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

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Introduction

IV drugs are often infused simultaneously in ICU and drug incompatibilities are frequent[1]. Incompatibilities may lead to precipitates occluding catheters. Occlusion alarms should alert nurses of an overpressure in the catheter to prevent clinical consequences as bolus release, over-infusion or extravasations.

Methods

MATERIAL
- Smart pumps (Module DPS/MVP, Orchestra® workstation base intensive Fresenius Kabi), pressure offset: 300 mm Hg
- 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))
- Volumetric pumps (Volumed μVP7000, Arcomed) (test B only)

Base intensive Orchestra®

Module DPS

Volumed μVP7000

Material used in Test A

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

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	BW 5 kg conc. [mg/ml]	BW 10 kg conc. [mg/ml]	BW 20 kg conc. [mg/ml]	Infusion rate [mg/kg/h] min	max
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

→ Four infusion rates tested with or without filters: Fmin and Mmin, Fmax and Mmax, Fmin and Mmax, Fmax and Mmin.

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
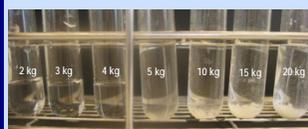
Results

Fig.1 1:1 Mixing of furosemide and midazolam

Fig.2 Drugs precipitate in the stopcock

In-line filter	Infusion rate	5 kg F 0.5 mg/ml M 1 mg/ml	10 kg F 1 mg/ml M 2 mg/ml	20 kg F 2 mg/ml M 4 mg/ml
Drugs precipitate in the stopcock		Present, less visible	Present, visible	Present, highly visible
PALL	max-max	no occlusion	1h18 (M)	1h15 (F)
	max-max	no occlusion	no occlusion	no occlusion
	min-max	no occlusion	no occlusion	no occlusion
	min-min	no occlusion	no occlusion	no occlusion
CODAN	max-max	no occlusion	no occlusion	1h35 (F)
	max-max	no occlusion	no occlusion	no occlusion
	min-max	no occlusion	no occlusion	no occlusion
	min-min	no occlusion	no occlusion	no occlusion
No filter	max-max	no occlusion	14' (M), 15' (F)	13' (M)
	max-max	no occlusion	no occlusion	no occlusion
	min-max	no occlusion	12h11 (F)	no occlusion
	min-min	no occlusion	no occlusion	no occlusion

Tab.1 Occlusion alarms during Y-site administration of furosemide (F) and midazolam (M)

Test A :
→ In vitro 1:1 mixing of furosemide and midazolam visually incompatible at concentrations used for patients ≥ 5kg (*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*)

- 119 infusion alarms recorded over 206.5 h *(tab.2)*
- Estimated incidence: 13.8 infusion alarms per patient per day
  4.1 occlusion alarms per patient per day

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	TOTAL
Age	Premature	Neonate	9 years	Premature	1 year	
BW [kg]	0.48	2.6	30	2	4.5	
Pathology	Very low birth weight	Infection	Cardiac surgery	Malformation	Cardiac surgery	
Hours recorded [h]	44	42.5	24	48	48	206.5
Number of alarms	8	33	22	18	38	119
Occlusions	0	21	3	2	9	35 (29.4%)
Infusion completed	1	8	13	7	4	33 (27.7%)
Door open	5	4	6	5	24	44 (37.0%)
Air detection	2	0	0	4	1	7 (5.9%)

Tab.2 Details of infusion alarms

Infusion alarms recorded (n = 119)
5.9%
29.4%
37%
27.7%
■ Occlusions
■ Infusion completed
■ Door open
■ Air detection

Fig.3 Type of infusion alarms

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)[2]
→ Occlusion alarms possibly consecutive to drug incompatibilities in 3 cases (TPN + rifampin or flucloxacilline or midazolam)
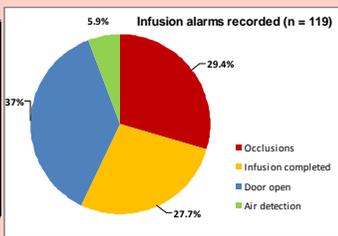→ No alarm with other incompatible drugs (Y-site infusion of furosemide + milrinone)
→ No clinical consequences observed

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: 1. Gikic M et al. Pharm World Sci 2000;22:88-91 / 2. Kiener A et al. http://pharmacie.hug-ge.ch/rd/posters/gsasa08_ak.pdf