Notes of consultation - 14 June 1996

Re: Strain Inquest

In attendance:- Dr G A Murnaghan
Dr J Gaston
Dr R Taylor
Dr M Savage - joined the consultation after some 10-15 mins
Mr G D H Brangam
Mrs H Neill

Dr Taylor provided a textbook "Intravenous Technique and Therapy" by A A Gilbertson. This textbook describes one-fifth saline as an isotonic solution.

It was pointed out that the Coroner's finding for the cause of death would concur with the autopsy finding unless this was successfully challenged during the Inquest. Dr Taylor's concern was whether accepting the phrase impaired cerebral perfusion would leave us open to the charge that we should have realised this was occurring and dealt with this problem.

He would accept the word hyponatraemia but was concerned about describing this as dilutional as he feels one cannot explain how the hyponatraemia occurred. There is no evidence in other organs of oedema.

It was explained that in a child there is little space in the head for expansion of the brain. Also there is no evidence that this child was more at risk than any other child.

Mr Brangam said he did not feel that accepting the autopsy cause of death was tantamount to an admission of any sort and he also pointed out that it would appear that no-one has the truth for how this event occurred. It was confirmed that the monitoring guidelines obtained are the correct ones.

Dr Taylor explained that if water is in a vein, the red blood cells will absorb that water and burst. To prevent this type of occurrence they use an isotonic solution and he pointed out again that saline and dextrose together is an isotonic solution. Hartmanns solution is also isotonic.

During the procedure the child received 1,500 mls of the saline solution in three 500 mls bags, one 500 mls bag of Hartmanns solution, 1,000 mls of plasma HPPF given in two 400 and one 200 supply and packed cells. There is no volume on the packed cell bags but these were probably between 200 and 250 mls.

To replace blood loss one must provide 2½ times the volume of blood lost.

On arrival in theatre Dr Taylor was concerned that the child may have been dehydrated. His concern for the transplant operation was that if the kidney was in place quickly there must be enough fluid to properly perfuse it. Normally the kidney would be in place in around an hour.

Generally for surgery one would hope to replace half of the fluid deficit in the first hour, a quarter in the second hour and a quarter in the third hour. During this procedure judging by

the CVP and BP Dr Taylor felt that he was not ahead of the fluid requirement and at 9.30am he started to give the Hartmanns. He pointed out that the Hartmanns may not have been necessary if the kidney had been in situ quickly. The first packed cell was given after the blood gas readings had been checked. It is generally the situation that they prefer not to give blood if this is avoidable particularly with children as it may contain viruses.

Dr Taylor mentioned the analogy of a colander in that the more fluid you put in the more pours out.

His figures of fluid to be given were based on reasonable actions at the time.

Normally this child was receiving 1,500 mls of fluid feed during the night up until around 8.00 or 9.00am. On the morning of surgery the fluid feed was stopped at 5.00am and the child had only therefore received 900 mls of fluid feed. There was therefore a deficit of 600 mls.

His urine output was assumed to be fixed but was not measurable as the child was in nappies. However over a period of time the child had been receiving 2,100 mls of fluid per day and his weight was steady so therefore his fluid input and output were balanced.

Usually the child received a low sodium feed ie 3 milimoles of sodium per 100 mls of feed. This is why the one-fifth normal saline was used as it had the same sodium concentration as his feed would have had. He was therefore receiving the same sodium concentration but less fluid.

It was pointed out that one would not routinely catheterise patients going to theatre simply to measure their urinary output.

To maintain fluid one requires 4 mls per kilo of weight per hour for the first 10 kilos which would equal 40 mls per hour plus
2 mls per kilo per hour for the next 10 kilos which would equal 20 mls per hour
therefore for maintenance one requires 60 mls per hour for a normal child.

This child was passing large quantities of urine, perhaps up to 100 mls per hour of dilute urine ie low in sodium.

His maintenance requirements were therefore :-

100 mls per hour	To compensate for urinary output
60 mls per hour	For metabolism
160 mls per hour	Total requirement
Less 10-20 mls per hour	Urinary output of a normal child
150 mls per hour	Total fluid requirement

Dr Taylor pointed out it was very possible that this kidney could have been in place within an hour. Therefore one needed to have the child adequately perfused to take the new kidney ie he needed to be pre-loaded with fluids so that the kidney could be properly perfused and would not fail initially. Failure of the new kidney is particularly likely in a child especially if

there is a lack of fluid and there is a child giving out large quantities of urine. Pre-load is a standard term used in relation to fluids for kidney transplants.
In this case the kidney was in at around 9.30am. The vein was in and the arteries were being finished. At this stage Dr Taylor did a blood gas assessment and based on the results of this then started to give the blood. Once the blood was being put through the clamps were released and further blood was given at a later stage.

The kidney was not working and it was felt that more fluids were required.

The CVP readings although showing as 17 were felt to really provide a base of 12 because of the gradient between the jugular and the heart which was assessed at around 5 cms. For this procedure one would push up the CVP as high as one would dare ie around 5 cms. Therefore one would allow it to go up to 22 when starting with the base of 17.

Dr Taylor is adamant that the fluid being used was isotonic and not hypotonic. He did start to indicate that a dextrose solution which is initially isotonic can become hypotonic in the body.

He discussed the alternatives:-

1. No dextrose provided. This child was used to overnight feeding and therefore produced enough insulin to keep the sugar levels under control at night. He was therefore producing high insulin levels at night and if not given food ie dextrose then his sugar levels would be severely effected by the high insulin levels and would drop very low. It was asked whether there was an opportunity to do the electrolytes when the child was in theatre and it was confirmed that the opportunity was certainly there. However, this procedure was planned to last 1-1½ hours. A blood result taken at the start of the procedure would not have been back from the labs for perhaps 1-1½ hours so the procedure would have been almost complete leaving no opportunity to act on any results received.

There was also no reason to expect the sodium level to need to be checked and it would not be normal to send off for electrolyte tests at this stage. In the ward the child had been "screaming and yelling" and it wasn't possible to do the test. The child has been receiving the same sodium levels and it was not anticipated that there would be any change in those so there was no reason to do the blood electrolyte tests.

2. Another alternative to the solution given would have been to use 5% dextrose with normal saline. However this child was not passing normal saline so the lower concentration sodium was used. At the end of the procedure the child's blood sugar was 4 which is at the low end of normal. Had he not been given large volumes of food during the procedure then his blood sugar levels would have been very low at the end of the procedure and he would have suffered brain damage as a result of this.

The low haematocrit level could be explained either by blood loss or over transfusion of water. If this was explained by an over transfusion of water one would have expected the haemoglobin level to be very high at the end of the procedure whereas in fact it was normal at the end of the procedure suggesting that the haematocrit low level had been due to blood loss.

The blood loss was measured as approximately 1,200 mls. Only 500 mls of packed cells were given but these actually are equivalent to double the amount of fluid.

It was pointed out that it was of vital importance that one was not able to measure the urine output during the procedure as the bladder was open. Normally one would be able to measure urinary output during operation every 5mins except for a short period when the bladder was open. However during this procedure the bladder was opened immediately and was opened for some 2 hours so it was not possible to measure the urinary output and this child was known to have high urine output.

It was also pointed out that some of what was thought to be blood loss could in fact have been a mixture of urine and blood. However, the haemoglobin at the end of the procedure was fine showing that the sums to compensate for this had been correct.

Dr Alexander concludes that there was dilutional hyponatraemia but he had not considered the fluid deficit in drawing this conclusion. He has looked at this as if it was the quantity of fluid going in a normal situation into a sponge but this was not a normal situation.

Dr Gaston pointed out that there is very little literature on this subject. He said to provide the one-fifth normal saline solution was providing the same sodium concentration as the child had previously been receiving in the same type of fluid as the child was used to. This child was not retaining fluid as his output was high.

It was briefly referred to that there is a move in North America away from providing dextrose. Dr Taylor confirmed that they would generally not use dextrose in babies over 6 months of age.

Dr Savage commented that one could not argue against the point that there was hypernatraemic fluid overload although there was correct logic in how the fluid calculations were done.

Dr Taylor was very strongly of the view that there had not been a fluid overload.

Dr Gaston felt there were two main issues to consider:-

Firstly, the issue of volume replacement which he felt had been appropriately covered and the calculations had been reasonable, and
Secondly, was this the most appropriate fluid to use. The other options being 10% dextrose and saline which was not appropriate as this child was not passing normal urine or Hartmanns which was not appropriate either. However obviously the fluids provided had not been correct but one does not know why.

Again Dr Taylor was concerned to say that one could not conclude that there had been fluid overload and it was confirmed that this phrase would not be used.

Mr Brangam said that the issues he would wish to take Dr Sumner through would be as follows:-

1. The calculations.
2. The bladder disadvantage.
3. The CVP and the false readings.

4. Whether there was some unforeseen reason why this child had an accumulation of fluid. Again Dr Taylor referred to the issue of overload and said if there was overload then there would be heart failure and on x-ray the child's heart was not enlarged so clearly there had been no fluid overload. What had occurred was that fluid had sequestered in the brain. There was a higher concentration in the brain of sodium than elsewhere and the child then coned. However, what had been done was reasonable. This child got no free water, every fluid used contained salt.

There had also been a query raised that there was a delay in providing blood replacement. The doctors considered the following to be of guidance:-

If one has lost 10% of blood volume then you could provide a drip of platlets and fluid.
If 15-20% of blood volume was lost then one could give blood.

However it was felt not to be as clear cut as to when one would start to replace the lost blood volume and it was commented that some people would bleed down to 30% prior to surgery. They said that the anaesthetist monitoring the situation would look at all factors and may not rush straight in to replace blood depending on the situation.

The Doctors pointed out that the mother in this situation needs to understand that the child did not drown. It was also pointed out that the volume of fluids provided here was typical of the volume of fluids provided in many situations for children, for example, for sepsis they may in fact give as much as 1 litre of fluid an hour.

A query was also raised about whether the new kidney had been properly perfused. The kidney was not performing well and it was felt that more fluids were required. It was pointed out that one can get a situation where the new kidney just simply does not work and in fact perhaps 5-10% of transplanted kidneys will not work. During the surgery when this kidney was failing to operate a needle was put into the artery and no blood came out and clearly the kidney was not working when the operation site was closed however, the performance of the kidney was no longer relevant at this stage.

Again the Doctors were concerned to point out that this was a polyuric child who was still putting out urine from his own kidneys and this made pre-loading of fluids all the more important to ensure that there was additional fluid to cope with output from the new kidney if it was working immediately on being placed insitu.

Mr Brangam pointed out that Dr Sumner's conclusion is that on the balance of probabilities the oedema was caused by hypernatraemia and does not put the case any more strongly than this. It was felt that Dr Alexander had somewhat muddied the waters and that the article by Arieff was not particularly relevant.

What the Doctors need to do at the Inquest is to explain what was done and why.

Dr Taylor is to write out a document reiterating the points of what was done and why and is to fax this to Mr Brangam over the weekend.

Dr Taylor pointed out that his practice would tend to be to have the CVP on a pole and to keep the transducer well away from the dialysis tube.

He also pointed out that there seemed to be some suggestion in the reports that the fluids had perhaps been given via the neck. He pointed out that this was not the case. All the fluids were given into the arm and there were no fluid tubes leading to the brain.

When asked if the central line would ever be used for giving fluid he said that generally one would prefer not to do this but if it was the only line available then it may have to be used but that was not the case with this child.

When asked the question, if it happened again what would one do differently and would they choose the same fluid again? Dr Taylor said he would have to balance between the glucose and salt paying attention to the sodium levels, fluid balance and blood sugar levels.

It was also pointed out that within the UK, nine children have died with hyponatraemia following renal transplant and the Doctors would wish to propose that UK Nephrologists should look into this matter.

Again it was pointed out that for some reason this child had higher sodium levels in the brain than elsewhere in the body so fluids administered where absorbed into the brain to try to balance the sodium levels.

The Doctors are to meet at the Crumlin Road on Tuesday at 9.15am in the Main Hall.

The issues raised by the two experts for the Coroner are really in essence:-

1. Dr Sumner has raised the volume issue, and
2. Dr Alexander has raised the hypernatraemia issue.

As an aside it was mentioned that Dr Coppel would routinely give a 1,000 mils of dextrose on arrival in theatre but it was felt that this was an issue which should not be raised.

Dated this day of 1996

HN/GMcC

Notes of Inspection of Equipment

Re: Strain Inquest

At: The Royal Belfast Hospital For Sick Children

Date: 14 June 1996

The monitor shows heart rate, arterial pressure, percent saturation, CVP and a mean pressure all shown as beat to beat figures.

There are default alarms on the screen with the CVP alarms at 20 and minus 5. However, the alarm had been suspended in this case so did not go off even though the CVP readings went above 20.

There is also a trend facility to enable the trends over a particular period to be reviewed. One would not routinely print out for every screen but if the alarms go off the paper trace can be printed as a one off. Only the senior registrars and consultants would adjust the monitor.

The CVP attachment was then viewed. The line can be flushed with saline with a small piston like attachment. The pump for the central line administers heparin and saline at 1 mil per hour. This is a high concentration at a low rate designed to prevent the tip of the line from clotting and is not intended for the patient in any respect. Dr Taylor would have the transducers, arterial and CVP clipped onto the drip stand rather than attached to the table. In either situation when the table surface, that the patient is lying on, is tilted the CVP would have to recalibrated and indeed in this particular case the table was moved and Dr Taylor recalibrated the settings.

There are three sizes of central line available, 5 cm which is used for babies, 8 cm which is used for young children and 12 cm which is used for adults. In this case an 8 cm central line was used.

Ideally one would want the tip of the central line next to the heart but here Dr Taylor could feel that it was in the neck and knew that it was in a vein due to the trace being produced. For the tip of the line near the heart Dr Taylor would consider there to be no gradient difference so the base line reading would be the correct reading. However, for the tip of the line to be in the neck he assessed that there would be a gradient difference of 5 cm so although the reading being obtained was 17 he assessed this to in fact be a base line of 12 allowing for that gradient difference of 5 cm.

There are three injection ports on the CVP and those not being used would be sealed in theatre. The CVP in this instance was only being used for the heparin and saline mixture and the low dose dopamine.

The solutions were then viewed and the details of the concentrations are as follows:-

1. One-fifth normal saline solution is a mixture of 0.18% sodium and 4% glucose. The sodium concentration in this is 30 mmol per litre.
2. Hartmanns which has a sodium concentration of 131 mmol per litre.

3. 0.9% sodium ie normal saline which has a sodium concentration of 150 mmol per litre.
4. HPPF which has the same sodium concentration as normal saline.

Again it was pointed out that the one-fifth saline solution provided the same sodium concentration as the feeds that the child had been receiving and the same concentration as was in his urine.

The sodium levels would then have increased when the Hartmanns solution and blood were provided as these have higher sodium concentrations.

Dated this day of 1996

HN/GMcC