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S-J Hyde, M G Coulthard, B Jaffray, et al.

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S-J Hyde,[1] M G Coulthard,[2] B Jaffray,[3] M E Vallely,[3] S M Harding[3]

[1] Medical School, Newcastle University, Newcastle, UK; [2] Department of Paediatric Nephrology, Royal Victoria Infirmary, Newcastle, UK; [3] Department of Paediatric Surgery, Royal Victoria Infirmary, Newcastle, UK

Correspondence to: Dr Malcolm G Coulthard, Department of Paediatric Nephrology, Royal Victoria Infirmary, Newcastle NE2 2RE, UK; malcolm.coulthard@nuth.nhs.uk

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ABSTRACT

We had found that twice-normal saline (2NS) antegrade continence enema (ACE) lavages were better than with normal saline (NS) but caused unpleasant symptoms. We therefore undertook a double-blind crossover study comparing water, NS and 2NS in four children. NS produced no disturbances, but water caused a transient fall in plasma osmolality of 7.3 mosmol/kg at 20 min, and falls in urine sodium and osmolality. With 2NS, the plasma sodium rose by 2.5 mmol/l, the plasma proteins rose by 2.3 g/l and the lavage fluid sodium fell, suggesting that about 10 ml/kg of plasma water had moved into the colonic lumen, and two subjects became thirsty. Five other children did home testing. Their home-produced saline was too concentrated and varied widely, and they found that 30 ml/kg of NS produced the same washout result as 20 ml/kg of 2NS. Carefully made-up NS should be used for lavage, increasing volumes if necessary.

Antegrade continence enemas (ACEs) allow colonic lavage to manage intractable faecal incontinence, predominantly in children.[1] Although various lavage fluids have been used, none has been rigorously tested. Reports have warned of severe hyperphosphataemia and hypocalcaemia with phosphate washouts,[2] hyponatraemia with tap water,[3 4] and hypernatraemic death using twice-normal saline (2NS).[5] Our children used 20 ml/kg of home-made normal saline (NS) initially, and if this produced poor results they changed to 2NS, usually with benefit. However, some then complained of feeling unwell or thirsty during some or all of their hypertonic washouts. We hypothesised that the 2NS may have resulted in the osmotic movement of plasma water into the bowel lumen, giving an increased lavage volume, but also transiently reducing intravascular volume. We therefore investigated the pathophysiological effects of using hypotonic, isotonic and hypertonic lavage fluids. As a result of these findings, we also asked families to test at home whether lavage with NS could be as effective as using 2NS if the volume was increased appropriately, and we measured how precisely parents made up NS and 2NS solutions at home.

THREE FLUIDS STUDY

We aimed to study six children using a double-blind crossover design on 3 separate days (spaced 2 days apart to prevent carry-over), while they performed their usual ACE washout technique, but using 20 ml/kg of commercially made solutions of NS, 2NS or water. The study was approved by the ethics committee and required the signed consent of the parents and assent of the children, all of whom had complained of having symptoms when they used 2NS at home.

The study protocols needed to be complex to detect rapid or transient changes (most complaints of thirst occurred about 20 min into lavage), making serial clinical and laboratory observations necessary. Because this made it a relatively arduous study, we only approached children over 10 years of age, and recruited the smallest number we estimated would be needed to detect an effect. We therefore invited six children, each randomised to receive one of the six possible fluid administration sequences.

At the start (0 time), and at 20, 40 and 60 min, we measured pulse, blood pressure, central and peripheral (toe) temperature, and capillary refill time. Blood was sampled at 0, 20 and 60 min from a cannula inserted at −20 min using local anaesthetic cream, and the following were assayed: haemoglobin, creatinine, electrolytes, total protein, albumin, osmolality, renin activity and arginine-vasopressin concentration. Children were weighed before and after lavage, and had urine collected for creatinine, electrolytes and osmolality, allowing fractional excretions of water and sodium to be calculated. The washout effluent was measured, and assayed for sodium and osmolality. Symptoms were recorded throughout, and families reported whether there was faecal incontinence over the next day. Discontinuous variables were analysed using Fisher's exact test. Within-subject continuous data were analysed with paired t tests, and between-subject results with unpaired t tests.

Four children (two girls) aged 10.2–18.2 years completed the study, 1.8–4.1 years after their ACE surgery. One child withdrew after a failed cannulation, and one was excluded because some specimen tubes were lost. No differences were detected in clinical observations, or haemoglobin, renin, creatinine or arginine-vasopressin either with time or between the different fluids. Changes were seen transiently at 20 min for some parameters (table 1). We consider these for each fluid below.

NS produced no detectable changes, but 20 min after lavaging with water the plasma osmolality fell by 7.3 mosmol/kg (a lower level than for NS, $p = 0.02$), and the urine sodium and osmolality fell, which did not happen with the other fluids. With 2NS, the 20 min plasma sodium rose by 2.5 mmol/l (a higher level than for NS, $p = 0.03$) and the plasma proteins rose by 2.3 g/l.

The sodium concentration in the NS effluent lavage fell a little from a mean (SD) of 153 (1) mmol/l to approximate the plasma concentration of 138 (6) mmol/l ($p = 0.04$), and did not change significantly in the water. By contrast, the 2NS lavage effluent sodium concentration fell by a third from 311 (9) mmol/l to 209 (51) mmol/l ($p<0.02$), which could be due to sodium absorption from 2NS, or to water shifting from the child's

Table 1 Changes after 20 min of lavage in those variables in which statistically significant differences were found, using water, normal saline (NS) or twice-normal saline (2NS), in a study of four children with antegrade colonic enemas

Variables	Water, mean (SD)	NS, mean (SD)	2NS, mean (SD)
Plasma sodium (mmol/l)	−0.8 (1.3)	−1.3 (1.3)	2.5 (0.5)***
Plasma osmolality (mosmol/kg)	−7.3 (3.6)**	1.0 (1.4)	3.0 (3.5)
Plasma proteins (g/l)	2.5 (2.4)	1.8 (1.3)	2.3 (1.3)*
Urine sodium (mmol/l)	−164 (100)*	−58 (80)	12 (58)
Urine osmolality (mosmol/kg)	−550 (404)*	−318 (366)	−36 (192)

Differences between 0 and 20 min values (paired t tests): *$p \leqslant 0.05$, **$p = 0.03$, ***$p = 0.02$.

plasma into the colonic lumen, or a combination. For the fall to be entirely due to sodium absorption, the quantity absorbed would have had to have been 102 mmol/l×0.02 l/kg = 2 mmol/kg. Assuming a sodium space of approximately 0.5, this would increase the plasma sodium by about 4 mmol/l, compared to the 2.5 mmol/l recorded, making this hypothesis unlikely. For water movement to be entirely responsible would require a shift of (102/209)×20 = 9.8 ml/kg of lavage fluid, causing approximately 1% dehydration, and an increase in lavage fluid volume of about 50%. Thirst can be an early symptom of dehydration, and was reported by two children, and only during 2NS lavage.

HOME TESTING OF NS AND 2NS LAVAGES

Five other families whose children used lavages with home-produced 2NS were invited to compare using their usual regimen with using NS at a 50% larger volume, in an open study of five lavages with each fluid, at home. The families also collected the 10 lavage fluid samples for sodium estimation, which averaged about 45% higher than the target value for both solutions, and also showed wide within-family variation (table 2).

Detailed diaries showed that the duration and ease of the washouts, and the faecal clearance and any subsequent soiling were no different between the two regimens, and there was no consensus that one or other solution was better.

DISCUSSION

ACE procedures improve the quality of life for many children. We have demonstrated that lavaging with isotonic NS does not perturb them clinically or biochemically, but that water and 2NS do. The changes produced using water suggest that some is absorbed from the bowel and excreted as urine. The changes

Table 2 Sodium concentrations of normal saline (NS, 150 mmol/l) and twice-normal saline (2NS, 300 mmol/l) lavage solutions that were made up by families at home

Solution	Concentration (mmol/l), mean (range)	Percentage of target, mean (range)
NS (150)	215 (145–285)	144 (97–190)
2NS (300)	437 (317–590)	146 (106–197)

seen with 2NS lavage fluid are probably mostly due to the osmotic shift of plasma water into the colon, and only partly to sodium moving into the plasma. This fluid shift increases the effective washout volume, making it more effective, and simultaneously causes dehydration and thirst. Because this study had only four completed cross-overs, it may have missed subtle changes, but it has highlighted some important effects.

The changes we detected were too mild to induce measurable clinical changes other than thirst, or increases in renin activity or arginine-vasopressin release. However, children with ACEs perform washouts regularly, including when they have intercurrent infections that may predispose them to dehydration. The side-effects of hypertonic lavage are mild, but they are also unnecessary.

The hypothesis that the benefit of 2NS over NS lavage is mediated entirely through its increased effective intra-colonic volume is strongly supported by the families who tested 20 ml/kg of 2NS against 30 ml/kg of NS at home. This study also showed how imprecisely families made saline, probably by measuring salt with heaped domestic teaspoons. They now use only 5 ml spoons, scraped level (containing 4.9 g).

In conclusion, we suggest using only NS for ACE lavage, carefully made, commencing with 20 ml/kg but increasing to 30 or 40 ml/kg in some children. There is no logical basis for using hypertonic solutions, and potential hazard in doing so.

Competing interests: The authors declare that the ideas and writing of this manuscript were entirely their own, and that there are no competing interests.

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