Editorial
Inappropriate perioperative fluid management in children: time for a solution?!

PER-ARNE LÖNNQVIST MD DEA FRCA PhD
Associate professor, Paediatric Anaesthesia & Intensive Care, Astrid Lindgrens Children’s Hospital, Karolinska University Hospital, Stockholm, Sweden

Over the years, perioperative fluid management in children has been the focus for considerable interest and debate. Unfortunately, these discussions have not resulted in consensus guidelines and thus, clinical practice varies considerably. The large difference in everyday clinical practice has recently again been pointed out by a survey among members of the Association of Paediatric Anaesthetists of Great Britain and Ireland (APAGBI) (1), where a large number of responding anesthetists still use what can be considered unsuitable, or in some cases even inappropriate, i.v. fluids in this setting.

The risks of using suboptimal perioperative i.v. fluid strategies can be illustrated by a cluster of very unfortunate cases in parts of the UK, where children suffered serious morbidity and even mortality because of severe iatrogenic hyponatremia. The number and severity of these cases has resulted in a national inquiry regarding the circumstances surrounding these cases (2).

One of the first issues that received scientific attention in this context was whether or not glucose needs to be administered to smaller children undergoing surgery. As even small babies are capable of mounting a stress response secondary to surgery, a number of research groups have clearly shown that it is possible to manage the majority of even small pediatric patients by using glucose-free i.v. solutions without the risk of hypoglycemia. However, certain risk categories do exist that still may develop intra- or postoperative hypoglycemia if glucose is not given and many pediatric anesthetists still believe that glucose containing fluids should be used in order to safeguard against such a dangerous situation. Even if a slightly elevated blood glucose level most likely does not cause any harm to the patient, more pronounced degrees of hyperglycemia may cause problems, e.g. osmotic diuresis, increased rate of wound infection, and less favorable outcome in situations where the patients may be at risk for periods of cerebral ischemia (i.e. cardiac bypass surgery and certain neurosurgical interventions).

The next thing that needs to be taken into account is the issue of isotonicity and sodium administration. It is generally regarded that administration of isotonic fluids is preferred in most instances. Thus, to keep glucose containing solutions isotonic only limited amounts of sodium can be added, because the most normally used glucose solutions will in fact only contain $\leq 70 \text{ mmol} \text{ l}^{-1}$ of sodium. However, such glucose containing fluids will only be isotonic in the i.v. bag as they will become effectively hypotonic as soon as the glucose component is transported intracellularly and metabolized when infused. For obvious reasons this will cause hyponatremia, especially if delivered at higher infusion rates. Adding to the risk of hyponatremia and edema formation is the fact that the normal surgical stress response involves an increased secretion of antidiuretic hormone (ADH) which will result in water retention by increased resorption of water in the distal renal tubulus and collecting ducts. This ADH response makes it reasonable to restrict the administration of postoperative fluids by approximately 33–50% compared with normal requirements (3,4). If not, the risk for overhydration and hyponatremia will increase. This situation can even be further compounded if the clinician by ignorance, or even worse based on lethargy, will use boluses of the glucose containing maintenance solution to treat volume deficits instead of appropriate crystalloids or volume expanders. If all the above three factors are combined the stage is set for potentially disastrous overhydration and

Correspondence to: Prof. Per-Arne Lonnqvist, ALB/Karolinska University Hospital Solna, Stockholm S-171 76, Sweden (email: per-arne.lonnqvist@ki.se).
hyponatremia that will result in cerebral edema, brain stem herniation, respiratory arrest, and ultimately death, as exemplified by the tragic cases that are currently under inquiry. Arieff et al. (5) in 1992 published a retrospective study of >24 000 pediatric anesthetics and found an incidence of postoperative hyponatremia of 0.34% with a mortality rate as high as 8.4% of those afflicted (4). These figures clearly show that this serious problem is a much more common complication than many others that we are taking precautions against in our normal daily practice. Arieff (7) has also pointed out that children represent a special risk category with respect to the development of postoperative symptomatic hyponatremia (6) and did already in 1998 publish an excellent editorial on this topic in *Paediatric Anaesthesia* (7).

One would expect that government alerts (8) as well as the communications by Arieff (5–7) mentioned above would have improved the situation over time. Unfortunately, this does not appear to be the case. We published a questionnaire study in *Paediatric Anaesthesia* (9) 5 years ago, describing the perioperative fluids used by mainly Europe-based pediatric anesthetists (APAGBI and ADARPEF members). It is sad to see that 5 years later no apparent change has taken place, as the recent survey by Way et al. (1) shows. This fact clearly illustrates how difficult it is to change people’s mindset and practice in this regard.

So, what can be done to make the situation better? One obvious reaction is that we need to provide more and better information regarding this problem complex. However, previous attempts at this have been crowned with very limited success.

Another option would be to meticulously scan patients to identify potential at-risk patients, to apply frequent sampling protocols intra- and postoperatively for glucose and sodium monitoring, to perform repeated fluid balance calculations including weighing the patient two or more times daily, etc. This would make it possible to nicely individualize care but in the current situation of budget cuts, reduced healthcare personnel and the ever increasing demands put on doctors, I very much doubt that this represents an effective road forward.

What then could be the solution? As often a golden compromise, would in my mind solve the problem. One should create an i.v. solution that does contain a fraction of glucose, so that the risk of unexpected hypoglycemia can be disregarded, but small enough not to cause significant hyperglycemia. At the same time the amount of sodium should be at or at least very close to normal physiologic extracellular levels. Such a high concentration of sodium would safeguard against the development of severe hyponatremia, even if wrongly used for volume expansion. This solution could then be used as the standard perioperative intravenous solution in virtually all pediatric patients as it can be regarded as being almost ‘foolproof’.

As always there is nothing new under the sun. The fact is, this suggested mix has been in front of us since 1991 when Murat et al. (10–12) first described it. The composition of the solution has now been further refined and in 2004 they have provided us with a recipe of an i.v. infusion that contain 0.9% glucose and 120 mmol l⁻¹ of sodium and to the benefit of the children in Paris one of its central pharmacies is now providing the hospitals in the area with this ‘golden compromise solution’ (13).

The crucial factor why this concept has not yet been a flying success lies in the fact that the ‘golden compromise solution’ must be made available ‘off the shelf’ and thus, does not require individual mixing by the anesthetist. As most regions and hospitals do not have the luxury of a dedicated pharmacy that can prepare this infusion fluid on demand, some responsible medical company must take up this idea and make it into a commercially available product. A positive spin-off of the inevitable company marketing process of such a product would also provide an excellent opportunity to inform clinicians about safer strategies for perioperative fluid management in children. As the message this time will be very simple and straightforward (‘use the purpose-made solution and restrict the volume of postoperative infusions’), I personally believe that the chance of people listening and changing their practice is better than ever. So medical companies out there, please provide us with this special perioperative infusion fluid as it will definitely have the potential of saving lives!

References


Accepted 31 August 2006