiener MSc1, N. Bochaton Nurse2, P. Regard Engineer3, P. Rimensberger MD2, P. Bonnabry PhD1
- Central venous catheter (CVC) (Deltec 27G, 20mm))
- Volumetric pumps (Volumed µPV7000, Arcomed) (test B only)

**Results**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Preparation</th>
<th>BW 5 kg conc. [mg/ml]</th>
<th>BW 10 kg conc. [mg/ml]</th>
<th>BW 20 kg conc. [mg/ml]</th>
<th>Infusion rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furosemide (F)</td>
<td>5 mg x BW ad</td>
<td>0.5 mg/ml</td>
<td>1 mg/ml</td>
<td>2 mg/ml</td>
<td>0.5 mg/ml</td>
</tr>
<tr>
<td>Midazolam (M)</td>
<td>4 mg x BW ad</td>
<td>1 mg/ml</td>
<td>2 mg/ml</td>
<td>4 mg/ml</td>
<td>1 mg/ml</td>
</tr>
</tbody>
</table>

**Test A:** Experimental infusion of incompatible drugs

Y-site infusion during 24h of furosemide (F) and midazolam (M) at incompatible concentrations prepared and administered as followed:

- **Drug Preparation**
  - Furosemide (F) 5 mg x BW ad 50 ml NaCl 0.9% 0.5 1 2 0.05 0.85
  - Midazolam (M) 4 mg x BW ad 20 ml NaCl 0.9% 1 2 4 0.03 0.3

**Test B:** Incidence and analyze of occlusion alarms in NICU and PICU (Pilot study)

- Infusion alarms recorded: occlusion, infusion completed, door open, air detection
- 5 patients on two smart pumps and volumetric pumps
- Details of occlusion alarms: ICU nurses had to describe occlusion alarms on a standardized form at the time of occurrence

**Test A:**
- In vitro 1:1 mixing of furosemide and midazolam visually incompatible at concentrations used for patients ≥5 kg (fig.1)
- Rapid formation of a precipitate in the stopcock observed in all conditions (fig.2)
- No occlusion alarm during the 24h Y-site infusion of F and M at 0.5 and 1 mg/ml respectively (patient 5 kg) (tab.1)
- Occlusion alarm only at maximal infusion rates (after 15 min without and 1h15 with filter) at higher concentrations (tab.1)

**Test B:**
- Of 13/35 detailed occlusion alarms:
  - Main reasons for occlusion:
    - stopcock off (2/13)
    - infusion rate greater than central venous catheter tolerance (4/13)
  - Occlusion alarms possibly consecutive to drug incompatibilities in 3 cases (TPN + rifampin or flucloxacilline or midazolam)
  - No alarm with other incompatible drugs (Y-site infusion of furosemide + midazolam)
  - No clinical consequences observed

**Conclusion**
Pressure offset at 300 mm Hg is not an efficient way to avoid risks consecutive to incompatibilities when very low infusion rates are used. To prevent any clinical consequences, it is either necessary to change the pressure management (lower alarm levels) or to use systematically in-line filters to prevent administration of drug precipitates to pediatric patients. An incidence of 13.8 infusion alarms (4.1 occlusions) per patient per day was estimated in this pilot study.

References:

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