

CORONERS ACT (Northern Ireland), 1959

Deposition of Witness taken on TUESDAY the 18TH day of JUNE 1996,
at inquest touching the death of ADAM STRAIN, before me MR J L LECKEY
Coroner for the District of GREATER BELFAST
as follows to wit:-

The Deposition of DR ALISON ARMOUR

of INSTITUTE OF STATE PATHOLOGY

(Address)

who being sworn upon her oath, saith

On the instructions of HM Coroner for Greater Belfast Mr J L Leckey LLM, I
Alison Armour, MB, BCh, MRCPATH, DMJ (Path) registered medical practitioner
and pathologist approved by the Northern Ireland Office made a postmortem
examination on a body identified to me as that of Adam Strain. I now produce a
copy of my report marked C2. This was massive cerebral

oedema and I have never come across anything
of a similar degree. The cause of it in this
case is extremely rare and never encountered
by me previously. On a worldwide basis
it would be equally rare.

Mr. Branham: It was a complex case because of
Adam's underlying condition, his previous surgery
and the technical difficulty of the operation. He
experienced substantial blood loss during the
operation & that ~~caused~~ ^{made} his haemodynamics
very difficult to manage. Adam was not a healthy
child - he was a sick little boy.

139 mmol/l is within the normal range.
So far as no significant oedema of any other
organ my understanding is that fluid is
absorbed into the brain in preference to any
other organ. I distinguish between hyponatraemia &
dilutional hyponatraemia. The latter is due to
fluid gain. Children are more susceptible to

TAKEN before me this 18th day of JUNE 1996

Mr. Leckey,

Coroner for the District of Greater Belfast

CORONERS ACT (Northern Ireland), 1959

Deposition of Witness taken on _____ the _____ day
of _____ 19____, at inquest touching the death of
_____, before me

Coroner for the District of _____

as follows to wit:—

The Deposition of DR ALAN ARMOUR

of _____

(Address)

who being sworn upon her oath, saith

cerebral oedema and then adults and
so far as dilutional hyponatraemia females
are more susceptible than males. The paper I
referred to refers to healthy children but it is
still a good reference to this condition. There
was unpaired cerebral perfusion as there was a
suture on the left side and a catheter tip on
the right. 1200 ml blood loss during the
operation. I do not know what problems this
would have caused for the anaesthetist.
Miss Higgins: A critical point was the
fluids used by the anaesthetist to replace
blood loss. At the autopsy I had 10 sets of
notes relating to Adams and the clinicians'
statements. The suture unpaired the blood flow
to the brain and the catheter tip on the right
may have had a role to play. The suture had
been there for some time. Dr Taylor advised me
at the autopsy of the calculation he made
to replace blood loss. Haematocrit = packed cell
volume. In this case the reading ^{could} indicated he
was bleeding as in a dilutional stroke.

[Lined area for text entry]

TAKEN before me this 18th day of June 1996,

AS - CORONER

Mark Kelly

Coroner for the District of Greater Belfast

TRANSCRIPTION OF DEPOSITION OF DR ALISON ARMOUR

This was massive cerebral oedema and I have never come across anything of a similar degree. The cause of it in this case is extremely rare and never encountered by me previously. On a worldwide basis it would be equally rare.

Mr Brangham: It was a complex case because of Adam's underlying condition, his previous surgery and the technical difficulty of the operation. He experienced substantial blood loss during the operation and that made his haemodynamics very difficult to manage. Adam was not a healthy child - he was a sick little boy. 139 mmol/l is within the normal range. So far as no significant oedema of any other organ my understanding is that fluid is absorbed into the brain in preference to any other organ. I distinguish between hyponatraemia and dilutional hyponatraemia. The latter is due to fluids given. Children are more susceptible to cerebral oedema than adults and so far as dilutional hyponatraemia females are more susceptible than males. The paper I referred to refers to healthy children but it is still a good reference to this condition. There was impaired cerebral perfusion as there was a suture on the left side and a catheter tip on the right. 1200 mls blood loss during the operation. I do not know what problems this would have caused for the anaesthetist.

Miss Higgins: A critical point was the fluids used by the anaesthetist to replace blood loss. At the autopsy I had 10 sets of notes relating to Adam and the clinicians' statements. The suture impaired the blood flow to the brain and the catheter tip on the right may have had a role to play. The suture had been there for some time. Dr Taylor advised me at the autopsy of the calculation he made to replace blood loss. Haematocrit = packed cell volume. In this case the reading could indicate he was bleeding or in a dilutional state.

c1
/

**THE QUEEN'S UNIVERSITY OF BELFAST
NORTHERN IRELAND OFFICE**

REPORT OF AUTOPSY

Name: Adam STRAIN **Sex:** Male **Age:** 4 yrs. **F.No:** 46,728
Date of Death: 28th November, 1995. MDEC
Date and Hour of Autopsy: 29th November, 1995. 2.40 p.m.
Place of Autopsy: The Mortuary, Royal Victoria Hospital, Belfast.

CAUSE OF DEATH:

I (a) CEREBRAL OEDEMA

due to

(b) DILUTIONAL HYPONATRAEMIA AND IMPAIRED CEREBRAL PERFUSION
DURING RENAL TRANSPLANT OPERATION FOR CHRONIC RENAL FAILURE
(CONGENITAL OBSTRUCTIVE UROPATHY)

On the instructions of H.M. Coroner for Greater Belfast, Mr. J. L. Leckey, LLM, I, Alison Armour, MB, BCh, MRCPATH, DMJ(Path), registered medical practitioner and pathologist approved by the Northern Ireland Office, made a postmortem examination of the body of -

ADAM STRAIN
aged 4 years

identified to me at the Mortuary, Royal Victoria Hospital, Belfast, on Wednesday, 29th November, 1995, by Constable S. R. Tester, R.U.C. Grosvenor Road.

**THE QUEEN'S UNIVERSITY OF BELFAST
NORTHERN IRELAND OFFICE**

REPORT OF AUTOPSY

Name: Adam STRAIN Sex: Male Age: 4 yrs. F.No: 46,728
Date of Death: 28th November, 1995. MDEC
Date and Hour of Autopsy: 29th November, 1995. 2.40 p.m.
Place of Autopsy: The Mortuary, Royal Victoria Hospital, Belfast.

HISTORY:

He was a child and lived with his mother and grandparents in a bungalow in the town. He was born with a renal abnormality - an obstructive uropathy which resulted in polyuric renal failure. He had five ureteric reimplant operations, a fundoplication for gastro-oesophageal reflux and more recently in October, 1995 an orchidoplexy. He ate nothing by mouth and was fed via a gastrostomy button 1,500 mls. at night and 900 mls. during the day. He also received peritoneal dialysis. He was being prescribed calcium carbonate, Keflex, iron, one alpha vitamin, sodium bicarbonate and erythropoietin.

On 26th November, 1996, he was admitted to the Royal Belfast Hospital for Sick Children at 11.30 p.m. for a renal transplant operation. His blood pressure was 108/56 and a haemoglobin of 10.5 g/dl with a sodium of 139 mmol/l, potassium 3.6 mmol/l and urea 16.8 mmol/l. Overnight he was given 900 mls. dioralyte (4% dextrose 0.18% saline). Peritoneal dialysis was performed as usual, 750 ml. fluid volume 1.36% dextrose solution. He was given 8 cycles before going to theatre the next morning.

He arrived in theatre at 6.45 a.m. and general anaesthesia was induced using thiopentone, atropine and atracium. Intravenous access was difficult and attempts were made to pass a central venous pressure catheter. Three attempts were made with the left subclavian vein, one with the left internal jugular vein and then the catheter was successfully passed into the right subclavian vein. A lumbar epidural between L1 and L2 was also sited with 0.25% bupivacaine and Fentanyl 5 mcg/kg. Apart from the anaesthetic drugs Augmentin an antibiotic, prednisolone, asathioprin (anti-rejection drug) and a continuous infusion of dopamine were administered intravenously. An initial central venous pressure reading was taken at 17 mm.Hg. Intravenous units were administered from 7.00 a.m. to 8.30 a.m., of three 500 ml. bags of dextrose saline (4% and 0.18%). The operation technically was difficult due to previous surgical procedures and there was an increase in blood loss, calculated to be approximately 1,200 mls. at the end of the procedure. Further fluids of 500 mls. Hartman's solutions 1,000 mls. of HPPF (human plasma protein fraction) and 500 mls. of packed cells were administered. At 9.32 a.m. a blood gas analysis revealed a sodium of 123 mmol/l (normal 135 - 145) and a haematocrit of 18% (normal. 35 - 40%). During the procedure the CVP rose to 20 -21 mm.Hg, the Hb was 6.1 g/dl which was 10.1 g.dl. at the end of the procedure and the blood pressure rose and the pulse rate gradually decreased. The donor kidney perfused and the operation was completed. At the end of the procedure the neuromuscular block was reversed with neostigmine but this boy did not wake up. His pupils were noted to be fixed and dilated at midday. He was transferred from theatre to the paediatric Intensive Care Unit at 12.05 p.m. He was intubated and hand ventilated on admission. He was treated with intravenous mannitol and intravenous fluids were restricted. An emergency CT scan at 1.15 p.m. revealed gross cerebral oedema. His body temperature was 36.5°C. the CVP was 30, heart rate 120 beats per minute and systolic blood pressure 120. Electrolytes revealed a

sodium of 119 mmol/l; and a chest X-ray revealed pulmonary oedema with the CVP catheter tip in a neck vessel. Neurologists carried out brain stem tests and life was pronounced extinct by a hospital doctor on 28th November, 1995 at 9.15 a.m.

EXTERNAL EXAMINATION:

The body of a young male child, 104 cm. in length and weighing 20 kilograms. Rigor mortis was present. Hypostasis of light purple colour stained the back of the body.

Back: There was a needle puncture mark in the midline, centred 11 cm. above the natal cleft, corresponding to an epidural cannula.

Eyes: The corneas had been taken for transplantation.

Ears: Normal.

Nose: Normal.

Neck: There was a needle puncture mark on the left side. There was a healed operation scar, 3 cm. long, on the left side. There were two further healed operation scars on the right side, 2.5 cm. long.

Chest : There was a needle puncture mark on the left upper chest, in the region of the subclavian vein. There were a number of bruised needle puncture marks on the right upper chest, corresponding to a subclavian line. There was a bruise, 1.5 x 1 cm., in the left upper chest, centred 3 cm. lateral and 1 cm. above the left nipple. There was a bluish-blackish bruise on the right chest, 2.5 x 1 cm., diameter, centred 3 cm. lateral to the right nipple.

Abdomen: There was a gastrostomy button situated in the left hypochondrium. The gastrostomy hole measured 6 mm. diameter. There was a healed operation scar, 18 cm. long, horizontally in the upper abdomen, corresponding to previous fundoplication. There was a further healed operation scar, 18 cm. long, traversing the mid-abdomen. There was a peritoneal dialysis tube in situ in the left upper abdomen. There were two further puckered scars, one situated in the left side of the lower abdomen, 5 cm. lateral and 2 cm. below the umbilicus. The other puckered scar was situated 4.5 cm. beneath the umbilicus. There was a recent elliptical surgical incision, 15 cm. long, on the right side of the lower abdomen with a drain protruding from its upper margin. Its edges were slightly bruised. A bladder catheter protruded from the lower end on the left side of the abdomen. There was a further drain in situ just at the level of the pubic bone, corresponding to the donor ureteric catheter.

Left Upper Limb: There were a number of bruised needle puncture marks in the fold of the elbow and a healed operation scar, 5 cm. long, again in the fold of the elbow.

Right Upper Limb: There were a number of bruised needle puncture marks in the fold of the elbow.

Left Lower Limb: There were a number of petechial bruises on the inner aspect of the thigh, in an area 4 x 1 cm. There was a bruise, 1 cm. diameter, on the front of the shin. There was a bruised needle puncture mark on the dorsum of the foot.

Right Lower Limb: There was a healed operation scar, 4 cm. long, in the right groin, corresponding to an orchidoplexy. There was a fading bruise, 0.5 cm. diameter, on the outer aspect of the upper thigh. There was a bluish bruise on the outer aspect of the thigh, 0.5 cm. diameter, and there were a number of fading bruises on the front of the shin. There were two bruised needle puncture marks on the dorsum of the foot.

Scrotum: There was a healed operation scar, 3 cm. long, on the right scrotal sac. The right testis had been removed. The left testis was present

INTERNAL EXAMINATION:**HEAD:**

Brain: To be described after fixation.

Mouth: There were natural teeth in good condition in each jaw. The lips were dry and parchmented. The tongue was held between the clenched teeth.

Tongue, Pharynx: Normal.

NECK AND CHEST:

Hyoid Bone and Laryngeal Cartilages: Intact.

Thyroid Gland: Normal.

Pericardial Sac: Normal.

Heart: 120 gm. The organ was taken for transplantation.

Aorta: Normal.

ABDOMEN:

Abdominal Cavity: Was crossed by a number of adhesions. There was a little blood clot formation around the renal transplant on the right side.

Stomach: A gastrostomy hole was present. The stomach contained a little bile.

Intestines: Externally appeared normal.

Duodenum: Normal.

Liver: Weighed 875 gms. A little congested.

Gall Bladder: Normal.

Pancreas: Normal.

Native Kidneys: Both were markedly contracted, scarred and contained a number of cysts. Little normal functioning kidney remained. Both ureters were hugely distended and dilated.

Transplanted kidney: Was in situ in the right pelvis, the ureter drained freely and the vascular attachments were intact.

Bladder: Contained a little straw-coloured urine.

Prostate: Normal.

SPINAL CORD: To be described after fixation.

INTERNAL EXAMINATION OF NECK:

There was no evidence of congestion or obstruction of the major blood vessels or the carotid arteries and jugular veins. There was no evidence of superior vena caval obstruction. The carotid arteries were normal. There was a suture in situ on the left side of the neck at the junction of the internal jugular vein and the sub-clavian vein.

DESCRIPTION OF ORGANS AFTER FIXATION:

Brain - Was cut on 12.1.96

External Examination: Fixed weight of brain 1,680 gm; cerebellum and brain stem 176 gm; cerebellum only 154 gm. The brain was grossly swollen with loss of sulci and uncal swelling. This was symmetrical. There was no uncal necrosis. There was swelling of the cerebellar tonsils but no necrosis. There was no cortical venous thrombosis. The anatomy of the circle of Willis was normal.

On cut section there was massive brain swelling and constriction of the ventricles. There was no ventricular haemorrhage. There was no asymmetrical lesion. There was severe white matter congestion and marked congestion of the blood vessels in the basal ganglia, white matter and deep grey matter. There was no necrosis of the mid-brain or brain stem.

Blocks were taken from:

1. Right frontal white matter
2. Left cingulate gyrus
3. Left basal ganglia
4. Right and left hippocampus
5. Left occipital lobe
6. Cerebellum
7. Pons in toto
8. Thalamus

The brain was photographed sequentially

Cervical Cord: No macroscopical lesion seen.

Blocks were taken from:

1. Cervical
2. Thoracic
3. Lumbar

MICROSCOPY:

Lungs: There was congestion of the capillaries and there were moderate numbers of alveolar macrophages. There was no evidence of embolism or infarction.

Larynx: There was ulceration of the mucosa, in keeping with intubation.

Liver: There was no evidence of cyst formation within the portal tract. There were scattered foci of clear cell change.

Kidney: There was widespread scarring and cyst formation, interstitial fibrosis and chronic inflammation. There was widespread glomerulo-sclerosis and the arterioles were thickened.

Transplanted Kidney: There was complete infarction.

Spleen: There was congestion of the red pulp.

Lymph Node: Normal.

(The above slides were seen by Professor J. Berry, Consultant Paediatric Pathologist).

Brain: There was massive cerebral oedema of the cortex and white matter. There was no evidence of terminal hypoxia. There was no evidence of myelinolysis.

Spinal Cord: No specific pathological features were noted.

(The brain, spinal cord and histological slides were seen by Dr. M. Mirakhur, Consultant Neuropathologist)

COMMENTARY:

This little boy with a past medical history of polyuric renal failure, numerous hospital admissions and operations was admitted to hospital one evening for a renal transplant operation. He was fed via a gastrostomy and ate nothing by mouth. Usually he would receive 1,500 mls. a night and 900 mls. during the day. That night investigations included blood pressure 108/56, sodium 139 mmol/l and haemoglobin 10.5 g/dl. Overnight he was given 900 mls. dioralyte (4% dextrose 0.18% saline) and peritoneal dialysis was performed as usual. He went to theatre the next morning.

General anaesthesia was induced. Intravenous access was difficult and four attempts were made to pass a central venous pressure catheter before it was successfully passed into the right subclavian vein. A lumbar epidural was also sited with .25% bupivacaine and fentanyl. An initial CVP reading was taken at 17 mm.Hg. and intravenous fluids were given of 3 x 500 ml. bags of dextrose saline (4% and .18%). The operation itself was technically difficult due to the previous surgical procedures and there was an increased blood loss calculated to be approximately 1,200 mls. This was replaced by intravenous fluids of 500 mls. of Hartman's, 1,000 mls. HPPF and 500 mls. of packed cells. At 9.32 a.m. a blood gas analysis revealed a sodium of 123 mmol/l (normal 135-145) and a low haematocrit. During the operation the CVP increased to 20-21 mm.Hg., the haemoglobin fell to 6.1 g/dl., the systolic blood pressure rose to 150 mm.Hg. and the pulse gradually fell but rose steadily from 10.15 a.m. onwards. When the procedure was completed and the neuromuscular block was reversed this little boy did not wake up. A CT scan of the brain revealed gross cerebral oedema. Brain stem function tests were carried out and he was declared dead a little over 26 hours from the start of the operation.

The autopsy revealed gross cerebral oedema. The fixed weight of the brain at postmortem was 1,680 gms., the average weight for a boy of this age being 1,300 gms and the average weight of a man's brain being 1,450 gms. It was the effects of this massive swelling of the brain which caused his death. There was no significant oedema of any other organ.

This is a highly complex and difficult case. To try to understand the underlying cause for this cerebral oedema first some physiological mechanisms for maintaining fluid and electrolyte balance will be reviewed.

In healthy people the composition of body fluids vary within narrow limits. The kidneys are largely responsible for maintaining this constancy and the excretion of waste products of metabolism represents merely one aspect of this task. The control of water volume and sodium are maintained by the hormones A.D.H. (anti-diuretic hormone) and aldosterone.

In this case the volume of urine output was greatly increased and the urine was also dilute. This was probably due to the fact that the kidneys did not function and their ability to concentrate the urine was minimal.

Generalised cerebral oedema in children has many causes including hypoxia. In this case this has been excluded. The history indicates that during the operation this little boy received a quantity of intravenous fluids. There was also a considerable blood loss during the operation of 1,200 mls. However a CVP, central venous pressure, catheter was in situ in the right subclavian vein and is usually in place to avoid overloading of the circulation by intravenous fluids. A rise in the CVP indicates an excessive load and a fall can be an early sign of haemorrhage. In this case the initial reading was 17 mm.Hg. (for an operation such as this 10-12 mm.Hg. is the norm) and this was taken as the base line. A subsequent reading was a little higher again. Also during the operation the sodium was low along with the haematocrit. It is known that a condition called dilutional hyponatraemia can cause rapid and gross cerebral oedema. This is no doubt in this case that the sodium level was low during the operation. A study revealed that in children undergoing operations there was substantial extra renal loss of electrolytes and with a minimal positive balance of hypotonic fluid could lead to fatal hyponatraemia. This study however must be taken in context as it refers to healthy children undergoing operations like tonsillectomies. Thus they had normally functioning kidneys which was not the situation in this case. It seems likely therefore that the hyponatraemia in this case was the cause of the cerebral oedema and most of the intravenous fluids given in the cases cited in this paper were administered as 280 mmol glucose per litre in water or in sodium chloride 38 mmol/l.

Another factor to be considered in this case is cerebral perfusion. The autopsy revealed ligation of the left internal jugular vein. The catheter tip of the CVP was situated on the right side. This would mean that the cerebral perfusion would be less than that in a normal child. This would exacerbate the effects of the cerebral oedema and should also be considered as a factor in the cause of death. Therefore the most likely explanation is that the cerebral oedema followed a period of hyponatraemia and was compounded by impaired cerebral perfusion.

The autopsy also revealed changes in the kidneys, in keeping with chronic renal failure and total infarction of the transplanted kidney. These played no part in the fatal outcome.

There were marks due to treatment and bruises to both legs. They were trivial however.

REFERENCES:

Arieff et al
 "Hyponatraemia and death or permanent brain damage in healthy children"
 British Medical Journal 1992; 304; 1218-22

