

EDITORIAL

Fluid management in association with neonatal surgery: even tiny guys need their salt

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The practice of giving i.v. fluids as part of routine paediatric care was established during the 1950s, and important initial questions to answer were what type of solution to give and at what infusion rates. In 1957, Holliday and Seger¹ published a seminal manuscript, recommending the well-known '4-2-1 rule', which almost immediately was adopted as a worldwide standard. The composition of a normal i.v. maintenance fluid was however somewhat more difficult to determine but was heavily influenced by the composition of normal breast milk, which has a sodium content in the range of 10–40 mmol litre⁻¹.² Thus, effectively hypotonic glucose solutions with a low sodium content came into wide-spread use maybe best exemplified by the British 4% glucose 0.18% sodium ('four and a fifth').³ The history since the 1950s has shown that the approach described above works sufficiently well in the vast number of routine paediatric cases.

However, using the standard Holliday and Segar volume recommendations paired together with the use of an i.v. solution with a sodium concentration that diverges substantially from that of the extracellular fluid does become a problem in a situation of a neuroendocrine stress response, either provoked by surgery or significant medical illness. The reason for this is that the stress response includes a substantially increased secretion of anti-diuretic hormone (ADH) that will result in retention of free water. A physiologically more appropriate approach during these circumstances is to use a solution with a close to physiological concentration of sodium (120–140 mmol litre⁻¹) combined with the administration of a reduced infusion volume compared with the normal situation (50–70% of normal infusion rate).^{4 5} If not adhering to a more physiological approach, the stage is set for dilutional hyponatraemia that can be life-threatening or even fatal.^{6–11}

The insight that the paediatric use of i.v. low sodium solutions was unsuitable in the context of a stress response and that a sodium content closer to that of extracellular fluid is more appropriate was published as early as 1964.¹² However, since no appropriate i.v. solutions were commercially made readily available by the manufacturers, the regimen of using effectively hypotonic solutions in association with paediatric anaesthesia and surgery has continued in many centres even to

this day. A questionnaire-based study from 2001 reported that 97% of UK-based anaesthetists routinely used effectively hypotonic i.v. solution intraoperatively in children.¹³ A similar study published in 2006, also surveying the UK practice, reported no major change of practice with a majority of anaesthetists still using hypotonic solutions both intraoperatively and after operation (66% and 87%, respectively) and as many as 11% admitted that they even used the same hypotonic solutions for volume replacement.¹⁴

A paramount initiative to set things straight was taken by the French paediatric anaesthesia community in the early 1990s, spearheaded by Murat and colleagues. In a number of clinical studies, they could show that the perioperative use of an i.v. solution made available by the Paris pharmacy (Polyionique B66, 0.9% glucose with sodium 120 mmol litre⁻¹) did keep plasma sodium within the normal range during the postoperative period and did also avoid clinically relevant hypotonic or hyperglycaemia.^{15–17} Furthermore, the use of this type of i.v. solution has also been found considerably safer should there occur unintentional over-infusion or if it would be used for volume replacement.¹⁸ This taken together with a still ongoing UK National Inquiry into the tragic outcomes of the use of hypotonic i.v. solutions in ill children¹⁹ and expert opinion^{3 20–23} has led to new and more appropriate recommendations.^{24–26} Currently, proper i.v. solutions are commercially available in a number of individual European countries and hopefully soon the main manufacturers of i.v. solutions will provide such solutions readily available to clinicians in all European countries.²⁶

Thus, currently the use of an intra- and postoperative i.v. solution containing close to physiological concentrations of sodium is recommended in children >6 months of age.¹⁷ However, until now, data for children 0–6 months of age have been scarce²⁷ and recommendations have mainly been based on extrapolations based on normal physiology combined with the insight that even our smallest children can and will respond with a relevant neuroendocrine stress response when subjected to surgical procedures.^{28 29} Studies focused on neonates and small infants in this context have been largely lacking.

It is therefore with great pleasure and satisfaction that we now can enjoy the results of yet another French initiative, which provide us with much sought after information in this regard. In this issue of the *BJA*, Edjo-Nkilly and colleagues³⁰ report data generated from 34 neonates (0–7 days old) undergoing a variety of neonatal surgical procedures. The main focus of their study was to investigate the effect on plasma sodium in relation to the amount of free water that was administered i.v. during the perioperative period. Despite the inherent problems with standardization associated with this type of study, the authors have been able to provide us with two new and very important pieces of insight in the neonatal context, apart from identifying a 12% overall incidence of postoperative hyponatraemia in this group of neonates.

First, the reduction in plasma sodium correlated only to the amount of free water that is administered intraoperatively and not to the amount of free water administered before operation. This makes sense for two reasons. Based on decades of clinical experience using regular i.v. maintenance solutions containing a low content of sodium, we know that normal children without any major ongoing stress response (as is the case before surgery) will be able to handle such infusions without any risk of hyponatraemia. Thus, the lack of correlation to preoperative free water administration appears intuitively correct. However, as surgery commences, the neuroendocrine stress response will be initiated, including a rapid increase in ADH, which in turn will render the child unable to handle the challenge represented by continued administration of effectively hypotonic solutions. Secondly, intraoperative free water administration in excess of $6.5 \text{ ml kg}^{-1} \text{ h}^{-1}$ was found to be associated with a postoperative reduction in plasma sodium ($\geq 4 \text{ mmol litre}^{-1}$) with a sensitivity and specificity of 0.7 and 0.5, respectively. This provides us with a very useful guideline to how much free water can be allowed during neonatal surgery with regard to the risk of producing clinically relevant postoperative hyponatraemia.

The data now published by Edjo-Nkilly and colleagues lend support for extending the current paediatric consensus regarding intra- and immediately postoperative use of i.v. solutions containing ~1% glucose with a near to normal content of sodium ($120\text{--}140 \text{ mmol litre}^{-1}$)²⁶ to also include infants <6 months of age. Thus, give our little guys their salt during anaesthesia and surgery!

Declaration of interest

P.-A.L. is a member of the *BJA* Editorial Board and is also Section editor/Editorial Board member of *Paediatric Anaesthesia*.

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