Fluid balance in children with respiratory failure.

Introduction.

These guidelines are designed to help staff who are looking after ventilated children outside the PICU during the flu pandemic.

Children presenting with respiratory failure may be dehydrated and hypovolaemic initially as a result of one or more of the following:

- Poor feeding
- Iatrogenic fluid restriction (if in hospital)
- Increased insensible losses resulting from pyrexia and tachypnoea.
- Vomiting and diarrhoea
- Some degree of systemic inflammatory response

Early reports suggest that some children with swine flu present with profound shock and ARDS and may need aggressive fluid resuscitation.

In order to tolerate ventilation children require fluid resuscitation to the usual end-points i.e. adequacy of central and peripheral perfusion as measured by conscious level, capillary refill time, urine output, blood pressure and reduction in tachycardia. This should be achieved by carefully titrated boluses of fluid and possibly inotropic support. They may need 60ml/kg of fluid or more.

Failure to resuscitate prior to, and after, initiation of ventilation can result in increased V/Q mismatch and, in severe cases, cardiovascular collapse.

Unfortunately much of this fluid re-distributes to extra-vascular spaces - especially the lungs – compounding any gas exchange problems, and after resuscitation and a stabilisation phase (which can last for several days), management focus switches to running the patient dry.

Early reports have suggested that this “dry management” may be crucial to the successful treatment of patients with swine-flu induced pneumonitis.

Fluid restriction and diuretic therapy are the first and second line treatments. Peritoneal dialysis is not normally used, but may have a place in areas where the expertise in (and access to) Paediatric Extra-corporeal renal replacement therapy (RRT) is limited. It is probably safer in relatively inexperienced hands. RRT may be required by a proportion of patients, but the careful use of simpler techniques should minimise demand for it.

Remember that children with respiratory failure can present with SIADH and hyponatraemia, which should be treated by fluid restriction (after adequate volume resuscitation with normal saline, HAS or other volume expander).

Caveats/cautions

Excessive dehydration may cause cardiovascular instability, increase V/Q mismatch and induce renal failure. The margins for error are smaller in children and therefore the therapies require careful monitoring of fluid balance, of indicators of adequate perfusion, of renal function and electrolyte concentrations.

Fluid balances may be misleading because insensible losses are not adequately included. Some children have significantly positive balances without any other evidence of fluid accumulation, and fluid balance must be evaluated as one part of the clinical picture before making treatment decisions.

Dr.Mark Darowski, PICU Consultant LTHT,
Teresa Brookes, Paediatric Pharmacist LTHT
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Fluid balances determined by nappy weighing may also be unreliable because of the presence of liquid stool and it may not be clear in these should or should not be included (predominantly liquid stool should be included, whereas predominantly solid stool should not). The situation can also be complicated by simultaneously dirty and wet nappies.

Paediatric urinary catheters block readily, and can result in apparent periods of anuria or oilguria. Always palpate the bladder and/or flush the catheter before treating the patient for isolated oliguria. A blocked catheter can also be bypassed, resulting in an inappropriately positive fluid balance.

Regular weighing is possible in all but the sickest patients and should be considered at the onset of diuretic therapy and in situations where there is ongoing debate as to fluid balance status.

Indications for dehydration therapy.

- Persistent tissue oedema in the face of cardiac and/or respiratory failure.
- Inadequate oxygenation in patients with persistently positive fluid balance.
- Chest X-ray evidence of pulmonary oedema and/or pleural effusions in patients with cardio-respiratory failure.

Fluid restriction.

Ventilated patients are normally fluid restricted to 80% of maintenance requirements if they are on IV fluid, but this is relaxed once enteral nutrition is established to enable nutritional targets to be met. The most simple step is to reduce fluid input, to 60% if on IV fluid and initially to 80% on enteral feeds. This should only be done for periods of a few days because nutritional targets cannot be met on this degree of fluid restriction. Hypoalbuminaemia resulting from starvation will then exacerbate fluid retention and make the treatment of oedema more difficult.

When fluid restricting, ensure that sodium and glucose content of the fluid is adequate to avoid hypoglycaemia and hyponetraemia. You may need to give 0.9% sodium chloride with 10% glucose. The blood sugar must be monitored 1-4 hourly (hourly in neonates, 2 hourly in infants, 4 hourly in children) until you are certain that the glucose provision is adequate. Sodium must be measured at least once a day.

Diuretic therapy

Single bolus.
Furosemide (0.5 - 2 mg/kg/dose enterally or 0.5 - 1 mg/kg/dose IV) can be given to improve fluid balance. An enteral dose may produce a gentler and more prolonged diuresis than IV dosing. In the event of a large diuresis (more than 5ml/kg) it is important to check the potassium concentration regularly.

Multiple boluses.
Furosemide can be given up to 4 times a day to a total dose of 20mg/kg (max 1g/day). It is advisable to combine it with spironolactone (1-2 mg/kg 12 hourly, only available as an oral preparation) to ensure a more effective diuresis and to minimise potassium losses.

Furosmide infusion
Furosmide infusion can give a more effective diuresis than boluses. A starting dose is 0.1 mg/kg/hr and can go up to 2 mg/kg/hr. Negative balance needs to be monitored at regular intervals (4-6) hourly and the infusion rate adjusted accordingly. Excessively rapid fluid loss must be avoided with maximum daily losses of 10-20 ml/kg.
Spironolactone boluses are usually continued to minimise potassium loss.

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Monitoring diurectic therapy.

Potassium loss is the most common and acute complication. Patients commencing on bolus diuretics must have serum potassium measured daily. Those receiving furosemide infusions must have 6-8 hourly measurements (depending on the degree of diuresis).
Hypernatraemia can also result from excessive diuresis and the sodium content of the maintenance fluid may need to be adjusted.

Urea and Creatinine should rise in response to successful therapy. Upper limits depend on the clinical condition, but urea levels of 8 to 10 mmol/l and creatinine levels of 100 micromol/l in infants and 150 micromol/l in older children probably indicate adequate “dryness” in a previously well, ventilated child.

Peritoneal dialysis may be considered in children in renal failure and in those where maximum diuretic therapy has not produced an adequately negative fluid balance. Please see LTHT guidelines for Management of Acute Renal Failure and Peritoneal Dialysis in Paediatric Intensive Care Patients.

Extra-corporeal Renal Replacement Therapy.

This should only be considered in patients in whom peritoneal dialysis has failed or is contra-indicated.
Indications for extracorporeal RRT.

- Failure to achieve negative fluid balances in a cardiovascularly stable patient with ARDS.
- Persistent severe acidosis (ph < 7.15) unresponsive to adequate volume resuscitation and inotropes.
- Hyperkalaemia. Unresponsive to diuresis and review of postassium input. Glucose-insulin and salbutamol must be considered, but only buy time while the underlying problem is corrected - they do not remove potassium, only re-distribute it. Calcium resonium can result in potassium removal.

Contraindications to RRT

- Hopeless prognosis
- Significant life limiting condition
- An inability to achieve satisfactory venous access

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