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SYRINGE PUMP PERFORMANCE TIPS

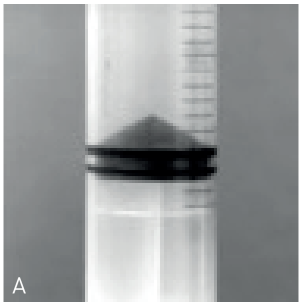
Medfusion® 3500 Syringe Infusion Pump (version 6) with PharmGuard® Medication Safety Software

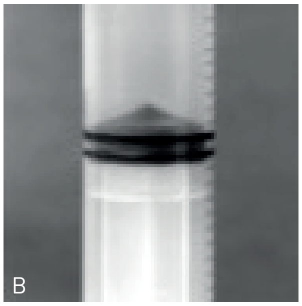
Multiple factors impact syringe pump performance and the following information is beneficial for safe and effective syringe pump operation. Review the technical content below and refer to the clinical reference articles for supplemental reading.

SYRINGE PROPERTIES

Syringe challenges

- Syringes are primarily designed for manual use
- Plunger sticking is a factor to consider with syringe selection
- This "sticktion" is a result of friction in the syringe barrel and plunger seal elasticity and compression, known as compliance
- Friction varies among syringe manufacturers[1]
- Seal compression contributes to "sticktion" and mechanical slack: observe syringe A (relaxed) versus B (compressed)
- This compliance variation impacts delivery startup and continuity of flow
- Low flow rates in larger syringe sizes intensifies the problem
- In this situation, there may be clinical implications for medication therapies critically dependent on timing of delivery
- Clinically significant hemodynamic fluctuations may occur with short-acting vasoactive drugs





Enhancing syringe performance

- Select syringe brands based on best performance[1]
- Use the smallest syringe for the volume of solution being delivered
- Be aware of the lowest recommended rate for the syringe size for the Medfusion® 3500 v6 pump based on the following charts (from Medfusion® Syringe Infusion Pump, Model 3500 version 6, Operator's Manual)

Model (Manufacturer)	Size (mL)	Min.Rate (mL/hr)	Max.Rate (mL/hr)	Minimum Volume to Infuse (mL)	Minimum Recommended Rate (mL/hr)	
					FlowSentry™ Monitor Disabled	FlowSentry™ Monitor Enabled
B-D® (Becton-Dickinson)						
Tuberculin (Slip Tip)	1	0.01	29	0.0016	0.033	N/A*
Luer Lok	1	0.01	29	0.0016	0.033	N/A*
	3	0.01	98	0.005	0.1	0.03
	5	0.03	191	0.0083	0.17	0.05
	10	0.05	277	0.0166	0.33	0.1
	20	0.1	483	0.0333	0.67	0.2
	30	0.1	622	0.05	1	0.3
	60	0.1	944	0.1	2	0.6
Monoject® (Covidien)						
Tuberculin (Slip Tip)	1	0.01	29	0.0016	0.033	N/A*
Luer Lok	3	0.01	105	0.005	0.1	0.03
	6	0.03	213	0.01	0.2	0.06
	12	0.05	325	0.02	0.4	0.12
	20	0.1	536	0.0333	0.67	0.2
	35	0.1	735	0.0583	1.2	0.35
	60	0.1	944	0.1	2	0.6
Terumo® (Terumo Medical)						
Tuberculin (Slip Tip)	1	0.01	29	0.0016	0.033	N/A*
Luer Lok	3	0.01	106	0.005	0.1	N/A*
	5	0.03	225	0.0083	0.17	N/A*
	10	0.05	333	0.0166	0.33	N/A*
	20	0.1	541	0.0333	0.67	N/A*
	30	0.1	712	0.05	1	N/A*
	60	0.11	1130	0.1	2	N/A*
BB Perfusor® (B.Braun)						
Luer Lok	20	0.1	481	0.0333	0.67	0.2
	50	0.1	1042	0.0833	1.7	0.5
BB Omnifix™ (B.Braun)						
Luer Lok	5	0.03	207	0.0083	0.17	0.05
	10	0.05	338	0.0166	0.33	0.1
	20	0.1	537	0.0333	0.67	0.2
	50	0.1	1042	0.0833	1.7	0.5

MECHANICAL SLACK

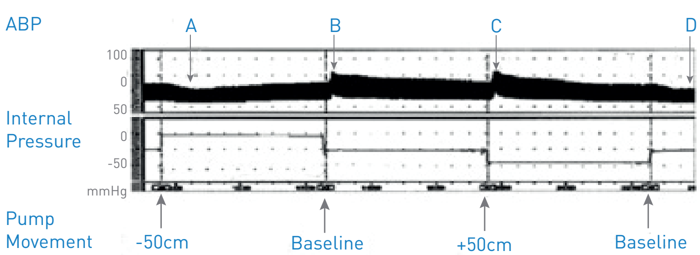
Mechanical slack

- Mechanical slack is a phenomenon related to the time necessary for a syringe pump to pressurize an infusion system from the syringe plunger through all connectors, filters, stopcocks, IV tubing, and IV catheter
- The following mechanical slack variables can delay or compromise the initial start of an infusion
  - Syringe plunger is not tightly engaged in the pump driver
  - Friction in the syringe between the barrel and the plunger may result in a jerky start until initial resistance is overcome
  - Plunger seal or tip compression contributes to this resistance
  - Slack exists in the infusion system due to compliance of disposables (e.g. IV tubing, plunger rubber compression, etc.) and dead space volume
- Eliminating Mechanical Slack
  - Prime the syringe pump to pressurize the infusion system from the syringe plunger all the way through the infusion system including IV tubing, connectors, filters, stopcocks, etc.

VERTICAL DISPLACEMENT

Vertical displacement issues

- Gravity related phenomenon where syringe pump elevation relative to patient height impacts IV infusion delivery
- During a syringe pump infusion, raising the pump above its original height, even briefly, can cause bolusing due to increase in hydrostatic pressure
- During a syringe pump infusion, lowering below the patient, even briefly, can cause interruptions in flow due to decreases in hydrostatic pressure
- The greater the change in syringe pump height relative to the patient increases the hydrostatic pressure effect both above and below the patient
- Hydrostatic pressure generates approximately 25 mm Hg per linear foot of elevation
- Larger syringe sizes have more pronounced effect with more compliance in the plunger rubber tip to expand and contract
- Slower infusion rates, typically less than 1 mL/hr, also accentuate the effect
- For the figure below, note the arterial blood pressure (ABP) and infusion system internal pressure (IP) changes in mm Hg with 50 cm syringe pump movement up and down from the baseline. In this animal study, norepinephrine was infused continuously at a rate of 3 mcg/kg/min. For examples A and D, observe the ABP decreased and IP increased following a relative 50 cm downward pump displacement. For examples B and C, observe the ABP increased and the IP decreased following a relative 50 cm upward pump displacement [2]



Avoiding Vertical Displacement

- Avoid vertical displacement once the infusion system is connected to the patient, whenever possible
- Be aware that patient activity can also influence hydrostatic pressure

OTHER FACTORS INFLUENCING THE INFUSION SYSTEM

Other factors that influence infusion systems are related to IV tubing and in line devices, which add to additional dead space volume

- Tubing inner diameter significantly influences dead space volume and impacts flow rate
- Filters, stopcocks, injection ports, "Y" sites, etc. all add additional dead space volume and resistance to the infusion system
- Resistance in the infusion system is proportional to the length of the infusion system, fluid viscosity, and inversely related to the tubing inner diameter
- Dynamic pressure is the actual pump pressure necessary to overcome the resistance of the infusion system, venous pressure, and fluid viscosity to achieve the desired flow rate

Overcoming Other Factors

- Use the shortest length of micro-bore tubing whenever possible; since it requires less volume and provides quicker delivery times
- Use the least amount of in line devices to minimize dead space volume
- As previously mentioned, prime the syringe and infusion system to prime dead space volume and remove any mechanical slack
- 2006 Infusion Nursing Standards of Practice, by the Infusion Nurses Society (INS), recommend flush volumes at least 2x the dead space volume [3]

OCCLUSION DETECTION AND POST-OCCLUSION BOLUS REDUCTION

Occlusion Detection

- Rapid occlusion detection is important for patient safety
- Occlusion pressure increases over time and is not always immediate
- Occlusion detection does not monitor infiltration directly
- Time to occlusion detection is dependent on pump pressure, rate, resistance and compliance in the infusion system, and the IV site
- Syringe pumps typically offer multiple sensitivity settings for monitoring occlusion detection

Post-Occlusion Bolus Reduction

- Pressure behind a syringe increases with length of occlusion time
- When the occlusion is removed, the syringe has a tendency to deliver an unintentional bolus
- This unintentional post-occlusion bolus increases with syringe size
- Syringe pumps typically offer post-occlusion bolus reduction, where the pump automatically pulls back a specified volume, determined by the size of the syringe size, to minimize the bolus phenomenon

Acknowledging Occlusion Detection and Post-Occlusion Bolus

- Be aware of syringe pump occlusion detection sensitivity settings
- Be aware of the syringe size loaded since smaller syringe sizes generate higher pressures than larger syringes
- Be aware of resistance in the infusion system due to the IV tubing inner diameter and other in-line devices, since smaller inner diameter causes disproportional higher pressures
- Be aware of compliance in the infusion system due to elasticity and in-line air entrapment

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References

1. Capes DF, Dunster KR, Sunderland VB, et al. Fluctuations in syringe pump infusions: Association with blood pressure variations in infants. Am J Health Syst Pharm. 1995 Aug 1;52:1645-1653.

2. Igarashi H, Obata Y, Nakjima Y, et. al. Syringe pump displacement alters line internal pressure and flow. Canadian Journal of Anesthesia. 2005: 52:685-691.

3. Infusion Nursing Standards of Practice. Journal of Infusion Nursing. 2006 Jan/Feb; 29(1S):S55-S57.

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