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"Remote" Intravenous Smart Pump Use During COVID-19: Accuracy and Safety Concerns

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Background

- IV smart pumps (IVSP) are one of the most used devices in acute care
- IVSPs were moved outside of patient rooms during the COVID-19 pandemic to decrease use of personal protective equipment, decrease risk to clinician safety & improve workflow
- Despite emergency use authorization for this practice flow rate has not been evaluated until now
- Accurate flow means the rate programmed and displayed by the pump matches what is flowing to the patient resulting in errors that are difficult to detect at the bedside

IV Smart Pump Types

Linear Peristaltic Pumps:
Approximately 85% of large volume IVSP used in US acute (BD/Alaris; Baxter/Sigma; B.Braun). Flow accuracy is significantly impacted by variations in system setup and resistance.

Cassette-Based Pumps:
The remaining 15% of large volume IVSP in US acute care (ICU Medical Plum; recently approved Ivenix). The system setup has a much lower impact on flow rate accuracy.

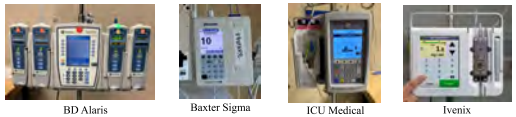


Figure 1: Four IVSP studied and currently in use in US acute care.

Dead Volume

Dead volume is the fluid volume in the IV tubing between point of connection and the patient, longer tubing will have more dead volume.

What affects dead volume?

- The rate of all medications or fluids running through a single lumen
- Medication concentration
- Length of tubing between point of connection and vascular access
- The volume capacity of the venous access device (ie a 50cm PICC has greater capacity than a peripheral IV)

What are the clinical implications?

- Variations in medication onset of action
- Upstream flush through dead volume can cause inadvertent bolus of medication with potentially dangerous effects

Outlet Pressure

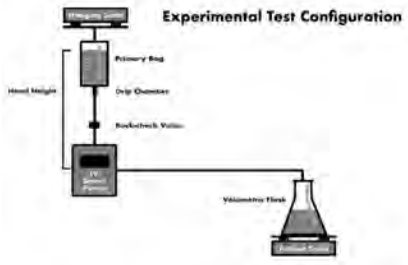
- Outlet pressure refers to the pressure/resistance that the IVSP encounters caused by friction between the fluid and the tubing and connectors
- As outlet pressure increases, flow rate can be reduced, even though the programmed flow rate is displayed leading to an undetectable medication administration error
- The use of extension tubing can have an impact on outlet pressure

Laboratory Study of Outlet Pressure

The purpose of this research study was to measure the flow rate accuracy of four intravenous smart pumps (IVSP) when set up using extension tubing to move IVSP outside of patient rooms.

Methods

- Laboratory study – no risk to patient safety
- Hanging volumetric scales used to measure dispensed volumes from primary bags
- Volumetric scale to measure dispensed volume
- Dispensed volumes were recorded and used to calculate actual flow rates and **percent flow rate deviation** compared to the programmed rate



		Length (ft)	Priming Volume (mL)	Volume/ft (mL)
1	Control			
2	REF#12394	15.83	21.5	1.36
3	REF#12394x2	31.67	43.0	1.36
4	B4121	25.00	9.0	0.36
5	B2048	20.00	4.0	0.20
6	B4055	15.17	5.6	0.37
7	B4055x2	30.33	11.2	0.37

Table 1: Variables of interest; x2 indicates two lengths connected together.

Results

- The cassette-based IVSP models (Ivenix and ICU Medical) experienced the least flow rate deviation from the programmed rate across all extension tubings tested
- Missing data was due to persistent downstream occlusion alarms at the highest rate of 999mL/hr and therefore did not yield a flow rate accuracy with the current model of analysis

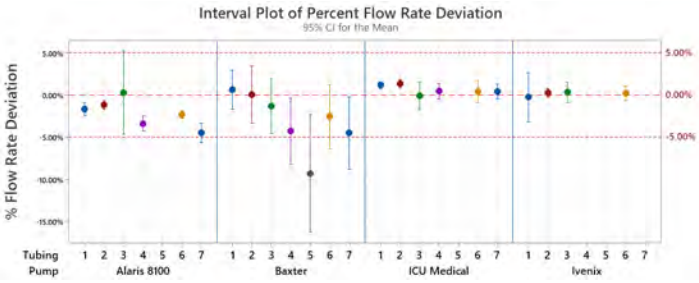


Figure 2: Mean flow rates measured with error bars based on 95% confidence intervals. Variable numbers on X axis align with Table 1 variables.

Tubing	Alaris	Ivenix	Baxter	ICU Medical
Control	-1.74%	-0.30%	0.59%	1.13%
REF#12394	-1.19%	0.23%	0.03%	1.32%
REF#12394x2	0.25%	0.31%	-1.37%	-0.14%
B4121	-3.44%		-4.33%	0.42%
B2048			-9.30%	
B4055	-2.37%	0.15%	-2.60%	0.35%
B4055x2	-4.53%		-4.53%	0.39%

Table 2: Mean flow rate deviation for each IVSP across all flow rates. Missing data due to downstream occlusion pressure alarms.

Conclusion

- Linear peristaltic IVSP models present significant opportunity for flow deviation when extension tubing is added
- Tubing with especially small priming volumes and long lengths (B4121 and B2048) resulted in occlusion alarms that prevented flow in some IVSP models and prevented use of that tubing for medication delivery
- It is important to recognize that this study looks at an isolated alteration of outlet pressure related to the use of extension tubing, any other setup conditions which are known to impact flow can have compounding effects

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