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Editorial

Prevention of hyponatraemia in children receiving fluid therapy

Severe hyponatraemia (serum sodium <130 mmol/1) has become increasingly recognised in recent years as a potential complication of fluid therapy in children,[1] and at least two children in Northern Ireland have died in recent years as a result. Worldwide, death or neurological morbidity related to this condition has recently been reported in more than 50 children.[2] Hyponatraemia has also been reported in as many as 5% of adults undergoing elective surgery[3] and in 25% of children following spinal fusion.[4] It has been suggested that menstruant women and prepubertal children are particularly at risk of brain damage in this situation.[5] Although risk factors include vomiting, pain, anxiety, disturbances of the central nervous system and metabolic and endocrine disorders, it has become recognised that any child receiving intravenous fluids or oral rehydration is potentially at risk. The particular risks associated with the post-operative period were highlighted by Arieff who pointed out that plasma levels of vasopressin (antidiuretic hormone, ADH) are elevated in virtually every child in the post-operative period.[5] If such children are given fluids containing less than 140 mmol/1 of sodium there will always be a tendency towards post-operative hyponatraemia.

The complex inter-relationships between multiple factors influencing decisions regarding fluid and electrolyte management in children are described in standard texts. These result in difficulty in establishing simple guidelines for fluid administration in children. A solution containing 0.18% sodium chloride in 4% glucose has commonly been used in paediatric practice and is generally held to be isotonic. However, in the catabolic child the glucose is metabolised rapidly causing the fluid to become hypotonic in vivo, with the potential for significant fluid shifts. If the child is in the post-operative period or in any other situation where there is a high level of circulating vasopressin a situation can arise where excess free water is retained within the circulation. This can be compounded by water effectively administered in the intravenous fluids. This condition has been called "dilutional hyponatraemia" because the "free" water component of the serum has increased, causing dilution of the major cation, sodium. This "free" water will pass rapidly and unhindered across cell membranes with the particular risk of development of cerebral oedema. Children may be at particular risk of brain damage due to increase in intracranial pressure in this situation.[2]

GUIDANCE AND ADVICE

A Working Group in Northern Ireland has developed guidelines (figure), which have been published by the Department of Health, Social Services and Public Safety, and can be downloaded from the internet.[6] These guidelines emphasise that every child receiving intravenous fluids requires a thorough baseline assessment, that fluid requirements should be assessed by a doctor competent in determining a child's fluid requirement, and fluid balance be rigorously monitored. They emphasise the value of accurate measurement of body weight and monitoring of serum urea and electrolytes in any child requiring prescribed fluids after 12 hours, together with the importance of assessment of fluid balance and prescription at least every 12 hours by an experienced member of clinical staff. This assessment needs to take account of all oral and intravenous intake, together with the measurement and recording of all losses (including urine, vomiting, diarrhoea, etc.) as accurately as possible.

While general guidance can be given regarding *maintenance* fluid requirements in children of different weights, these must be assessed in the clinical context of each individual child. Requirements for water and electrolytes should be considered separately and an appropriate solution chosen. Although the baseline maintenance requirement for 2 to 3 mmol/kg/day of sodium can be applied to children of all ages, the amount of water needed varies with weight. It will readily be apparent that this means that the concentration of sodium in the maintenance fluid has to be different for children of different ages and weights. For example, an infant of 5 kg requires 150 ml/kg/day of water, so the daily sodium requirement will be provided by a fluid

any CHILD [illegible] FLUIDS is AT RISK OF HYPONATRAEMIA

INTRODUCTION

- **Any child on IV fluids or oral rehydration is potentially at risk of hyponatraemia.**
- Hyponatraemia is potentially extremely serious, a rapid fall in sodium leading to cerebral oedema, seizures and death. Warning signs of hyponatraemia may be non-specific and include nausea, malaise and headache.
- Hyponatraemia most often reflects failure to excrete water. Stress, pain and nausea are all potent stimulators of anti-diuretic hormone (ADH), which inhibits water excretion.
- Complications of hyponatraemia most often occur due to the administration of excess or inappropriate fluid to a sick child, usually intravenously.
- Hyponatraemia may also occur in a child receiving excess or inappropriate oral rehydration fluids.
- Hyponatraemia can occur in a variety of clinical situations, even in a child who is not overtly "sick". Particular risks include:
  - Post-operative patients • CNS injuries
  - Bronchiolitis • Burns • Vomiting

BASELINE ASSESSMENT

Before starting IV fluids, the following must be measured and recorded:

- **Weight:** accurately in kg. [In a bed-bound child use best estimate.] Plot on centile chart or refer to normal range.
- **U&E:** take serum sodium into consideration.

FLUID REQUIREMENTS

Fluid needs should be assessed by a doctor competent in determining a child's fluid requirement. Accurate calculation is essential and includes:

Maintenance Fluid

- 100mls/kg for first 10kg body wt. plus
- 50mls/kg for the next 10kg, plus
- 20mls/kg for each kg thereafter, up to max of 70kg

[This provides the total 24 hr calculation; divide by 24 to get the mls/hr].

Replacement Fluid

- Must always be considered and prescribed separately.
- Must reflect fluid loss in both volume and composition (lab analysis of the sodium content of fluid loss may be helpful).

CHOICE OF FLUID

- **Maintenance fluids** must in all instances be dictated by the anticipated sodium and potassium requirements. The glucose requirements, particularly of very young children, must also be met.
- **Replacement fluids** must reflect fluid lost. In most situations this implies a minimum sodium content of 130mmol/l.
- **When resuscitating** a child with clinical signs of shock, if a decision is made to administer a crystalloid, normal (0.9%) saline is an appropriate choice, while awaiting the serum sodium.
- The composition of oral rehydration fluids should also be carefully considered in light of the U&E analysis.

Hyponatraemia may occur in any child receiving any IV fluids or oral rehydration. Vigilance is needed for all children receiving fluids.

MONITOR

- **Clinical state:** including hydrational status. Pain, vomiting and general well-being should be documented.
- **Fluid balance:** must be assessed at least every 12 hours by an experienced member of clinical staff.

<u>Intake:</u> All oral fluids (including medicines) must be recorded and IV intake reduced by equivalent amount.

<u>Output:</u> Measure and record all losses (urine, vomiting, diarrhoea, etc.) as accurately as possible.

If a child still needs prescribed fluids after 12 hours of starting, their requirements should be reassessed by a senior member of medical staff.

- **Biochemistry:** Blood sampling for U&E is essential at least once a day - more often if there are significant fluid losses or if clinical course is not as expected.

The rate at which sodium falls is as important as the plasma level. A sodium that falls quickly may be accompanied by rapid fluid shifts with major clinical consequences.

Consider using an indwelling heparinised cannula to facilitate repeat U&Es.

Do not take samples from the same limb as the IV infusion.

Capillary samples are adequate if venous sampling is not practical.

Urine osmolarity/sodium: Very useful in hyponatraemia. Compare to plasma osmolarity and consult a senior Paediatrician or a Chemical Pathologist in interpreting results.

SEEK ADVICE

Advice and clinical input should be obtained from a senior member of medical staff, for example a Consultant Paediatrician, Consultant Anaesthetist or Consultant Chemical Pathologist.

- In the event of problems that cannot be resolved locally, help should be sought from Consultant Paediatricians/ Anaesthetists at the PICU, RBHSC.

The Department Of Health, Social Services And Public Safety. Guidance is also available on the Departmental website: www.dhsspsni.gov.uk containing 15 to 20 mmol/1 of sodium. The standard 0.18% saline solution contains 30 mmol/1 and so will adequately provide for this requirement. On the other hand, a child of 40 kg requires 50ml/kg/day, so a solution containing 3 times as much sodium will be needed to provide adequate maintenance sodium. A solution containing 0.18% saline will thus not provide adequate sodium to maintain the normal plasma level in the older child unless there are clinical reasons to limit sodium intake. This would require instead a solution containing 40 to 60 mmol/1. Half normal saline contains 75 mmol/1 of sodium.

Replacement fluids must reflect fluid loss, and in most situations this will imply a minimum sodium content of 130 mmol/1. This must be considered and prescribed separately, reflecting the fluid loss in both volume and composition. In some situations laboratory analysis of the electrolyte content of the fluid lost may be helpful.

It is important to remember that, while children receiving intravenous fluids are at particular risk, children receiving oral rehydrating fluids may also be at risk as these are invariably hypotonic. Vigilance is therefore required for all children receiving fluids. Medical and nursing staff need to be aware of risks in this situation, and of early signs of developing cerebral oedema such as vomiting, deteriorating level of consciousness or headache before more serious symptoms such as seizures occur, as deterioration to this extent is associated with significant morbidity and mortality.

Particular attention needs to be given to fluid management in specific situations such as diabetic ketoacidosis, renal failure and in the newborn, but attention to detail in assessment and management of intravenous and oral fluids in all children where these are required for medical or surgical reasons is essential to minimise the risks associated with hyponatraemia. It must be clearly recognized that prevention is quite different from treatment of hyponatraemia. All those working with children must be familiar with good practice to *prevent* hyponatraemia but not all will have the necessary expertise in *treating* a child with hyponatraemia which can be extremely complex. If concern is raised regarding clinical deterioration or biochemical abnormality then advice and clinical input should be obtained from a senior member of medical staff, for example a Consultant Paediatrician, Consultant Anaesthetist or Consultant Chemical Pathologist.

We recommend that complications and critical incidents related to intravenous fluids are reported to the Medicines Control Agency (MCA) in the same way as drug side-effects, by using the "yellow card" system. Fluids are included in the British National Formulary and are under the regulatory authority of the MCA. This will permit a nationwide analysis of the problem and also direct information to clinicians. When one of the deaths locally was reported to the MCA the Agency was asked to consider issuing a "hazard warning" about the use of a solution containing 0.18% sodium chloride in 4% glucose in children following surgery. After due consideration the MCA replied that electrolyte imbalance is a risk with the use of all intravenous solutions. The MCA Working Group on Paediatric Medicines advised that there should be no amendments to product information (personal communication).

CONCLUSION

It is important that all doctors caring for children are aware of current literature and advice in relation to the rare but serious condition known as "Dilutional Hyponatraemia". A complex neuro-endocrine response in susceptible children can occur where the "free" water component of intravenous fluids can cause a sudden and unheralded decrease in the serum sodium concentration. Preventative measures to avoid this potentially fatal condition need to be instituted in all units caring for children.[7]

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