STANDARDISING INTRAVENOUS INFUSION CONCENTRATIONS FOR NEONATES AND CHILDREN IN THE UK

A Proposal for a National Approach

From the Neonatal & Paediatric Pharmacists Group

Endorsed by:

British Association of Perinatal Medicine

Paediatric Critical Care Society

Royal College of Paediatrics and Child Health

STRATEGIC SUMMARY

The time for the NHS to standardise neonatal and paediatric intravenous (IV) infusions is now. Policy and practice drivers are all in alignment, and the future of NHS procurement, technology and safety, demand an urgent change from the standard weight-based approach to standard concentrations, which are proven to be safer and more efficient for patient care.

The proposed framework is not complete, but offers the first list of published standard IV infusion concentrations in the UK. It will also support strategic efficiencies and support the development of “smart pump” drug libraries, the uptake and implementation of electronic prescribing, and the future development of licensed formulations.

Framework of Concentrations for Neonatal and Paediatric patients

Medication	Weight band	Concentration	Volume
Adrenaline	Less than 2kg	10 microgram/mL	20mL or 50mL
	2-5kg	20 microgram/mL	20mL or 50mL
	5-20kg	40 microgram/mL	50mL
	>20kg	160 microgram/mL	50mL
Amiodarone	2-5kg	2.5mg/mL	20mL
	5-20kg	12mg/mL	50mL
	>20kg	24mg/mL	50mL
Atracurium	2-5kg	2.5mg/mL	20mL
	5-20kg	5mg/mL	50mL
	>20kg	10mg/mL	50mL
Clonidine	2-5kg	7.5microgram/mL	20mL
	5-20kg	15microgram/mL	50mL
	>20kg	40microgram/mL	50mL
Dinoprostone	Less than 5kg	1 microgram/mL	20mL or 50mL
	>5kg	4 microgram/mL	20mL or 50mL
Dobutamine	Less than 2kg	1mg/mL	20mL or 50mL
	2-5kg	2mg/mL	20mL or 50mL
	>5kg	5mg/mL	50mL
Dopamine	Less than 2kg	1mg/mL	20mL or 50mL
	2-5kg	2mg/mL	20mL or 50mL
	5-20kg	5mg/mL	50mL
	>20kg	12mg/mL	50mL
Fentanyl	2-5kg	10 microgram/mL	20mL
	5-20kg	20 microgram/mL	50mL
	>20kg	50 microgram/mL	50mL
Furosemide	2-5kg	3mg/mL	20mL
	5-20kg	5mg/mL	50mL
	>20kg	10mg/mL	50mL
Heparin	2-5kg	75 units/mL	20mL
	5-20kg	200 units/mL	50mL
	>20kg	1000units/mL	50mL
Insulin	2-5kg	1unit/mL	20mL
	>5kg	1unit/mL	50mL
Labetalol	2-5kg	5mg/mL	20mL
	>5kg	5mg/mL	50mL
Midazolam	2-5kg	500microgram/mL	20mL
	5-20kg	1mg/mL	50mL
	>20kg	2mg/mL	50mL
Milrinone	2-5kg	100 microgram/mL	20mL
	5-20kg	400 microgram/mL	50mL
	>20kg	1mg/mL	50mL

Medication	Weight band	Concentration	Volume
Morphine	Less than 2kg	25 microgram/mL	20mL or 50mL
	2-5kg	50 microgram/mL	20mL or 50mL
	5-20kg	200microgram/mL	50mL
	>20kg	1mg/mL	50mL
Nordrenaline	2-5kg	20 microgram/mL	20mL
	5-20kg	40 microgram/mL	50mL
	>20kg	160 microgram/mL	50mL
Rocuronium	2-5kg	10mg/mL	20mL
	>5kg	10mg/mL	50mL
Vasopressin	Presents specific challenges with delivery systems that are unable to express infusion doses to four decimal places Currently no standard concentration is offered Some units use 20 or 50units in 50mL		
Vecuronium	2-5kg	1mg/mL	20mL
	>5kg	1mg/mL	50mL

BACKGROUND

Intravenous medications for neonates, children and young people are primarily prescribed and administered on a bespoke weight-based basis using complex and highly variable approaches. A survey study in the UK identified over 150 discrete methods for preparation of infusions across multiple paediatric and neonatal care settings. (Oskarsdottir, Harris, Sutherland, Wignell, & Christiansen, 2018)

This variation adversely effects systems safety, and has been implicated in serious medication errors.(Keers, Williams, Cooke, & Ashcroft, 2013; National Patient Safety Agency, 2011) It has been demonstrated that bespoke weight-based preparation of infusions is unsafe with many infusions prepared incorrectly – in some cases with two-fold variations in concentration of prepared versus intended. (Aguado-Lorenzo et al., 2013; Parshuram et al., 2003; Wheeler et al., 2008)

The move to "standardised solutions" is one part of an approach to IV medication safety internationally, with demonstrable improvements in safety and service efficiency that comes with provision of ready-to-administer preparations. (Howlett, Breatnach, Brereton, & Cleary, 2020; Lehmann et al., 2006; Manrique-Rodríguez et al., 2013; Perkins, Aguado-Lorenzo, & Arenas-Lopez, 2016) By moving to pre-prepared solutions, nursing time used in IV preparation may be reduced by up to 60% releasing more time for care.(Sutherland et al., 2016)

These clear advantages in process efficiency have been taken fully on board by the Department of Health and Social Care with their plans for the reorganisation and transformation of NHS Aseptic Services in England.(Lord Carter of Coles, 2020) Primarily this will involve the mass manufacture of intravenous medications for patients in licensed manufacturing facilities and later in collaboration with private sector capacity. Standardisation of products, processes and training is a keystone element of this policy, and a UK-wide approach is required, with similar capacity reviews completed or being planned in the other UK home countries.

Without a national approach to standardisation, there is a risk that there will be variation at local or regional levels in the concentrations being used.

Drug-Error Reduction Systems (DERS) are now being incorporated within infusion pumps – termed 'smart-pumps'. DERS refers to the integral computer software in smart infusion pumps, intended to aid prevention of infusion programming-related erros and warning users of potential over- or under- delivery of a medication by checking the programmed doses/rates against configurable preset limits specific to that medication. The Health Safety Investigation Board has directed that smart pumps must be configured using a national library. (Healthcare Safety Investigation Branch, 2020) This intervention cannot be implemented in the UK without a national consensus on standard concentrations for children and neonates. This approach is feasible and has been delivered successfully in the Republic of Ireland (Howlett et al. 2019), Queensland, Australia (Cree et al., 2017) and is being developed in the United States of America.

PROPOSAL

That the Joint RCPCH/NPPG Standing Committee on Medicines (JMC) approves a framework of standard concentrations for use in neonates and children as part of a national drug library.

THE FRAMEWORK

The framework proposed (page 1), has been developed using a multi-disciplinary approach in a single large tertiary children's centre. This has been thoroughly evaluated for safety and effectiveness in populations from 2kg and up, and has been found to be safer than weight based infusions.(Arenas-López et al., 2017; Rashed et al., 2015; Rashed et al., 2016) There is additional data supporting the longer term safety and effectiveness of the framework using "smart pump" data that is being prepared for publication.

This framework has been evaluated against a similar conceptual framework developed using inter-professional consensus methods by the Making it Safer Together (MiST) collaborative (Sutherland et al., 2017) and similarity extends to around 70%.

For neonates <2kg, five medications (morphine, adrenaline, dopamine, dobutamine and dinoprostone) have been reviewed in conjunction with the British Association of Perinatal medicine (BAPM) to ensure that there are standard concentrations in the framework for this population. Work is ongoing to model and define infusion concentrations for another 5 to 10 medicines commonly used in the pre-term population. Appendix 1 provides a summary of how the framework would work for these five medications in neonates and infants. Appendix 2 provides examples of different neonatal scenarios, to demonstrate how the framework could be used in practice.

Given the time sensitive nature of the National Drug Library project, and the need to be "ahead of the curve" the leads for both frameworks have agreed that the proposed framework is suitable for all purposes and should form the basis of the National Drug Library for Children.

STRENGTHS

The proposed framework is:

- Reliably and robustly designed and validated using clinical simulation with clear acceptance thresholds of fluid load, in-use stability, and acceptable diluents

- In successful use in a large multi-speciality children's hospital for infants and children >2kg and rollout is in progress to areas outside of PICU at this site, and is being actively considered by other centres.

- The standard concentrations for pre-term neonates <2kg are also being used in practice in a large neonatal unit, and this provides confidence around its use.

- Peer reviewed for safety and effectiveness and published in respected journals

- Has great similarity to the MiST framework which JMC has previously endorsed. This framework has the added benefit of evidence of application and in-use data

CONSIDERATIONS

- Apart from the 5 medications agreed with BAPM, this framework cannot generally be extrapolated into premature neonatal care, however it has been used in infants down to 2kg.

- This framework is not exhaustive. There are many more infused medicines that are used throughout paediatric and neonatal practice. However, we are confident that this framework covers 90-95% of infused medicines used in the NHS in these populations.

- Standardised infusions are not a solution in themselves and may serve to present other opportunities for error elsewhere in the process.(Blandford et al., 2019). These errors include:
    - Selection errors (the wrong strength for a patient)
    - Calculation errors (as different calculations are required for administration)
    - Preparation errors (e.g. using the wrong diluent or volume)
    - Infusion device programming errors

- Rolling out standard concentrations is not straight forward and there is the need for supporting infrastructure and training to support delivery.

- It is believed that “smart pump” technology is the safest way to implement use of standard concentration infusions in paediatrics – not all centres currently have this technology
    - However, the strategy of pump manufacturers is currently to only offer DERS-enabled systems when infusion systems come up for replacement.

- This framework only covers continuous infusions and does not address the variation in bolus medications or intermittent infusions. However it provides a framework from which to start this process. This intervention may be viewed as a single measure to improve medication safety, but must be considered as part of a bundle of interventions (including “smart pumps,” bar code administration

checks and pre-filled containers) to foster a systems-approach to IV medication safety.

- Any medication intervention carries risks associated with change. This requires careful consideration and consultation with stakeholders on the infrastructure and training requirements to safely implement them. For example:
    - There may be a perception that this represents a shift from “patient centred care” to “one size fits all”
    - The NHS needs to plan for how these ready-to-use solutions will be presented, and safely and securely stored

- The move to ready-to-administer infusions may be perceived to be a costly solution when ingredient medication costs are low, however this will offer far greater improvements in nursing efficiency and will release their time to nursing care. (Sutherland et al., 2016)

OPPORTUNITIES

- With appropriate support and infrastructure, there is the potential high uptake of these standard concentrations as seen in adult Intensive Care (Titiesari, Barton, Borthwick, Keeling, & Keeling, 2016) which in turn will drive development of ready-to-administer preparations

- A national drug library will offer efficiencies to the wider NHS in reducing the workload associated with development and implementation of smart pumps, electronic prescribing and patient records, and broader harmonisation initiatives across integrated care systems.

- A national framework once adopted will offer improvements in:
    - Nursing capacity as time to prepare medication doses is reduced substantially
    - Demand and capacity planning for medicine shortages and requirements
    - Uptake of medication safety interventions including barcode medication administration, electronic prescribing, information presentation
    - Training efficiency with reduced resource required to induct practitioners into local practice as these infusion practices will be transferrable.

- A national framework will provide a basis for the strategic development of licensed formulations of IV medications specifically for neonates and children which continues to be an enormous gap in our needs.

FUTURE WORK

The implementation of standard concentrations offers a great deal to the NHS, however much of this has not been evaluated. Nor would it be appropriate to delay

implementation to facilitate “more research” – infusion systems are being replaced, DERS systems are being updated and EPR systems are being selected and implemented today.

In line with the NHS Strategy for Patient Safety, there is an imperative to ensure that evaluation and measurement is embedded in this intervention to demonstrate ongoing benefits. Furthermore, while we present this framework “as is”, there must be space for pragmatic adaptation and adjustment with time, that can be implemented centrally with appropriate adjustments throughout the system. Thus we recommend a national approach, with co-ordination through Medusa or other suitable group, and collaboration with educational institutions and industry to ensure adaptations are made swiftly and safely.

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Appendix 1

Summary of framework for Neonates and infants

Medication	Typical weight band	Concentration	Preparation	Dose range	Rate range	Examples of minimum and maximum rates					
						0.4kg	1kg	2kg	2.5kg	5kg	10kg
Morphine	Less than 2kg	25microgram/mL	0.5mg in 20mL 1.25mg in 50mL	5-60microgram/kg/hr	0.2-2.4mL/kg/hr	0.08-0.96mL/hr	0.2-2.4mL/hr	0.4-4.8mL/hr			
	2-5kg	50microgram/mL	1mg in 20mL 2.5mg in 50mL	5-60microgram/kg/hr	0.1-1.2mL/kg/hr		0.1-1.2mL/hr	0.2-2.4mL/hr	0.25-3mL/hr		
	5-20kg	200microgram/mL	10mg in 50mL	5-60microgram/kg/hr	0.025-0.3mL/kg/hr				0.06-0.75mL/hr	0.13-1.5mL/hr	0.25-3mL/hr
	>20kg	1mg/mL	50mg in 50mL	5-60microgram/kg/hr	0.005-0.06mL/kg/hr						
Adrenaline	Less than 2kg	10microgram/mL	0.2mg in 20mL 0.5mg in 50mL	0.1-1.5microgram/kg/min	0.6-9mL/kg/hr	0.24-3.6mL/hr	0.6-9mL/hr	1.2-18mL/hr			
	2-5kg	20microgram/mL	0.4mg in 20mL 1mg in 50mL	0.1-1.5microgram/kg/min	0.3-4.5mL/kg/hr	0.12-1.8mL/hr	0.3-4.5mL/hr	0.6-9mL/hr	0.75-11.25mL/hr		
	5-20kg	40microgram/mL	2mg in 50mL	0.1-1.5microgram/kg/min	0.15-2.25mL/kg/hr				0.38-5.6mL/hr	0.75-11.25mL/hr	1.5-22.5mL/hr
	>20kg	160microgram/mL	8mg in 50mL	0.1-1.5microgram/kg/min	0.0375-0.5625mL/kg/hr						0.38-5.6mL/hr
Dopamine	Less than 2kg	1mg/mL	20mg in 20mL 50mg in 50mL	5-20microgram/kg/min	0.3-1.2mL/kg/hr	0.12-0.48mL/hr	0.3-1.2mL/hr	0.6-2.4mL/hr	0.75-3mL/hr		
	2-5kg	2mg/mL	40mg in 20mL 100mg in 50mL	5-20microgram/kg/min	0.15-0.6mL/kg/hr		0.15-0.6mL/hr	0.3-1.2mL/hr	0.38-1.5mL/hr		
	5-20kg	5mg/mL	250mg in 50mL	5-20microgram/kg/min	0.06-0.24mL/kg/hr				0.15-0.6mL/hr	0.3-1.2mL/hr	0.6-2.4mL/hr
	>20kg	12mg/mL	600mg in 50mL	5-20microgram/kg/min	0.025-0.1mL/kg/hr						
Dobutamine	Less than 2kg	1mg/mL	20mg in 20mL 50mg in 50mL	5-20microgram/kg/min	0.3-1.2mL/kg/hr	0.12-0.48mL/hr	0.3-1.2mL/hr	0.6-2.4mL/hr	0.75-3mL/hr		
	2-5kg	2mg/mL	40mg in 20mL 100mg in 50mL	5-20microgram/kg/min	0.15-0.6mL/kg/hr		0.15-0.6mL/hr	0.3-1.2mL/hr	0.38-1.5mL/hr		
	>5kg	5mg/mL	250mg in 50mL	5-20microgram/kg/min	0.06-0.24mL/kg/hr				0.15-0.6mL/hr	0.3-1.2mL/hr	0.6-2.4mL/hr
Dinoprostone	Less than 5kg	1microgram/mL	20microgram in 20mL 50microgram in 50mL	5-100nanogram/kg/min	0.3-6mL/kg/hr	0.12-2.4mL/hr	0.3-6mL/hr	0.6-12mL/hr	0.75-15mL/hr	1.5-30mL/hr	3-60mL/hr
	>5kg (or high doses)	4microgram/mL	80microgram in 20mL 200microgram in 50mL	5-100nanogram/kg/min	0.075-1.5mL/kg/hr	0.03-0.6mL/hr	0.075-1.5mL/hr	0.15-3mL/hr	0.19-3.75mL/hr	0.38-7.5mL/hr	0.75-15mL/hr

Appendix 2

Example scenarios to demonstrate use of the standardised infusion framework in practice for neonatal and paediatric patients

The following scenarios are intended to demonstrate how the standardised infusion framework can be used to manage different neonatal and paediatric patients, particularly to maximise fluid availability for nutrition.

Recommended infusion concentrations have been indicated for specific body weights in the framework. However, where the infusion rates will result in a higher fluid volumes to deliver these infusions (usually at the higher end of the dosing range), any of the other infusion concentrations on the framework (outside the usual recommended concentration for the patient's weight) can be used to provide a more concentrated solution and reduce the infusion volume being delivered.

For example, if an adrenaline infusion is required, the suggested concentration is 10 microgram/mL. However, if higher dosing rates are required, then any of the other concentrations 20microgram/mL, 40microgram/mL or 160microgram/mL could be used.

Scenario 1

Baby A 0.6kg requires 60mL/kg/day of fluid and is prescribed the following: -

- Adrenaline 1 microgram/kg/min
- Dobutamine 20 microgram/kg/min
- Dopamine 20 microgram/kg/min
- Morphine 20microgram/kg/hr

60mL/kg/day of fluid for 0.6kg = 36mL/day

Using the <2kg infusions on the framework would provide the following infusion rates and fluid volume delivery per day: -

- Adrenaline 0.5mg/50mL where 1 microgram/kg/min	= 3.6mL/hr	= 86.4mL/day
- Dobutamine 50mg/50mL where 20 microgram/kg/min	= 0.72mL/hr	= 17.3mL/day
- Dopamine 50mg/50mL where 20 microgram/kg/min	= 0.72mL/hr	= 17.3mL/day
- Morphine 1.25mg/50mL where 20microgram/kg/hr	= 0.48mL/hr	= 11.5mL/day
	TOTAL VOLUME	**= 132.5mL/day**

These infusions would therefore provide a total fluid of 132.5mL/day (220ml/kg/day) which is far in excess of 60mL/kg/day.

To concentrate these infusions, thereby reducing the fluid volume being delivered, other concentrations on the framework can be used, ignoring that they may be indicated for patients of a different body weight. Select a concentration that will appropriately reduce your rate of infusion, but still allow a minimum infusion rate of 0.1mL/hr to be delivered.

For example, in our case the following alternative standard concentrations could be used

- Adrenaline 8mg/50mL where 1 microgram/kg/min	= 0.23mL/hr	= 5.5mL/day
- Dobutamine 250mg/50mL where 20 microgram/kg/min	= 0.14mL/hr	= 3.4mL/day
- Dopamine 250mg/50mL where 20 microgram/kg/min	= 0.14mL/hr	= 3.4mL/day
- Morphine 2.5mg/50mL where 20microgram/kg/hr	= 0.24mL/hr	= 5.8mL/day
	TOTAL VOLUME	**= 18.1mL/day**

Thus reducing the total fluid volume for these infusions to 18.1mL/day (30.2mL/kg/day), leaving almost 30mL/kg/day that could be used for nutrition.

Considerations: -

- If infusion rate is close to 0.1mL/hr then weaning of infusion may be difficult. Once the medication begins to be weaned, the infusion would need to be changed to a less concentrated standard infusion.

Scenario 2

Baby B 1.9kg requires 90mL/kg/day of fluid and is prescribed the following: -

- Adrenaline 1 microgram/kg/min
- Dobutamine 20 microgram/kg/min
- Dopamine 20 microgram/kg/min
- Morphine 20microgram/kg/hr

90mL/kg/day of fluid for 1.9kg = 171mL/day

Using the <2kg infusions on the framework would provide the following infusion rates and fluid volume delivery per day: -

- Adrenaline 0.5mg/50mLwhere 1 microgram/kg/min	= 11.4mL/hr	= 273.6mL/day
- Dobutamine 50mg/50mL where 20 microgram/kg/min	= 2.28mL/hr	= 54.7mL/day
- Dopamine 50mg/50mL where 20 microgram/kg/min	= 2.28mL/hr	= 54.7mL/day
- Morphine 1.25mg/50mL where 20microgram/kg/hr	= 1.52mL/hr	= 36.5mL/day
	TOTAL VOLUME	**= 419.5mL/day**

These infusions would therefore provide a total fluid of 419.5mL/day (220.8mL/kg/day) which is far in excess of 90mL/kg/day.

To concentrate these infusions, thereby reducing the fluid volume being delivered, other concentrations on the framework can be used, ignoring that they may be indicated for patients of a different body weight. Select a concentration that will appropriately reduce your rate of infusion, but still allow a minimum infusion rate of 0.1mL/hr to be delivered.

For example, in our case the following alternative standard concentrations could be used

- Adrenaline 8mg/50mL where 1 microgram/kg/min	= 0.71mL/hr	= 17mL/day
- Dobutamine 250mg/50mL where 20 microgram/kg/min	= 0.46mL/hr	= 11mL/day
- Dopamine 600mg/50mL where 20 microgram/kg/min	= 0.19mL/hr	= 4.6mL/day
- Morphine 10mg/50mL where 20microgram/kg/hr	= 0.19mL/hr	= 4.6mL/day
	TOTAL VOLUME	**= 37.2mL/day**

Thus reducing the total fluid volume for these infusions to 37.2mL/day (19.6mL/kg/day), leaving almost 70mL/kg/day that could be used for nutrition.

Considerations: -

- If infusion rate is close to 0.1mL/hr then weaning of infusion may be difficult. Once the medication begins to be weaned, the infusion would need to be changed to a less concentrated standard infusion.

Scenario 3

Baby C 3.8kg requires 60mL/kg/day of fluid and is prescribed the following: -

- Dinoprostone 40 nanogram/kg/min
- Morphine 30microgram/kg/hr

60mL/kg/day of fluid for 3.8kg = 228mL/day

Using the '2-5kg' and '<5kg' infusions on the framework would provide the following infusion rates and fluid volume delivery per day: -

-	Dinoprostone 50micogram/50mL where 40 nanogram/kg/min	= 9.12mL/hr	= 218.9mL/day
-	Morphine 2.5mg/50mL where 30microgram/kg/hr	= 2.28mL/hr	= 54.7mL/day
		TOTAL VOLUME	**= 273.6mL/day**

These infusions would therefore provide a total fluid of 273.6mL/day (72mL/kg/day) which is in excess of 60mL/kg/day.

To concentrate these infusions, thereby reducing the fluid volume being delivered, other concentrations on the framework can be used, ignoring that they may be indicated for patients of a different body weight. Select a concentration that will appropriately reduce your rate of infusion, but still allow a minimum infusion rate of 0.1mL/hr to be delivered.

For example, in our case the following alternative standard concentrations could be used

Option 1

-	Dinoprostone 200micogram/50mL where 40 nanogram/kg/min	= 2.28mL/hr	=54.7mL/day
-	Morphine 50mg/50mL where 30microgram/kg/hr	= 0.11mL/hr	= 2.6mL/day
		TOTAL VOLUME	**=57.3mL/day**

Thus reducing the total fluid volume for these infusions to 57.3mL/day (15.1mL/kg/day), leaving almost 45mL/kg/day that could be used for nutrition.

Option 2 (with less concentrated morphine infusion, which may be more appropriate and more accurate for a neonatal unit)

-	Dinoprostone 200micogram/50mL where 40 nanogram/kg/min	= 2.28mL/hr	=54.7mL/day
-	Morphine 10mg/50mL where 30microgram/kg/hr	= 0.57mL/hr	=13.7mL/day
		TOTAL VOLUME	**=68.4mL/day**

Thus reducing the total fluid volume for these infusions to 68.4mL/day (18mL/kg/day), leaving 42mL/kg/day that could be used for nutrition.

Considerations: -

- If infusion rate is close to 0.1mL/hr then weaning of infusion may be difficult. Once the medication begins to be weaned, the infusion would need to be changed to a less concentrated standard infusion.

Scenario 4

Child A 55kg, is fluid restricted to 70% fluids and will have an allowance 1540mL/day. They are prescribed the following:-

- Midazolam 200 microgram/kg/hr
- Morphine 40 microgram/kg/hr
- Vecuronium 200 microgram/kg/hr

Using the >20kg concentrations for morphine and midazolam and the >5kg concentration for vecuronium from the framework, this would provide the following infusion rates and fluid volume delivery per day: -

- Midazolam 100mg/50mL where 200 microgram/kg/hr	= 5.5mL/hr	= 132mL/day
- Morphine 50mg/50mL where 40microgram/kg/hr	= 2.2mL/hr	= 52.8mL/day
- Vecuronium 50mg/50mL where 200microgram/kg/hr	= 11mL/hr	= 264mL/day
	TOTAL VOLUME	**= 448.8mL/day**

These infusions would therefore provide a total fluid of 448.8mL/day (8.2mL/kg/day) and leave 1091mL (19.8mL/kg/day) for nutrition etc.

Scenario 5

Child B 15kg, is fluid restricted to 70% fluids and will have an allowance 875mL/day. They are prescribed the following:-

- Dobutamine 20microgram/kg/min
- Furosemide 0.5mg/kg/hr
- Midazolam 200microgram/kg/min
- Morphine 20microgram/kg/hr
- Noradrenaline 1microgram/kg/min
- Rocuronium 1000microgram/kg/hr

Using the 5-20kg infusions on the framework would provide the following infusion rates and fluid volume delivery per day: -

- Dobutamine 250mg/50mL where 20 microgram/kg/min	= 3.6mL/hr	= 86.4mL/day
- Furosemide 250mg/50mL where 0.5mg/kg/hr	= 1.5mL/hr	= 36mL/day
- Midazolam 50mg/50mL where 200 microgram/kg/hr	= 3mL/hr	= 72mL/day
- Morphine 10mg/50mL where 40microgram/kg/hr	= 3mL/hr	= 72mL/day
- Noradrenaline 2mg/50mL where 1 microgram/kg/min	= 22.5mL/hr	= 540mL/day
- Rocuronium 500mg/50mL where 1000microgram/kg/hr	= 1.5mL/hr	= 36mL/day
	TOTAL VOLUME	**= 842.4mL/day**

These infusions would therefore provide a total fluid of 842.4mL/day which takes up most of the fluid allowance available.

To concentrate these infusions, thereby reducing the fluid volume being delivered, other concentrations on the framework can be used, ignoring that they may be indicated for patients of a different body weight. Select a concentration that will appropriately reduce your rate of infusion, but still allow a minimum infusion rate of 0.1mL/hr to be delivered.

For example, in our case the following alternative standard concentrations could be used (changes in bold)

- Dobutamine 250mg/50mL where 20 microgram/kg/min	= 3.6mL/hr	= 86.4mL/day
- **Furosemide 500mg/50mL where 0.5mg/kg/hr**	**= 0.75mL/hr**	**= 18mL/day**
- **Midazolam 100mg/50mL where 200 microgram/kg/hr**	**= 1.5mL/hr**	**= 36mL/day**
- **Morphine 50mg/50mL where 40microgram/kg/hr**	**= 0.6mL/hr**	**= 14.4mL/day**
- **Noradrenaline 8mg/50mL where 1 microgram/kg/min**	**= 5.63mL/hr**	**= 135.1mL/day**
- Rocuronium 500mg/50mL where 1000microgram/kg/hr	= 1.5mL/hr	= 36mL/day
	TOTAL VOLUME	**= 325.9mL/day**

Thus reducing the total fluid volume for these infusions to 325.9mL/day (21.7mL/kg/day) leaving almost 550mL (37mL/kg/day) available for nutrition etc.

Considerations: -

- If infusion rate is close to 0.1mL/hr then weaning of infusion may be difficult. Once the medication begins to be weaned, the infusions may need to be changed to a less concentrated standard infusion.