SPECIAL ARTICLE

European consensus statement for intraoperative fluid therapy in children
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The intraoperative infusion of isotonic solutions with 1–2.5% glucose in children is considered well established use in Europe and other countries. Unfortunately, a European marketing authorisation of such a solution is currently missing and as a consequence paediatric anaesthetists tend to use suboptimal intravenous fluid strategies that may lead to serious morbidity and even mortality because of iatrogenic hyponatraemia, hyperglycaemia or medical errors. To address this issue, the German Scientific Working Group for Paediatric Anaesthesia suggests a European consensus statement on the composition of an appropriate intraoperative solution for infusion in children, which was discussed during a working session at the 2nd Congress of the European Society for Paediatric Anaesthesiology in Berlin in September 2010.

Aim
Recently, several European Associations of Paediatric Anaesthetists changed their recommendations for intraoperative fluid therapy from hypotonic solutions with 5% glucose to isotonic solutions with 1–2.5% glucose. However, currently, such solutions are not commercially available in many European countries. As a consequence, paediatric anaesthetists tend to use suboptimal intravenous fluid strategies that may lead to serious morbidity and even mortality because of iatrogenic hyponatraemia, hyperglycaemia or medical errors. To address this issue, the German Scientific Working Group for Paediatric Anaesthesia suggests a European consensus statement on the composition of an appropriate intraoperative solution for infusion in children in order to facilitate the granting of a European marketing authorisation for such a solution, thereby improving the safety and effectiveness of intraoperative fluid therapy in children.

Background
Maintenance fluid therapy in children has for half a century been based on Holliday and Segar’s recommendations suggesting the use of hypotonic fluids with 5% glucose added. In recent years, many studies and case reports have shown that the routine use of such fluids may lead to serious hyponatraemia or hyperglycaemia and may occasionally result in permanent neurological damage or death. The two main factors for the development of perioperative hyponatraemia are first the stress-induced secretion of antidiuretic hormone leading to an impaired ability to excrete free water and second the administration of hypotonic solutions as a source of free water. Hyponatraemia leads to an influx of water into the brain, primarily through glial cell swelling, initially largely preserving neuronal cell volume. This process will ultimately lead to cerebral oedema, brain stem herniation and death. Prepubescent children are a high-risk group for a poor outcome associated with hyponatraemic encephalopathy because of the presence of a high brain size to cranial vault ratio and reduced Na-K-ATPase activity compared to the adult brain.

Infants also are at increased risk of perioperative lipolysis and hypoglycaemia due to a higher metabolic rate compared to adults. If hypoglycaemia does occur, this will induce a stress response as well as alter cerebral blood flow and metabolism. Permanent neurodevelopmental impairment can result if hypoglycaemia goes unrecognized and untreated. However, intraoperative administration of 5% glucose solutions for prevention of hypoglycaemia will often result in hyperglycaemia due to
stress-induced insulin resistance. Hyperglycaemia may also be detrimental to the brain due to an accumulation of lactate, a decrease in intracellular pH and subsequently compromised cellular function in the context of global or focal cerebral ischaemia. Last, the administration of glucose-free solutions increases the risk of lipolysis with the release of ketone bodies and free fatty acids. Against the above mentioned background, the use of isotonic fluids with lower glucose concentrations (i.e. 1–2.5%) represents a well accepted compromise between avoiding hypoglycaemia/lipolysis and hyperglycaemia in children. Unfortunately, a European marketing authorisation of such a solution is currently missing and nationally approved solutions or solutions produced by local pharmacies are only available in a few European countries:

- France: Polyionique B66 (Central Pharmacy, Paris, France).
- Switzerland: Ringer-Laktat mit Glucose 1%/Ringer-Laktat mit Glucose 2% (Laboratorium Bichsel, Interlaken, Switzerland).
- Belgium: Hartmann’s solution with Glucose 2.5% (Baxter, Lessines, Belgium).
- Austria: ELO-PAED balanced mit 1% Glucose (Fresenius Kabi Austria, Graz, Austria).
- Germany: Elektrolyt-Infusionslösung 148 mit Glucose 1 PÄD (Serumwerk Bernburg AG, Bernburg, Germany).

Consensus statement

An appropriate solution for intraoperative infusion in children should have an osmolarity and sodium content close to the physiologic range in order to avoid hyponatraemia, an addition of 1–2.5% glucose in order to avoid hypoglycaemia, lipolysis or hyperglycaemia and should also include metabolic anions (i.e. acetate, lactate or malate) as bicarbonate precursors to avoid acid–base balance disturbances (i.e. hyperchloraemic acidosis). The intraoperative infusion of isotonic solutions containing 1–2.5% glucose in children is considered well established use in Europe. The granting of a European marketing authorisation for such a solution is highly recommended and will improve the safety and effectiveness of perioperative fluid therapy in children.

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References