



Context

Administration of medications and fluids by intravenous (IV) infusion to pediatric patients may include the use of an in-line 150 mL capacity volumetric cylinder or burette-type chamber, commonly known in Canada by various brand names (e.g., Buretrol, SoluSet). These chambers, referred to as “volumetric cylinders” throughout this document, are placed in-line between the patient’s IV access site and the primary IV fluid container.

In-line volumetric cylinders may be used in pediatric patients for various purposes, including as a volume-control device to limit the amount of fluid or medication that a child could inadvertently receive due to free flow of an IV solution,^{1,2} or as a medication delivery chamber where a prescribed drug is added to a volume of primary IV solution in the volumetric cylinder and then infused.³

Institution-specific policies may specify which pediatric patients require use of an in-line volumetric cylinder for an IV infusion. These policies may be based on various factors, including patient age and/or body weight, or the type of medication being administered. Additionally, policies may outline how much IV solution can maximally be held in the volumetric cylinder at one time.¹

Objectives

The objective of this Environmental Scan is to identify current practices for administration of fluids and medications by IV infusion to pediatric patients across Canada.

Specifically:

1. Are in-line volumetric cylinders (e.g., Buretrols, Solusets) used in Canadian pediatric institutions?
2. If they are not used, what alternative technology is used to control the potential for excessive IV fluid or medication administration, or to facilitate medication administration? Are there any lessons learned when switching from volumetric cylinder use that can be shared?

Findings

It is not intended that the findings of this Environmental Scan provide a comprehensive review of the topic. Results are based on communication with key informants, gathered as of May 2011.

Respondents from 10 Canadian hospitals inform this Environmental Scan. Nine of the responding hospitals are dedicated children’s hospitals. The Saskatchewan-based hospital is a general hospital with pediatric-specific wards.

Of the 10 responding institutions, four (BC Children’s Hospital, Royal University Hospital in Saskatoon, Children’s Hospital – Health Sciences Centre Winnipeg, Ontario’s Hospital for Sick Children) no longer routinely use in-line volumetric cylinders for pediatric IV infusions. Five centres (Alberta Children’s Hospital, Children’s Hospital of Eastern Ontario, Children’s Hospital at Ontario’s London Health Sciences Centre, IWK Health Centre in Nova Scotia, and Janeway Children’s Hospital in Newfoundland and Labrador) are in the process of eliminating, or have future plans to move away from, the

routine use of volumetric cylinders for their pediatric IV infusions.

Eight of the surveyed hospitals (BC Children’s Hospital, Alberta Children’s Hospital, Children’s Hospital – Health Sciences Centre Winnipeg, Children’s Hospital of Eastern Ontario, Ontario’s Hospital for Sick Children, Children’s Hospital at Ontario’s London Health Sciences Centre, Ontario’s McMaster Children’s Hospital – Hamilton Health Sciences, and IWK Health Centre in Nova

Scotia) have implemented, or plan to implement, use of “smart pumps” with dose error reduction systems (DERS) that include hospital-defined drug libraries (drug lists), with standard drug concentrations, and dose limits programmed into the pumps to potentially improve the safety of IV medication administration.⁴

The following table summarizes the survey responses from the individual hospitals.

Hospital	Use Volumetric Cylinders?	Current Practice	Lessons Learned/Future Plans
BRITISH COLUMBIA			
BC Children's Hospital (Vancouver)	No	Volumetric cylinders have not been used for more than 10 years. Smart pumps with DERS were introduced at the hospital 3 years ago (Alaris pumps with Guardrails) and are used for all IV infusions. Drugs are administered by mini-bags, unless volumes are less than 50 mL, for which syringe pumps are used. Nurses are required to check IV volumes as part of their hourly “site to source” check.	If switching to smart pumps with DERS-type software, it is recommended that all drugs be input into the pump’s drug library and that clinicians be required to use the pump’s drug library when administering medication, versus a “limited” implementation in which only some drugs are included in the drug library. This helped clinicians buy into using the drug library technology and avoid developing bad habits that are difficult to change later. This strategy also helped reinforce clinicians’ comfort levels in administering only drugs that have been programmed into the pump’s drug library.
ALBERTA			
Alberta Children's Hospital (Calgary)	Yes; in process of changing	The process of eliminating volumetric cylinder use from general practice began 2 years ago. Oncology is the only unit in the hospital still routinely using volumetric cylinders. This will change in the near future with the delivery of chemotherapy from pharmacy in a manner that will allow elimination of volumetric cylinders (e.g., mini-bags, syringes for use in syringe pumps). This change is expected to occur in the next few months. It is standard to use a large-volume pump (Baxter Colleague) for each child receiving IV therapy	The institution is moving away from any IV device that may be considered an “open system,” such as volumetric cylinders. The hospital is standardizing IV supplies and related administration practices.

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		<p>maintenance solution and for intermittent medications where the volume is greater than 50 mL. In this case, the piggyback feature of the pump is used. One hour of IV fluid volume is programmed into the pump at a time. Hospital wide, intermittent medications with a volume of less than 50 mL are currently infused using a “smart pump.” In the coming months, a drug library with hard (unchangeable) and soft (can be overridden) dosing limits, currently in the process of validation, will be implemented for IV administration of intermittent medications. A “smart pump” is used in the pediatric intensive care unit for all inotrope/vasopressor, narcotic, and sedation infusions, with both hard and soft dosing limits.</p>	
SASKATCHEWAN			
Royal University Hospital (Saskatoon)	Yes, but only on a case-by-case basis	<p>Generally, volumetric cylinders are no longer routinely used, but may be used on a case-by-case basis along with an IV pump. There are no specific policies in place for situations in which a volumetric cylinder should be used. Volumetric pumps (not “smart pumps”) are used on all IV infusions, and volumes infused are checked on an hourly basis. Staff clear the volume infused from pumps at the end of their shifts. Staff have the IV rate of all high-alert medications double-checked at the pump prior to initiation.</p>	<p>Volumetric cylinders were used more often until 5 to 7 years ago. However, volumetric cylinders were not always being used as intended (e.g., opening the clamp to the IV solution and closing the cylinder air vent so solution would continually fill the cylinder; filling the cylinder to 150 mL when the IV rate was 10 to 20 mL/h, negating the need to check and refill the volumetric cylinder on an hourly basis). Advances in IV pump technology facilitated checking and clearing IV totals, and therefore practice changed to use pumps and eliminate volumetric cylinders.</p>
MANITOBA			
Children’s Hospital – Health Sciences Centre Winnipeg	No	<p>The use of mini-bags for the administration of intermittent intravenous medications requiring higher volumes of dilution was expanded in 2007, with volumetric cylinders removed. Medications that can be administered by direct IV push or diluted via the IV tubing are administered by means of these techniques. Other drugs are administered in mini-bags via</p>	<p>An extensive education strategy on medication administration via mini-bags was carried out prior to implementation, which facilitated the practice conversion. Support and endorsement of the program leadership team were found to be essential. Quick responses to unanticipated challenges upon implementation were essential for staff buy-in, continued</p>

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		<p>piggyback technique into the primary IV line. The rate of administration of the primary IV line and piggyback line are controlled by volumetric pump. All IV infusions are administered with large-volume pumps or syringe pumps that use “smart-pump” technology.</p>	<p>feedback, and patient safety. The complete removal of volumetric cylinders facilitated the implementation of new practice. Ongoing challenges include managing the imprecise overfill volume in mini-bags to ensure that all of the medication is infused and the IV lines flushed, and the need for nurses to remember to open the roller clamp on the secondary medication set tubing after a medication mini-bag is hung.</p>
ONTARIO			
<p>Children's Hospital of Eastern Ontario (Ottawa)</p>	<p>Yes; transition in planning phase</p>	<p>Until recently, volumetric cylinders were used on all IV lines, whether for IV fluids or medication delivery and regardless of the patient's age or weight. In 2010, the hospital transitioned to Medfusion 4000, a syringe pump with DERS (i.e., smart pump) for delivery of small-volume medications (< 50 mL, diluted to a standardized concentration). Medications that must be diluted to volumes > 50 mL continue to be administered via volumetric cylinder. For volumetric cylinders, practice is to set a volume limit of 2 to 4 hours fluid volume in the cylinder at one time in small and/or young patients, and run the system “open” in older children.</p>	<p>The hospital is currently planning a transition to a new large-volume smart pump with DERS software, which will see the removal of volumetric cylinders from practice. In preparing to move to a volumetric-cylinder-free environment, nursing and pharmacy have worked together to identify medications that can be delivered by the IV direct route. Nursing staff refresher education for IV direct administration has been provided. In addition, education on mixing mini-bags to the appropriate concentration and using a secondary medication set to deliver drugs will be incorporated into training as the institution moves toward volumetric-cylinder-free tubing.</p>
<p>Hospital for Sick Children (Toronto)</p>	<p>Yes, but only in specific instances for infants weighing ≤ 5 kg</p>	<p>Since 2008, smart pumps with DERS have been used to run all IV infusions of fluids or medications. It is the expectation that the drug library with the DERS is used for all fluids and medications. The DERS software provides additional dose-related safeguards for medications to prevent over-infusion. Syringe pumps are used for medication infusion volumes ≤ 50 mL, and mini-bags with a large-volume infusion pump are used for medication infusion volumes > 50 mL. For IV fluids, a 2-hour volume limit is set on the pumps. Exceptions to any of the above are only per standard policy guidelines. Generally, all fluids for infants weighing ≤ 5 kg should be run on syringe pumps. The exception is parenteral nutrition (TPN, TNA) and</p>	<p>It is important to distinguish between volumetric cylinder use as a medication delivery device and as a volume-control device. Our institution's aim was to eliminate volumetric cylinders as a medication delivery device for intermittent medications, to be replaced with syringe pumps (for drug infusion volumes ≤ 50 mL) and mini-bags with a large volume pump (for volumes > 50 mL). Practice review done before implementing the new pumps and practices revealed that the volumetric cylinders routinely used on IV infusions were frequently not used properly as a volume-control device (i.e., the clamp between the cylinder and IV bag was left open, and the air</p>

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		<p>high-dextrose solutions, which should be run on a pump module with a volumetric cylinder to reduce the risk of infection related to frequent syringe changes.</p>	<p>vent was closed). It is important to educate nursing staff on the need to clamp and disconnect large-volume pump tubing whenever the tubing is out of the pump. Although there is a safety clamp to prevent free flow, inadvertent fluid over-infusion related to tubing being out of the pump with all clamps open can occur. Syringe pump infusions should be considered for delivery of IV fluids in infants, especially if the IV bag is supplied only in a large volume.</p> <p>Whenever possible, the smallest available size of IV fluid bag should be hung. The hospital has made requests to a manufacturer to make smaller volumes of IV solutions available.</p>
<p>Children's Hospital at London Health Sciences Centre (London)</p>	<p>Yes; transition in planning phase</p>	<p>All IV infusions are administered with large-volume pumps or syringe pumps that use smart-pump technology and DERS software. Current DERS drug libraries will be expanded as use of volumetric cylinders is eliminated. A maximum of 2 hours of IV fluids is programmed into the pumps. Nurses are required to check IVs at least every 2 hours (every 1 hour for chemotherapy).</p> <p>The choice of medication infusion by syringe pump (depending on required dilution), mini-bag (mainly older children), or volumetric cylinder (used in oncology for more accurate measurement of chemotherapeutic drugs) is currently at the nurse's discretion.</p> <p>Numerous drug-specific policies are currently in place and include narcotic and sedative continuous infusions always being infused on a syringe pump or CADD pump.</p> <p>A gentamicin and tobramycin protocol specifies syringe pump use when infusion rates are less than 40 mL/h; a syringe pump or volumetric cylinder can be used for infusion rates greater than 40 mL/h (depending on the final concentration).</p> <p>Chemotherapy or other cytotoxic medications provided by the pharmacy with normal saline primed tubing attached do not include a</p>	<p>The hospital has started to reduce the use of volumetric cylinders for medication administration and increase use of syringe pumps and mini-bags with a large-volume pump. Implementation requires further exploration of specific medication needs and drug delivery possibilities by pharmacy, as well as equipment purchases.</p>

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		volumetric cylinder, and one is not to be added by nursing staff prior to administration.	
McMaster Children's Hospital – Hamilton Health Sciences (Hamilton)	Yes	All IV infusions of fluids or drugs for pediatric patients use volumetric cylinders with a maximum filling volume corresponding to a 2-hour delivery rate. In addition to a volumetric cylinder, an infusion device (smart pump with Guardrails software) is used for individual patients according to the institution's patient selection criteria and/or medication-based selection criteria. Patient-based selection criteria for infusion device use include: neonatal patients; pediatric patients who weigh less than 45 kg; fluid-restricted patients whose clinical status doesn't allow use of saline lock access; patients with specified types of central venous access; maintenance of IV access in patients with poor peripheral access; percutaneous lines; and patients unable to maintain arm in alignment, in cases where gravity is not dependable for consistent infusion rate. Medication-based selection criteria for infusion device use include parenteral nutrition infusions; antineoplastic therapy; and a medication requiring controlled delivery to maintain patient safety as per the institution's IV drug monographs or study protocol (e.g., heparin, insulin).	No immediate plans to change.
NOVA SCOTIA			
IWK Health Centre (Halifax)	Yes; conversion June 2011	IV infusions of drugs and fluids to pediatric patients use volumetric cylinders. The policy is a maximum cylinder-filling volume corresponding to a 1-hour infusion time. Conversion to smart pumps with DERS drug libraries and elimination of volumetric cylinder use is being implemented in June 2011. Pumps will be set to alarm for reset after 1 hour or less.	The hospital plans to eliminate volumetric cylinders from pediatric IVs in June 2011.

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NEWFOUNDLAND AND LABRADOR			
Janeway Children's Hospital (St. John's)	Yes; transition planned	Volumetric cylinders are used for IV infusion administration of drugs and fluids to pediatric patients.	The hospital is currently reviewing the practice in other pediatric centres across the country and plans to move away from the use of volumetric cylinders in the near future.

CADD = computerized ambulatory drug delivery; DERS = dose error reduction systems; IV = intravenous; TNA = total nutrient admixtures; TPN = total parenteral nutrition.

Complementing this Environmental Scan, CADTH prepared a Rapid Response report in 2011 pertaining to guidelines for intravenous fluid and medication administration by infusion in pediatric patients. This report is available free of charge on the CADTH website.⁵

Conclusion

For the majority of the 10 Canadian pediatric hospitals and units surveyed, advances in IV infusion device technology have significantly reduced or eliminated the use of in-line volumetric cylinders for pediatric IV infusions of fluids and medications. It appears that in order to meet the fluid and medication IV infusion needs of the diverse patient populations in pediatric settings, some centres use two different medical devices: syringe pumps to meet small-volume, low-flow-rate IV drug administration, and large-volume IV pumps with technology allowing piggybacked intermittent larger-volume, higher-rate IV drug infusions. The majority of surveyed hospitals have introduced “smart pumps” with DERS software, including hospital-defined drug libraries (drug lists) with standard drug concentrations, and dose limits, to potentially improve the safety of IV medication administration.⁴

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