

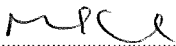
This is a report by
Dr Malcolm Coulthard

requested by the *Inquiry into Hyponatraemia-Related Deaths*

in response to 3 papers (Paut, Sicot, Auroy) provided to me
following the experts' meeting on 09/03/12

15/03/2012

Dr Coulthard; Hyponatraemia-Related Deaths Inquiry.

Signed 

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Cases of accidental intravenous water overload in the literature

The 2 articles translated from French by the Inquiry Team and provided for me on 13/03/12 are very instructive in allowing the quantities of fluid administered to Adam Strain case to be placed into a perspective. The paper by Sicot & Laxenaire¹ describes 1 child, and Paut et al² describe 7 who were accidentally administered hyponatraemic intravenous fluids in excess. An additional paper adds a further case.³

Sicot's paper also provides a useful clue about the impact of the sudden development of dilutional hyponatraemia on the possible appearance of the cerebral oedema it may induce.¹

Volumes of water administered

All 9 children reported to have had excessive IV hyponatraemic fluid were of similar size to Adam. They were all administered their fluids as 5% dextrose, that is as free-water in respect to its sodium content, whereas Adam was given an excess of 0.18% sodium chloride with 4% dextrose, or 1/5th normal (N/5) saline. However, each litre of N/5 saline infused is precisely equivalent to being given 800 ml of 5% dextrose (that is free-water) in parallel with 200 ml of physiological saline. Thus, to make a valid direct comparison between Adam and the other children it is simply necessary to express them all in terms of the quantities of free-water administered.

One of Paut's cases (2) does not provide any estimates of the volume of fluid administered. One (5) estimates it as being between 1 and 1.5 litres, so I have taken a figure of 1,250 ml to represent this case. One (3) does not give a precise infusion time, estimating it as less than 10 hours, so I have used a figure of 9 hours for this case.

This table compares these cases, presented in order of increasing water administration per kg:

reference	age years	weight kg	free water volume, ml	administration time, hours	water given ml/kg/hr	outcome
Auroy case	4	15	1200	25	3.2	died
Paut, case 7	4	20	750	10	3.8	lived
Paut, case 4	2	14	1500	18	6.0	lived
Paut, case 3	5	17	1000	9**	6.5	died
Sicot case	4	15	500	5	6.7	died
Paut, case 5	3	16	1250*	11	7.1	lived
Paut, case 1	3	14	1375	12	8.2	lived
Paut, case 6	4	15	1500	6	16.7	lived
ADAM STRAIN	4	19	1200***	3	21.1	died
			600***	1	31.6	

* = estimate from statement that 'she recieved 1 to 1.5 litres'.

** = estimate from statement that fluid given in 'less than 10 hours'.

*** = Free water administered in 1.5L and 0.75L of 0.18% sodium chloride + 4% dextrose solution.

It is clear that the rate per kg at which Adam was infused with free-water was greater than all the other cases, and very much greater than most of them.

The 2 entries for Adam indicate the least dramatic case, if the time from 7 am to 10 am when he received 1.5 litres of N/5 saline is counted as a single time period, and the more dramatic one in which the first hour is considered separately from the next 2 hours. Since the fluid was delivered intravenously, that is instantaneously into his plasma rather than given by mouth and absorbed slowly, the latter is the true situation. At 8 am, he had been given free-water at approximately twice the rate previously recorded in the literature, and between 5 and 10-times faster than the other 3 children who died of cerebral oedema as a consequence.

Rates of fall in the plasma sodium concentrations

It is not possible to compare the rates of fall in plasma sodium concentration between these children because none of the published cases had a baseline value measured, only a figure for the hyponatraemic state. However, it is of interest that if they are all assumed to have started from the same normal figure, Adam's rate of fall of plasma sodium concentration is the most rapid.

Pattern of cerebral oedema

The child reported by Sicot had a CT scan soon after the diagnosis of hyponatraemic encephalopathy. She was declared to be brain-dead about 5½ hours after the diagnosis was made, and though it is not precisely stated when the CT was undertaken, it is likely that it was prior to that, to assist in the assessment of her cerebral status. The CT was described as showing an engorged **cerebellum**, that is specifically involvement of the **posterior brain**.

She 'died'^(see footnote1) 22.7 hours after the diagnosis of hyponatraemia, and subsequently underwent an autopsy which is described as confirming the clinical diagnosis of cerebral oedema with herniation. The precise details of the brain findings are not supplied, such as the distribution of the macroscopic swelling within the brain, and no histology is mentioned.

The similarities between this case and Adam's is very striking, including the timings of the main events of diagnosis, CT and withdrawal of medical support. Would it be helpful if the authors of this article could be contacted to discover if any more detailed information might be available which could be informative in our understanding of Adam. In particular, is the CT scan available to compare, are there any more detailed descriptions or photographs of her brain, and is there any histology described or even slides available for review?

References

1. Sicot C, Laxenaire M-C. Décès d'une enfant par encéphalopathie hyponatrémique dans les suites immédiates d'une amygdaléctomie. *Annales Françaises d'Anesthésie et de Réanimation* 2007;26:893-96.
2. Paut O, Rémond C, Lagier P, Fortier G, Camboulives J. Encéphalopathie hyponatrémique sévère après chirurgie pédiatrique : analyse de sept cas cliniques et recommandations pour un traitement et une prévention efficaces. *Ann Fr Anesth Réanim* 2000;19:467-73.
3. Auroy Y, Benhamou D, Pequignot F, Jouglé E, Leinhardt A. Hyponatraemia-related death after paediatric surgery still exists in France. *British Journal of Anaesthesia* 2008;101:741.

¹ Technically, the time of death is the time at which the second brain-death tests are completed, and the child is declared brain-dead. In this context, 'died' in the paper presumably refers to the time that her bodily functions ceased.

Expert Witness Declaration

I Malcolm Coulthard DECLARE THAT:

- 1) I understand that my duty in providing written reports and giving evidence is to help the Court, and that this duty overrides any obligation to the party by whom I am engaged or the person who has paid or is liable to pay me. I confirm that I have complied and will continue to comply with my duty.
- 2) I confirm that I have not entered into any arrangement where the amount or payment of my fees is in any way dependent on the outcome of the case.
- 3) I know of no conflict of interest of any kind, other than any which I have disclosed in my report.
- 4) I do not consider that any interest which I have disclosed affects my suitability as an expert witness on any issues on which I have given evidence.
- 5) I will advise the party by whom I am instructed if, between the date of my report and the trial, there is any change in circumstances which affect my answers to points 3 and 4 above.
- 6) I have shown the sources of all information I have used.
- 7) I have exercised reasonable care and skill in order to be accurate and complete in preparing this report.
- 8) I have endeavoured to include in my report those matters, of which I have knowledge or of which I have been made aware, that might adversely affect the validity of my opinion. I have clearly stated any qualifications to my opinion.
- 9) I have not, without forming an independent view, included or excluded anything which has been suggested to me by others, including my instructing lawyers.
- 10) I will notify those instructing me immediately and confirm in writing if, for any reason, my existing report requires any correction or qualification.
- 11) I understand that;
 - 11.1) my report will form the evidence to be given under oath or affirmation;
 - 11.2) questions may be put to me in writing for the purposes of clarifying my report and that my answers shall be treated as part of my report and covered by my statement of truth;
 - 11.3) the court may at any stage direct a discussion to take place between experts for the purpose of identifying and discussing the expert issues in the proceedings, where possible reaching an agreed opinion on those issues and identifying what action, if any, may be taken to resolve any of the outstanding issues between the parties;
 - 11.4) the court may direct that following a discussion between the experts that a statement should be prepared showing those issues which are agreed, and those issues which are not agreed, together with a summary of the reasons for disagreeing;
 - 11.5) I may be required to attend court to be cross-examined on my report by a cross-examiner assisted by an expert;
 - 11.6) I am likely to be the subject of public adverse criticism by the judge if the Court concludes that I have not taken reasonable care in trying to meet the standards set out above.
- 12) I have read Part 35 of the Civil Procedure Rules and the accompanying practice direction including the "Protocol for Instruction of Experts to give Evidence in Civil Claims" and I have complied with their requirements.
- 13) I am aware of the practice direction on pre-action conduct. I have acted in accordance with the Code of Practice for Experts.

Statement of Truth

I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

Signed  Dr Malcolm Coulthard

Dated 15/3/12 15/03/2012

Dr Malcolm Coulthard, BSc, MB BS, DCH, FRCP, FRCPCH, PhD