IN THE CORONERS COURT
OF VICTORIA
AT MELBOURNE

Court Reference: COR 2006 1014

FINDING INTO DEATH WITH INQUEST

Form 37 Rule 60(1)
Section 67 of the ***Coroners Act 2008***

(Amended pursuant to s76 of the *Coroners Act 2008* on the 14 December 2012)

Inquest into the Death of: ALYSSA CHAN

Delivered On:	
Delivered At:	Level 11, 222 Exhibition Street Melbourne 3000
Hearing Dates:	19, 20 & 21 July 2010; and 14 and 15 February 2011
Findings of:	JANE HENDTLASS, CORONER
Representation:	John Snowden appeared for Southern Health
Police Coronial Support Unit	Sergeant Tracy Weir appeared to assist the Coroner

I, JANE HENDTLASS, Coroner having investigated the death of ALYSSA CHAN

AND having held an inquest in relation to this death on 19, 20, 21 July 2010 and 14 and 15 February 2011

at MELBOURNE

find that the identity of the deceased was ALYSSA TZE SIM CHAN

born on 8 January 2006

and the death occurred on 16 March, 2006

at Monash Medical Centre, Clayton 3168

from:

1 (a) COMBINATION OF LIVER FAILURE. BLOOD LOSS AND SHOCK FOLLOWING NEEDLE BIOPSY

1 (b) NEONATAL HEPATITIS

2 CLOSTRIDIUM PERFRINGENS SEPTICAEMIA

in the following circumstances:

1. Alyssa Tze Sim Chan was nine weeks old when she died. She lived with her parents, Felicia and Xander Chan, and her older brother at 78 Alderford Drive in Wantirna. Mr and Mrs Chan were born in Malaysia of parents with Chinese background.

2. Alyssa seemed well at birth but her jaundice persisted. Investigations using blood and urine analyses, ultrasound and blood clotting analyses failed to identify the cause of her jaundice.

3. On 14 March 2006, a consultant paediatrician at Monash Medical Centre, Dr Barry Kras, discussed Alyssa's case with the consultant gastroenterologist in charge of the Paediatric Gastroenterology Unit, Associate Professor Don Cameron. Dr Sarah Nunan (now McNab) was also present.

4. Associate Professor Cameron advised Dr Kras that prolonged conjugated jaundice needed to be investigated because it indicated an abnormality in liver function or bile secretion. Further, preliminary tests did not exclude the possibility of biliary atresia.

5. Therefore, Associate Professor Cameron arranged for Alyssa's elective admission to Monash Medical Centre to perform a liver biopsy. Dr Nunan was his registrar. Dr Carey-Anne Christie-Johnson was his resident medical officer.

6. On 16 March 2006, Associate Professor Cameron performed a liver biopsy on Alyssa. Bleeding is a known risk factor associated with liver biopsy particularly paediatric liver biopsy. However, Alyssa's procedure appeared to be uncomplicated.

7. At 12.35pm, Alyssa returned to the ward with orders for observations every 15 minutes for two hours and then 30 minute observations for a further four hours. However, the nurses responsible for her post-operative care were unable to find a recordable blood pressure. Medical staff attributed this problem to the technical difficulties that arise when trying to take manual blood pressures on infants.

8. At 2.15pm, Dr Nunan contacted Associate Professor Cameron. She told him that she was concerned about Alyssa's condition. She did not think it was a bleeding problem but rather a respiratory problem and hypoglycaemia.

9. At 2.35pm, Alyssa collapsed. She was resuscitated and an emergency ultrasound was performed at 3.35pm. Hand written notes on the ultrasound recorded at 4.53pm reported extensive fluid in the peritoneum which was presumed to be blood, an organising haematoma around the liver and active bleeding from the biopsy tract.

10. At 6.00 pm, Alyssa underwent further surgery but her condition did not improve.

11. At 10.45pm on 16 March 2006, Alyssa Chan died.

12. The forensic pathologist who performed the autopsy formed the opinion that the cause of death was combination of liver failure, blood loss and shock following needle biopsy and neonatal hepatitis. *Clostridium perfringens* septicaemia was a contributing factor.

13. No biliary atresia was observed at autopsy. The common bile duct and common hepatic duct were patent and ducts were identified in the portal triads together with giant cell transformation of liver cells.

14. Post mortem metabolic screen of Alyssa's dried blood taken at birth and stored on her Guthrie card showed she had elevated levels of methionine and citrulline and most acyl carnitines. Urine analysis further aroused suspicion that she may have had a citrin deficiency.

15. Specialised DNA analysis confirmed that Alyssa was a compound heterozygote with [I] 851del4 and [X] IVS6+5G>A mutations in the SLC25A13 gene.[1] Mutations in this gene are now known to be associated with citrin deficiency.

16. This Finding will now provide a more detailed review of Alyssa's management on 16 March 2006 including:

    - Pre-procedure testing;
    - Intra-operative procedure;
    - Post-operative procedures, and
    - Resuscitation.

17. It will then comment and make recommendations intended to prevent other children dying for the reasons that Alyssa died.

Pre-procedure testing

18. Dr Kras referred Alyssa to Associate Professor Cameron because investigations using blood and urine analyses, ultrasound and blood clotting analyses failed to identify the cause of her jaundice. However, the Court has no record of these tests being performed before 15 March 2006.

19. Blood tests taken at 11.30am on 15 March 2006 confirmed that Alyssa had elevated bile acid levels. Her pre-operative blood tests also indicated that she had slightly unusual blood composition and borderline clotting rates.

[1] This analysis was performed by Associate Professor Keiko Kobayashi at the Department of Molecular Metabolism and Biochemical Genetics, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan and reported on 21 July 2006.

20. In particular, Alyssa's INR was 1.3 where the normal level is less than 1.3. The pathologist reporting these results noted that they were consistent with possible Vitamin K deficiency, warfarin or liver dysfunction.

21. In evidence, Associate Professor Cameron said that Alyssa's pre-procedure blood tests were within normal limits and her INR was not considered a significant abnormality. However, bleeding is the main risk of liver biopsy. Therefore, he ordered Vitamin K to assist with clotting as a precaution. Cross matched blood was also ordered as routine.

22. Accordingly, at 10.30am on 15 March 2006 Dr Nunan gave Alyssa an intramuscular injection of Vitamin K under direction from Associate Professor Cameron.

23. At 8.00am on 16 March 2006, Alyssa was admitted to Ward 42N which is the paediatric ward at Monash Medical Centre for an elective liver biopsy.

24. Lena Lim and Belinda Fox were allocated to care for her. Ms Lim was a Year 10 Registered Nurse and Grade 2 Year 10 Midwife with postgraduate training in paediatric nursing. Ms Fox was a Graduate Div 1 nurse who was one month into her first year as a graduate nurse. She had been "buddied" with Ms Lim as part of her training program.

25. At 9.15am, Alyssa underwent pre-operative procedures including checks of her blood pressure and other vital signs and confirmation of her fasting status. Dr Nunan says she also arranged for Alyssa's blood tests to be repeated prior to surgery as directed by Associate Professor Cameron. However, no further blood tests were reported for the morning of Alyssa's admission or until 7.30pm on 16 March 2007.

26. At 8.50am, Ms Lim performed a full set of observations:

    - Her respiratory rate was 36 breaths per minute;
    - Her pulse was 128 beats per minute;
    - Her blood pressure was 63/47mmHg;
    - Her temperature was 37.5 degrees C;
    - She had fasted from 5.00am.

27. At 10.45am, Alyssa arrived in the Endoscopy Suite for a liver biopsy performed by Associate Professor Cameron.

28. Alyssa's procedure was third of five procedures performed by Associate Professor Cameron between 8.55am and 1.15pm on 16 March 2006.

Intra-operative procedure

29. At 11.00am on 16 March 2006, Alyssa was placed under a general anaesthetic for her percutaneous liver biopsy in the Endoscopy Suite at Monash Medical Centre.

30. The anaesthetist recorded Alyssa's respiratory rate continuously from 11.00am to 11.32am. I presume the surgery was complete when the anaesthetist stopped recording Alyssa's respiratory rate. Routine monitoring included pulse, electrocardiograph and oximetry. No blood pressure measurements were recorded.

31. Associate Professor Cameron said that an ultrasonographer and a radiology registrar first performed an ultrasound to identify the safest pathway for insertion of the biopsy needle into the biopsy site clear of any identifiable blood vessels. No images of this pre-operative procedure were retained.

32. Dr Aravinthan Sundaralingam was a Radiology Registrar at Southern Health in 2006.

33. Dr Sundaralingam explained that, generally, the radiology registrar and the sonographer would place the ultrasound probe to identify the most appropriate spot for insertion of the biopsy needle. The spot would then be marked in the presence of the surgeon who was to perform the procedure. The Registrar would leave the room prior to the surgeon performing the biopsy. The sonographer may wait while the procedure was performed and then undertake the post-procedure ultrasound.

34. I accept that this pre-procedure process occurred on 16 March 2006.

35. Dr Kumbla was the consultant radiologist on duty. She was not involved in performing any ultrasounds on Alyssa on 16 March 2006. However, the radiology reports indicate that she was responsible for signing off on the radiology reports.

36. Dr Kumbla's evidence is confusing on this issue in that she states on page 34 of the brief, that "*ultrasound guidance was provided*". She defines this "*ultrasound guidance*" as a quick ultrasound screening of the liver to localise major vessels, etc.

37. Melissa Cunningham was the sonographer named on the ultrasound reports associated with Alyssa's liver biopsy procedure.

38. Ms Cunningham graduated at the end of 2005 but she had prior experience as a radiographer. She does not remember working with Associate Professor Cameron in the Endoscopy Suite and it was rare for her to be called out of the radiology unit to assist with ultrasounds. She has no independent memory of Alyssa's case and she does not remember ever being called to perform an ultrasound for a paediatric liver biopsy. She does not usually work with babies under general anaesthetic. She does not remember ever performing an ultrasound on a baby under general anaesthetic.

39. Therefore, I have formed the opinion that Ms Cunningham did not perform Alyssa's pre-procedure ultrasound on 16 March 2005.

40. The pre-operative ultrasound allowed Associate Professor Cameron to mark Alyssa's skin to show where to perform the biopsy. He also calculated the distance from the skin to the liver was about 7mm and this distance was set on the needle guide of a 14 gauge Temno II biopsy needle.

41. Associate Professor Cameron also set the "throw" or specimen notch of the biopsy needle at 2cm. He also told the Court he aims to time insertion of the needle between breaths and it goes in and out very quickly.

42. In his statement[2], Associate Professor Cameron said the ultrasound did not show any major vessels along the planned biopsy needle track for more than 35mm from the liver surface.

43. However, I am unable to say who performed Alyssa's pre-procedure ultrasound on 16 March 2006, who influenced Associate Professor Cameron's opinion that there were no major vessels for more than 35mm from the liver surface or who failed to retain any images from the pre-procedure ultrasound.

44. At 11.15am, Associate Professor Cameron performed the Alyssa's liver biopsy procedure. He obtained adequate liver specimens on the first pass comprising three cores each of 2mm in diameter and between 4mm and 11mm in length. There were no known complications.

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[2] Dated 4 September 2006.

45. Subsequent histological analysis reported on 20 March 2006 indicated mild hepatic changes and:

> *"There appears to be a near total lack of normal small bile ducts in the portal tracts.*
>
> *The findings are consistent with obstructive jaundice due to paucity of interlobular bile ducts."*

46. There is no evidence that Associate Professor Cameron performed the procedure using on-going or real time ultrasound guidance:

- In her statement, Dr Nunan says that the ultrasound was "re-performed" after the procedure.
- Ms Cunningham stated that the proceduralist can use the transducer to align the biopsy needle guide with the chosen position prior to firing the biopsy gun. Neither Associate Professor Cameron nor Dr Nunan suggest that they performed this part of the procedure.
- No ultrasound image was saved showing the biopsy needle *in situ*. Dr Chris O'Donnell is a forensic radiologist employed by the Victorian Institute for Forensic Medicine. Dr O'Donnell stated that this is usually the case when real time ultrasound guidance is used.

47. Therefore, I have formed the belief that Associate Professor Cameron performed the liver biopsy using pre-procedure ultrasound guidance but he did not use real time ultrasound during the biopsy procedure.

Post-operative procedures

48. The anaesthetic record shows that the anaesthetist was recording Alyssa's respiratory rate until 11.30am on 16 March 2006. At 11.35am, Alyssa entered the recovery room.

49. Therefore, I presume that the post-operative ultrasound was performed immediately after Associate Professor Cameron completed the biopsy, that is at about 11.30am, and certainly before she was transferred to recovery at 11.35am. One image of this procedure was retained for the file.[3]

[3] The hard copy image is time stamped as 10.30am and reported at 5.04pm.

50. In evidence, Associate Professor Cameron confirmed that he had viewed the complete post-operative ultrasound performed in the operating theatre after the biopsy and that it showed the tract caused by the biopsy needle. At about 5.04pm, Dr Kumbla also viewed the entire ultrasound before reporting the results.

51. Dr Kumbla's report on Alyssa's post-operative ultrasound stated:

> *"Ultrasound guidance was provided for liver biopsy. Images performed immediately after the procedure indicates that they did not demonstrate any definite evidence of any free fluid in the region of the liver biopsy."*

52. Dr Kumbla also told the Court:

> *"..the ultrasound is a good modality to look in children because of their small size. So even if there is a small amount of bleeding on the surface of the liver or within the liver, it is easily picked up, unlike an adult.....*
>
> *As occurred in this case, we routinely perform an ultrasound examination immediately after the biopsy to check for the presence (of blood). I note that in Alyssa's case no such concern was raised at immediate post biopsy scan."*

53. Professor Michael Ditchfield is the Head of Paediatric Imaging at Southern Health.

54. Ms Cunningham, Dr O'Donnell and Professor Ditchfield confirmed that they viewed a single retained cameo image of the post-operative ultrasound. They could also see a thin echogenic structure transversing the liver and they both presumed this indicated the needle track mark. This retained cameo image did not show the portal vein or any other large blood vessel.

55. Ms Cunningham, Associate Professor Cameron, Dr Kumbla, Dr O'Donnell and Professor Ditchfield all said that they could not see any obvious fluid or haematoma or apparent vascular abnormality in this retained single image. They also confirmed that they could not see any blood flow along the biopsy tract and no collection of blood within the liver or beneath the capsule around the liver.

56. Therefore, I find that there was no heavy or explosive bleeding from or in the biopsy needle tract when the post-operative ultrasound was performed at about 11.30am on 16 March 2006.

57. Analysis of the Southern Health radiology records indicates that Ms Cunningham performed the post-operative ultrasound sometime between 11.00am and 11.30am on 16 March 2006.

58. However, we already know that Ms Cunningham does not remember ever performing a liver biopsy ultrasound on a baby under general anaesthetic. She also explained to the Court that the sonographer's name is an administrative entry added when the ultrasound is sent for reporting by the consultant radiologist. Therefore, it does not always reflect the name of the person who performed the ultrasound.

59. Accordingly, I am unable to say who performed Alyssa's post-procedural ultrasound on 16 March 2006 or who decided which single cameo to retain for the file and future analysis or whether the retained single cameo is representative of all the post-operative ultrasound interpreted by Associate Professor Cameron and Dr Kumbla as showing no bleeding from the biopsy site.

60. Associate Professor Cameron's post-operative instructions were for:

- Nurse of right side to put pressure on biopsy site
- Minimal handling
- Observations every 15 minutes for two hours after which she could be fed.
- Observations continue 30 minutes for four hours, hourly for six hours and two hourly for six hours.
- Nil orally for two hours
- Alyssa was expected to be discharged home in 24 hours if tolerating well.

61. These orders were also recorded in Alyssa's nursing care plan.

62. Associate Professor Cameron did not specify the observations he expected to be taken. However, in evidence he told the Court that he expected they would include heart rate and oxygen saturations using an oximeter, blood pressure and procedure site, as well as:

> *"The appearance of the child, restlessness, settledness, those sorts of things."*

63. Alyssa was observed in the recovery room for 55 minutes.

64. At 11.35am, her medical records indicated:

- Her respiratory rate was 34 breaths per minute;
- Her pulse was 154 beats per minute;
- Her oxygen saturations were 100% on room air;
- No blood pressure was recorded.

65. At 12.00pm, Dr Christie-Johnson reviewed Alyssa. She noted Associate Professor Cameron's directions and explained them as due to the risk of internal bleeding.

66. At about 12.05pm, Alyssa woke up from her anaesthetic and oxygen ceased.

67. At 12.20pm, she was wriggling and her last observation in recovery indicated:

- Her respiratory rate was 32 breaths per minute,
- Her pulse was 146 beats per minute,
- Her temperature was 35.1 degrees C,
- Her oxygen saturations were 100% on room air,
- No blood pressure was recorded.

68. At 12.35pm, Alyssa returned to Ward 42N. She was upset and crying.

69. At 12.45pm, Ms Lim recorded Alyssa's first set of observations on the ward. These observations indicated:

- Her respiratory rate was 48 breaths per minute;
- Her pulse was 145 beats per minute;
- Her temperature was 35.8 degrees C;
- Her oxygen saturations were 100% on room air;
- Her blood pressure was 'unable to be obtained'.

70. At 1.00pm, Associate Professor Cameron reviewed Alyssa. Ms Lim says in her statement that she told him about the nurses' inability to obtain a blood pressure.

71. Associate Professor Cameron told the Court he understood it was a technical difficulty and told her to keep trying. Further, he noted Alyssa's heart rate was stable. He was not alerted to any unusual observations and did not think she looked pale.

72. Associate Professor Cameron also said he would have expected the first signs of bleeding to be increased heart rate and declining capillary return as assessed by the pulse oximeter.

73. At 1.15pm, Associate Professor Cameron told Mrs Chan she could feed Alyssa. He then left the hospital.

74. Ms Lim and Ms Fox recorded subsequent observations at 1.00pm, 1.30pm and 2.05pm on 16 March 2006. None of these observations included blood pressure.

75. Ms Lim also said that it was difficult to obtain a blood pressure on paediatric patients because they frequently moved around. Further, using the electronic blood pressure machine and a paediatric cuff, it was impossible to distinguish between inability to obtain a reading because of the child's movements and the inability to obtain a reading because the blood pressure was too low. Ms Lim said she would usually revert to manual blood pressure equipment if she had trouble but, on 16 March 2006, she did not have time to look for the sphygmomanometer.

76. At 1.30pm, Ms Lim went for lunch and handed over Alyssa's care to Ms Fox.

77. At 1.30pm, the observation chart says Alyssa was awake and feeding. However, the family say she was pale, she did not take much feed from the bottle and was not interested in a breast feed.

78. Ms Fox also recorded a further set of observations. These indicated that:

- Her respiratory rate was 34 breaths per minute,
- Her pulse was 127 beats per minute,
- Her temperature was 37 degrees C,
- Her oxygen saturations were 97% on room air,
- No blood pressure was recorded.

79. In her statement, Ms Fox said she had experience taking manual blood pressures of paediatric patients and was competent in the task. However, the electronic blood pressure machine

could not pick up a reading after several attempts and the ward was not equipped with a manual paediatric cuff.

80. Ms Fox confirmed:

> *"The child was crying and unsettled and that usually makes it quite difficult to get a blood pressure reading. Even with a manual cuff that makes it difficult as well."*

81. At 1.30pm, Ms Fox contacted the gastroenterology resident, Dr Christie-Johnson, for a review because Alyssa looked quite pale.

82. At 1.35pm, Dr Christie-Johnson ordered 500ml N saline and oxygen with nasal prongs because Alyssa's oxygen saturations were decreasing.

83. At 1.40pm, Ms Fox notified Ms Booth that Alyssa's condition was deteriorating. Blood tests ordered by Dr Christie-Johnson showed she was hypoglycaemic (BSL 1.8mM). Therefore, 10% dextrose was administered and Mrs Chan tried to breast feed Alyssa.

84. At 1.50pm, Ms Booth asked Angie Winterscheidt to assist Ms Fox. Ms Winterscheidt is a Div 1 Year 5 nurse. She observed Ms Booth, Ms Fox and Dr Christie-Johnson were already in the room.

85. Over the next ten minutes, Ms Winterscheidt flushed Alyssa's intravenous line and demonstrated it was patent. She also established maintenance fluids and observed that Alyssa was being administered oxygen through a mask.

86. Ms Winterscheidt says she and Mr Fox also continued to try to take Alyssa's blood pressure for about 10 minutes using two different blood pressure machines and all limbs. They were unsuccessful.

87. Ms Winterscheidt and Ms Fox also tried to obtain oxygen and pulse readings using two different oximeter machines and a probe attached to Alyssa's foot. The first oximeter did not provide a trace. The second oximeter had a poor trace which suggested that the oxygen saturation was 80%. This was recorded at 2.05pm.

88. In evidence, Ms Fox told the Court:

> *"The first one, the 1.30, were filled in when I first saw Alyssa after I took over....*

I wrote that time, the other times might have been a bit after they actually happened because everything was busy and we were trying to get Alyssa better, and I didn't really have the time to - I don't think they were exactly at the same time, some of mine have been a bit after when everything had calmed down."

89. On the other hand, Ms Fox also said she thought that she usually wrote the records less than five minutes retrospectively. Therefore, I have formed the opinion that the nursing notes provide a reasonably accurate sequence of events but do not always reflect time differences for when events occurred.

90. Further Ms Winterscheidt told the Court that she recorded that the oximetry measurement was not a good reading after she and Ms Fox had discussed the inadequacy of the oximetry trace and agreed that they needed to record the results in the nursing notes:

"Belinda and I, I said we have to write down what we've done, and so it looks like Belinda has written some stuff and then I've added on the side."

91. Therefore, I have formed the opinion that the nursing records after 1.30pm on 16 March 2006 were determined retrospectively after Ms Fox and Ms Winterscheidt became concerned about their inability to obtain accurate oximetry readings.

92. At 2.05pm, Dr Christie-Johnson called Dr Nunan to review Alyssa because her oxygen saturation was around 90-93% and there was only a faint trace on the oximeter, her heart rate was increasing and she was lethargic. Dr Nunan recorded Alyssa was also crying.

93. Ms Winterscheidt told Dr Nunan and Dr Christie-Johnson about her difficulty in measuring Alyssa's blood pressure, oxygen saturations and pulse.

94. Ms Winterscheidt says Dr Nunan told her not to worry because the patient was a good colour, that is she was pale but not blue. Ms Fox confirmed this was Dr Nunan's instruction.

95. Dr Nunan also instructed Ms Winterscheidt to take the oxygen mask off. She told the Court she was not concerned about Alyssa's blood pressure because her heart rate and capillary refill were stable.

96. Dr Nunan examined Alyssa. She noted that Alyssa was upset, hungry and not feeding and requested a blood sugar reading. Alyssa's blood sugar was 1.8mM so Ms Fox was asked to

give her 12 ml bolus of 10% dextrose. At 2.14pm, Alyssa's blood sugar level was 5.0mM and Dr Nunan ordered another attempt to breast feed. However, Ms Winterschedt says that Alyssa took a few sucks and then became lethargic.

97. Further, at 2.14pm, Ms Winterscheidt still had difficulty obtaining an adequate oximetry trace and Alyssa's blood oxygen saturation was 90-95%.

98. At about 2.15pm, Dr Nunan contacted Associate Professor Cameron. She told him that there were concerns about Alyssa but she did not think it was a bleeding problem. Rather, Dr Nunan was concerned about a respiratory problem and hypoglycaemia.

99. Associate Professor Cameron accepted her advice.

100. By 2.25pm, Alyssa was floppy, unresponsive and remained lethargic. Her oxygen saturations were around 90-93% and dropping with a faint reading. Ms Winterscheidt spoke to Dr Nunan.

101. At 2.28pm, Dr Nunan and Dr Christie-Johnson reviewed Alyssa. Dr Nunan noted that:

- Her pulse was 130-180 beats per minute,
- Her oxygen saturations were up to 96% on room air,
- She was unable to obtain a blood pressure.

102. At 2.30pm, Dr Nunan stated that Alyssa was much more lethargic. She was not crying and minimally active. Dr Nunan ordered intravenous 0.45N saline and 20mM potassium in an 80ml fluid bolus and further blood tests to determine her blood sugar levels. She also sought intensive care review.

103. At 2.35pm, before Dr Nunan's orders could be executed, Alyssa became unresponsive. Ms Fox was still unable to record a blood pressure. Dr Nunan called a Code Blue and commenced resuscitation with a bag and mask.

Resuscitation

104. At 2.35pm on 16 March 2006, Dr Craig Walker was asked to assist the Code Blue response team. He is a consultant paediatric intensive care specialist. Dr Walker immediately assumed there was bleeding from the liver biopsy and commenced fluid resuscitation and organised an Intensive Care bed. Dr Nunan commenced external heart compressions.

105. At 2.43pm, Alyssa's heart recovered spontaneously and cardiac compressions ceased.

106. At 2.46pm, she was intubated and an intravenous line was inserted.

107. At 2.47pm, a nasogastric tube and, at 2.52pm, a second intravenous cannula were inserted. Alyssa's oxygen saturation levels remained at 99-100%.

108. At about 2.50pm, Dr Nunan informed Associate Professor Cameron of Alyssa's cardio-respiratory arrest and her intended transfer to the Intensive Care Unit.

109. At 2.53pm, blood samples were insufficient for analysis. Further arterial samples taken at 3.07pm indicated an oxygen saturation of 71%, acidotic pH 6.57, elevated carbonate and potassium and a normal glucose of 9.1mM.

110. At 3.17pm, a chest and abdominal x-ray was performed. No explanation of Alyssa's deterioration resulted from these x-rays.

111. At 3.37pm, a different sonographer used a portable ultrasound to show that Alyssa had extensive fluid in peritoneum which was presumed to be blood and an organising haematoma around the liver and active bleeding from the biopsy tract. A more comprehensive set of images was retained from this procedure.

112. Dr O'Donnell interpreted the images of the 3.37pm ultrasound as showing a needle track consistent with a 20mm throw, given that he says the tract of blood arose from an intra-hepatic structure which seems to be 1.5-1.8cm deep. He also told the Court:

> *"The tract in the liver is extending down to and entering that portal vein branch... What I can say is that* (the tract) *is at least 15 to 18 millimetres from the surface of the liver to the portal vein branch."*

113. Dr O'Donnell also told the Court that the large mass with blood flowing into it did not extend beyond the surface of the liver. He could not say whether it was just under the surface of liver or it could be just over the surface of the liver. It looked like a haematoma.

114. At 3.42pm, Ms Booth escorted Alyssa to the Intensive Care Unit.

115. On presentation to the Intensive Care Unit, Alyssa was cyanotic and ventilated and her condition was poor. Her veins and arteries were very constricted so that the intensive care

specialists were unable to gain access to insert a cannula for blood pressure monitoring. Her heart rate was 138 beats per minute.

116. Alyssa was treated with a blood transfusion and frozen plasma as well as calcium gluconate and bicarbonate.

117. At about 5.00pm, the paediatric registrar contacted the after-hours on-call paediatric surgeon, Mr Joseph Cramieri, and the after-hours on-call paediatric anaesthetist, Dr John Waters.

118. When Dr Waters arrived at Monash Medical Centre, he reviewed Alyssa. She was intubated and ventilated. Her observations included:

- Her pulse was 120 beats per minute;
- Her temperature was 37 degrees C;
- Her oxygen saturation was 100% on room air;
- Her blood pressure was 80/40mmHg.

119. However, her haematology remained compromised with acidosis and she was hyperkalaemic. These were treated with packed cells, fresh frozen plasma, platelets and cryoprecipitate prior to surgery commencing.

120. At about 6.00pm, after intensive resuscitation, Dr Waters took Alyssa to theatre for an emergency laparotomy performed by Mr Cramieri. Associate Professor Cameron was also present.

121. Mr Camieri stated:

> *"The site of the liver biopsy puncture could clearly be seen with some steady ooze coming from it.*
>
> *Also, interestingly, the area around the puncture site had evidence of disruption of the capsule and this certainly raised the possibility that in fact Alyssa had initially developed a subcapsular haematoma following the initial biopsy which may have initially controlled her bleeding but then subsequently ruptured because of the ongoing ooze...*

The nature of this bleeding was very difficult to control as it really was a raw surface that was bleeding rather than a specific bleeding point...Unfortunately there was evidence of ongoing bleeding and in fact the patient went into cardiac arrest.

Following resuscitation I then reopened the wound and noted that there was still ongoing ooze from the area which remained uncontrolled. I then attempted to patch the area again to tamponade the bleeding over the raw surface of the area but even these attempts were making no significant difference to the ongoing bleeding."

122. Associate Professor Cameron also recorded that Mr Cramieri found the liver biopsy site as expected. It was a single hole not a laceration. Suturing appeared to stop that bleeding but there was continued uncontrolled bleeding from the surface of the liver. Attempts to stem the bleeding from the surface of the liver failed.

123. Further, the gall bladder appeared pale and shrunken and was not bile coloured. No bile could be aspirated.

124. Alyssa became haemodynamically unstable with hypoglycaemaia, hypotension, broad complex bradycardiarryhthmias and two further cardiac arrests.

125. After the site was packed and the laparotomy site closed, Alyssa had three episodes of profound bradycardia without cardiac output. Resuscitation efforts were abandoned.

126. At 10.45pm on 16 March 2006, Alyssa Chan died.

COMMENTS

Pursuant to section 67(3) of the **Coroners Act 2008**, I make the following comment(s) connected with the death:

1. Alyssa Tze Sim Chan was nine weeks old when she died. She lived with her parents, Felicia and Xander Chan, and her older brother at 78 Alderford Drive in Wantirna.

2. Alyssa seemed well at birth but her jaundice persisted. Investigations using blood and urine analyses, ultrasound and blood clotting analyses failed to identify the cause of her jaundice.

3. On 14 March 2006, a consultant paediatrician at Monash Medical Centre, Dr Barry Kras, discussed Alyssa's case with the consultant gastroenterologist in charge of the Paediatric

Gastroenterology Unit, Associate Professor Don Cameron. Dr Sarah Nunan (now McNab) was also present.

4. After reviewing Alyssa, Associate Professor Cameron advised Dr Kras that prolonged conjugated jaundice needed to be investigated because it indicated an abnormality in liver function or bile secretion. Further, preliminary tests did not exclude the possibility of biliary atresia.

5. Biliary atresia is a blockage in the bile ducts from the liver to the gallbladder. This can lead to liver damage and cirrhosis of the liver if not treated. If required, surgery should be performed before the baby is eight weeks old.

6. Therefore, Associate Professor Cameron, in consultation with Dr Kras and Alyssa's parents, arranged to perform a liver biopsy at Monash Medical Centre.

7. Historically, liver biopsy has been the most specific test to assess the nature and severity of liver abnormalities.[4] It provides an accurate diagnosis in about 90% of patients with unexplained abnormalities revealed on liver function tests.

8. Post-operative bleeding is the known main risk factor associated with percutaneous liver biopsy particularly paediatric liver biopsy with a reported 2% incidence of post-procedural bleeding in children undergoing ultrasound guided suction liver biopsy.[5] This may be caused by deep inspiration during the biopsy or by penetrating injury of a branch of the hepatic artery or portal vein.[6]

9. Associate Professor Cameron performed Alyssa's paediatric percutaneous liver biopsy using a preset, spring-loaded biopsy suction aspiration needle. This process has been used internationally since about 1993.[7]

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[4] AO Bravo, SG Sheth & S Chopra, "Liver Bopsy" (2001) 344 N Engl J Med 495.

[5] AO Scheimann, JM Barrios, YS Al-Tawel, K M Gray & MA Gilger, "Percutaneous liver biopsy in children: The impact of ultrasonography in spring-loaded biopsy needles" J. Pediatric Gastroenterology & Nutrition 31(2000_ 536-539. 2000.

[6] AO Bravo, SG Sheth & S Chopra, "Liver Bopsy" (2001) 344 N Engl J Med 495.

[7] AO Scheimann, JM Barrios, YS Al-Tawel, K M Gray & MA Gilger, "Percutaneous liver biopsy in children: The impact of ultrasonography in spring-loaded biopsy needles" J. Pediatric Gastroenterology & Nutrition 31(2000) 536-539.

10. Associate Professor Cameron had 26 years experience in performing paediatric liver biopsies. He was cross-credentialed at Monash Medical Centre and the Royal Children's Hospital. He had been responsible for nearly all the paediatric liver biopsies performed at Monash Medical Centre at that time. He had previous experience with only one case of unexpected bleeding which was identified and controlled in a timely manner and the patient recovered.

11. On the other hand, Associate Professor Cameron's success in performing uncomplicated paediatric liver biopsies also means that he was inexperienced in identifying and managing the complication which is most likely to occur during the liver biopsy procedure.

12. At 11.15am on 16 March 2006, Associate Professor Cameron performed a percutaneous liver biopsy on Alyssa without known complications.

13. Subsequent histological analysis indicated mild hepatitic changes and:

> *"There appears to be a near total lack of normal small bile ducts in the portal tracts.*
>
> *The findings are consistent with obstructive jaundice due to paucity of interlobular bile ducts."*

14. However, nursing staff could not detect Alyssa's blood pressure and her condition deteriorated after she returned to the ward. At 2.35pm, she sustained a cardiac arrest and a subsequent ultrasound showed a large mass in or close to the liver consistent with a haematoma under or near the liver capsule. She was still actively bleeding around the biopsy site.

15. At 6.00pm, Mr Joseph Cramieri performed a laparotomy and secured the biopsy site. Alyssa's liver continued to bleed.

16. At 10.45pm on 16 March 2006, Alyssa Chan died.

17. The forensic pathologist who performed the autopsy formed the opinion that the cause of death was combination of liver failure, blood loss and shock following needle biopsy and neonatal hepatitis. *Clostridium perfringens* septicaemia was a contributing factor.

18. There was no biliary atresia. The common bile duct and common hepatic duct were patent and ducts were identified in the portal triads together with giant cell transformation of liver cells.

19. However, the post mortem metabolic screen suggested that Alyssa may have citrin deficiency. DNA analysis confirmed that Alyssa was a compound heterozygote with [I] 851del4 and [X] IVS6+5G>A mutations in the SLC25A13 gene.[8] Mutations in this gene are now known to be associated with citrin deficiency.

20. This review will discuss particular issues relating to Alyssa's management including:

- Citrin deficiency
- Pre-operative management of paediatric liver biopsy patients
- Ultrasound management of paediatric liver biopsies
- Post-operative observation of paediatric liver biopsy patients.

22. It will then make recommendations intended to prevent other children dying for the reasons that Alyssa died.

Citrin deficiency

23. Citrin deficiency or Type II citrullinaemia is an autosomal recessive genetic disorder predominantly restricted to children of Chinese, Korean, Vietnamese and Japanese heritage. Both Alyssa's parents carry genes associated with citrin deficiency. Therefore, statistically, she had a 25% chance of inheriting one of several genetic sequences known to be associated with symptoms of the disorder.

24. Physiologically, citrin deficiency can be associated with neonatal intrahepatic cholestasis or blockage of the bile ducts in the liver. Accordingly, symptoms may include unresolved conjugated jaundice associated with elevated serum bile acid concentrations and triglycerides, low levels of citrulline and increased levels of most amino acids including methionine, and/or phenylalanine, hypoproteinaemia, low levels of vitamin-K coagulation factors, hypergalactosaemia and, in some cases, hypoglycaemia.[9]

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[8] This analysis was performed by Associate Professor Keiko Kobayashi at the Department of Molecular Metabolism and Biochemical Genetics, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan and reported on 21 July 2006.

[9] T Ohura, K Kobayashi, Y Tazawa, D Abukawa, O Sakamoto, S Tsuchi & T Saheki, "Clinical pictures of 75 patients with neonatal intrahepatic cholestasis caused by citrin deficiency (NICCD)", J. Inherit. Metab. Dis. 30 (2007) 139. See also JS Wang, XH Wang, YJ Zheng, HY Fu, R Chen, Y Lu, LJ Fang, T Saheki, & K Kobayashi, " Biochemical characteristics of neonatal cholestasis induced by citrin deficiency", World J. Gastroenterol. (2012) 5601.

25. Some children with genes known to be associated with citrin deficiency do not exhibit these symptoms. In other children, these symptoms of neonatal citrin deficiency are not severe and disappear by age one year with appropriate treatment including fat-soluble vitamin supplementation and lactose free formula or formula containing medium-chain triglycerides. [10] However, their children remain at risk of inheriting the disorder.

26. There are also other differential diagnoses associated with similar amino acid imbalance, for example cholestasis. These conditions are also risky and some require liver biopsies for histological confirmation. Some can be excluded by other parallel analyses.

27. In the absence of Alyssa's pre-referral assessment results, I am unable to say to what degree she displayed symptoms of citrin deficiency other than unresolved jaundice prior to her referral to Associate Professor Cameron. However, I note that her blood citrulline levels were normal and her parents told the Court she was a healthy baby (other than being jaundiced) before surgery on 16 March 2006.

28. Further, the usual low level symptoms associated with citrin deficiency do not mean that unresolved paediatric conjugated jaundice should be ignored. There are reports of four children developing hepatic dysfunction requiring liver transplant before they were one year old.[11] Other carriers of genes associated with citrin deficiency may develop neuropsychiatric symptoms as adults.[12]

29. Further, in the absence of or parallel to citrin deficiency, unresolved paediatric conjugated jaundice may have other serious implications which need to be resolved early, for example Alagille syndrome which is the paucity of the intrahepatic bile ducts, neo-natal hepatitis syndrome, mitochondrial diseases, infection, hepatitis or gastrointestinal obstruction.

30. Therefore, in the absence of a diagnosis of citrin deficiency, unresolved paediatric conjugated jaundice requires an early alternative explanation and appropriate therapy.

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[10] K. Kobayashi & T. Saheki, "Citrin Deficiency", Gene Reviews, University of Washington, Seattle, updated 1 July 2008.

[11] K Kobayashi & T Saheki, "Citrin Deficiency", Gene reviews (2005 updated on 2 July 2008), University of Washington, Seattle, United States of America.

[12] A Tamadori, Y Okano, H Ozaki, A Fujimoto, M Kajiwara, K Fukuda, K Kobayashi, T Saheki, Y Tamani & T Yamano, "Neonatal intrahepatic cholestastis caused by citrin deficiency: severe hepatic dysfunction in a infant requiring liver transplantation", Eur. J. Pediatr. 161 (2002) 609.

31. Alyssa was suspected to carry citrin deficiency after her death when post mortem urine analyses contained amine derivatives and abnormal amino acid distribution was detected in retrospective analysis of blood collected at birth. This diagnosis was confirmed by genetic analysis performed in Japan and reported on 21 July 2006.

32. Associate Professor Avihu Boneh is Head of Metabolic Genetics at the Victorian Clinical Genetics Services which is a solely owned subsidiary of the Murdoch Childrens Research Institute associated with the Royal Children's Hospital.

33. On 15 February 2011, Associate Professor Boneh and Associate Professor Cameron participated in a Round Table discussion about the prevalence and management of citrin deficiency in the Victorian community.

34. In this discussion, Associate Professor Boneh said that citrin deficiency was a relatively new diagnosis in Australia. In his professional capacity, he always recommends monitoring of babies diagnosed with citrin deficiency with no other treatment unless clinical circumstances change.

35. Further, Associate Professor Cameron said that he and other gastroentrologists had never heard of citrin deficiency when Alyssa died. In evidence, Associate Professor Cameron also agreed that prior diagnosis of citrin deficiency would have meant he did not have to perform Alyssa's liver biopsy at all or, alternatively, that he took it into account in deciding whether or not the liver biopsy was required.

36. Accordingly, Associate Professor Boneh and Associate Professor Cameron both say that early diagnosis of citrin deficiency in babies with prolonged jaundice would reduce the frequency of paediatric liver biopsies with their associated risks.

37. Associate Professor Boneh has now introduced extra screening of neo-natal bloods for abnormal amino acid distribution. Therefore, I make no recommendation on that issue.

38. However, Associate Professor Boneh is concerned that routine screening of new born blood samples may miss 50% of citrin deficiency diagnosis because the samples may be taken too early for abnormal levels of amino acids to accumulate.

39. Therefore, babies who present with unresolved conjugated jaundice at about eight weeks, particularly those for whom liver biopsy is being considered, should undergo further screening

to assess the possibility that their condition is associated with citrin deficiency. **Recommendation 1.**

40. Objective diagnosis of citrin deficiency requires genetic analysis. This procedure is not available in Australia and is therefore slow and expensive.

41. However, if the genetic testing was available in Australia, the mutation testing would be cheaper than a liver biopsy. Further, the benefits of diagnosis are likely to outweigh the costs if early screening is comprehensive to reduce the frequency of false diagnoses.

42. Therefore, from a cost and risk perspective, genetic screening is justified for babies who would otherwise undergo liver biopsies and are selected to increase the likelihood of citrin deficiency. This selection process could include babies of Asian descent who have unresolved conjugated bilirubin jaundice associated with abnormal amino acid distribution consistent with citrin deficiency. **Recommendation 2.**

43. Further, absent a confirmed diagnosis of citrin deficiency, babies with conjugated bilirubin jaundice which remains unresolved at eight weeks need rapid diagnosis to minimise the long-term consequences of their condition. Associate Professor Cameron and Associate Professor Boneh agree that, for patients with unresolved conjugated bilirubin jaundice without a diagnosis of citrin deficiency, liver biopsy is the next step for determining management and reducing risk.

44. Conjugated bilirubin jaundice is not considered prolonged until about eight weeks and conditions like bilary atresia must be diagnosed and treated as early as possible to prevent the child suffering severe damage. Therefore, there is a very short window, maybe two weeks, within which diagnostic liver biopsies must be performed to inform alternative therapy options and minimise the potential severe repercussions of other conditions which express themselves as unresolved conjugated bilirubin jaundice.

45. Current arrangements for sending blood samples to Japan for genetic analysis remain ad hoc and subject to good will.[13] They are also slow. Alyssa's analysis took four months. Routine reliable analyses in Australia would be quicker and more responsive.

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[13] Dr Boneh said that the Japanese laboratory that performed Alyssa's test performed it for free because it was a rare request.

46. Further, parents who have been identified as carriers of citrin deficiency would be assisted by early prenatal diagnosis of the mutation in their unborn children using placental or amniotic fluid samples.

47. Therefore, in the context of increasing numbers of children with Chinese and other Asian heritage in Australia, routine analysis for the genetic carriers of citrin deficiency should be established here. **Recommendation 3.**

Pre-operative management of paediatric liver biopsy patients

48. The Royal Children's Hospital in Melbourne publishes policies and procedures on the internet in relation to performance of paediatric liver biopsy.[14] This Royal Childrens Hospital Liver Biopsy Clinical Path required and continues to require pre-operative nursing observations to include baseline temperature, pulse, respirations and blood pressure as well as taking of blood samples and insertion of an intravenous line. This Royal Children's Hospital policy has not changed.

49. Southern Health performs about six paediatric liver biopsies a year.[15] In 2006, they used the adopted Royal Children's Hospital pre-operative documentation. Accordingly, Dr Nunan ordered Alyssa undergo further pre-operative blood analyses on 16 March 2006.

50. However, no further blood tests were reported for the morning of Alyssa's admission as required by the Royal Children's Hospital medical checklist and ordered by Dr Nunan. In particular, no further pre-operative coagulation assessment was undertaken to confirm that the Vitamin K administered on 15 March 2006 was effective in improving Alyssa's coagulation rate.

51. In the absence of any other blood tests until 7.30pm on 16 March 2006, I am unable to say whether Alyssa's subsequent bleeding was exacerbated because her slow coagulation rate persisted when surgery commenced.

52. In September 2006, Southern Health introduced the Paediatrics - Pre and Post Liver Biopsy Protocol.[16] This protocol indicates that the reason for taking specified precautions is to ensure

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[14] Royal Children's Hospital, Melbourne Australia, "Liver Biopsy Clinical Path", Medical Checklist Liver Biopsy 2.doc last updated May 2003.

[15] Ward records from September 2006 to October 2010 identified 19 liver biopsy patients.

that bleeding post-biopsy is detected early. It also notes that blood pressure is a late indicator of deteriorating status in children and heart rate is a more accurate assessment. It was due for review in September 2008.[17]

53. Therefore, I recommend that the Royal Children's Hospital review their protocols in the light of this Finding and the changes introduced by Southern Health in September 2006 and September 2008. **Recommendation 4**

54. Despite this new protocol and Alyssa's death, an audit of implementation of this protocol in the Endoscopy suite and Ward 42 N at Monash Medical Centre in 2011 indicated that only 67% of medical officers ordered pre-operative bloods for cross matching and clotting analysis and only 60% reviewed these analyses prior to surgery. In 33% of cases, they reviewed the patient within two hours of return to the ward.

55. Further, nursing staff recorded vital signs in 80% of patients but these vital signs did not include blood pressure in 53% of cases. Further, blood pressure was recorded every 15 minutes in the first hour and every 30 minutes for the next three hours in only 53% of patients.

56. These data indicate that the medical and nursing staff in the Endoscopy suite and on Ward 42 N at Monash Medical Centre in 2011 were still not taking seriously the implications of Alyssa's death and the risks associated with bleeding following paediatric liver biopsy.

57. The Nurse Unit Manager of the Endoscopy Suite, Bettina Ketts, was not aware of the new Southern Health Paediatrics - Pre and Post Liver Biopsy Protocol until 2011. Since then, staff perform a post operative blood pressure reading on all liver biopsy patients and they are reminded whenever a liver biopsy is scheduled.

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[16] Southern Health, "Paediatrics - Pre and Post Liver Biopsy Protocol", Clinical Protocols and Guidelines, CP-PD09, Version 1.4, September 2006.

[17] I note that coagulation studies referred to in the Southern Health Paediatrics - Pre and Post Liver Biopsy Protocol 2006 apply to adult patients with stable chronic hepatobiliary disease: CS Pokorny & M Waterland (2002) 'Short-stay, out-of-hospital, radiologically guided liver biopsy", Med J Aust 2002; 176 (2): 67-69.

58. The Nurse Unit Manager of Ward 42N, Gina Ruwoldt has attempted to increase the status of the Pre and Post Liver Biopsy Protocol and promoted the ward culture of accessing protocols when patients are booked for rarely performed procedures. **Recommendation 5**

Ultrasound management of paediatric liver biopsies

59. At 11.00am on 16 March 2006, Alyssa was anaesthetised in the Endoscopy Suite at Monash Medical Centre. Then, a pre-operative ultrasound was performed to assist Associate Professor Cameron to determine the access site and biopsy equipment settings for the liver biopsy.

60. Associate Professor Cameron told the Court that the pre-operative ultrasound did not show any major vessels along the planned track for more than 35mm from the liver surface.

61. The pre-operative ultrasound allowed Associate Professor Cameron to mark Alyssa's skin to show where to perform the biopsy and to set up the needle guide. He also set the "throw" or specimen notch of the biopsy needle at 2cm.

62. Accordingly, I find that Associate Professor Cameron performed Alyssa's liver biopsy in 2006 using a pre-operative ultrasound to identify a safe access point and to pre-set the maximum intrusion distance for the biopsy needle.

63. However, the pre-operative ultrasound did not alert Associate Professor Cameron to the possibility that there may be a major blood vessel within the throw distance of his biopsy needle.

64. No sonographer is named on the report approved by the consultant radiologist on duty, Dr Surekha Kumbla, that indicated it was a "Non-radiologist ultrasound". No images were retained. Further, Dr Kumbla does not remember seeing the ultrasound.

65. Therefore, I am unable to say who performed Alyssa's pre-procedure ultrasound on 16 March 2006, who influenced Associate Professor Cameron's opinion that there were no major vessels for more than 35mm from the liver surface or who failed to retain any images from the pre-procedure ultrasound.

66. At 11.15am, Associate Professor Cameron began the biopsy procedure. He used a Temno II biopsy system with a 14 gauge Temno II biopsy needle to enter the liver and extract a liver specimen.

67. A Temno II biopsy system is an automated device which is designed to shoot a hollow needle into the body for a pre-set distance and withdraw a core sample of tissue for analysis.

68. Dr Chris O'Donnell is a forensic radiologist employed by the Victorian Institute for Forensic Medicine. He told the Court that the position of the liver in the peritoneal cavity and relative to the skin changes when the patient breathes.

69. Some minutes had passed between the pre-procedure ultrasound and the liver biopsy procedure.

70. Further, the anaesthetist recorded Alyssa's respiration rate from 11.00am to 11.32am. There is no indication in the anaesthetic record that artificial respiration was suspended at any time to allow Associate Professor Cameron to perform the biopsy unencumbered by respiratory movement.

71. Associate Professor Cameron also told the Court he aims to time insertion of the needle between breaths and it goes in and out very quickly.

72. Therefore, there is no reason to believe that Alyssa's liver's was in the same position when the liver biopsy was performed as it had been when the pre-procedural ultrasound was performed.

73. Accordingly, even if the pre-procedural ultrasound guidance used by Associate Professor Cameron had alerted him to the possibility that there was a major blood vessel within the throw of his biopsy needle when he performed the liver biopsy procedure, the distance he calculated would not have taken into account the changes in position of Alyssa's liver associated with her respiratory status.

74. Associate Professor Cameron performed the Alyssa's liver biopsy procedure without obvious complications. He obtained adequate liver specimens on the first pass comprising three cores each of 2mm in diameter and between 4mm and 11mm in length.

75. At about 11.30am, a post-operative ultrasound was performed. Only a single cameo image was retained.

76. Investigation of Alyssa's death has been limited by the failure to retain any images of her pre-procedural ultrasound and the retention of only a single cameo image of her post-operative ultrasound.

77. Southern Health can now retain digital images of all radiology indefinitely. I have formed the view that current technology enables retention of all ultrasound images of paediatric liver biopsies and that this retention would materially assist proceduralists, investigators and trainers in reviewing the circumstances surrounding a paediatric liver biopsy. **Recommendation 6**

78. Dr Kumbla reported this post-operative ultrasound at 5.04pm:

> *"Ultrasound guidance was provided for liver biopsy. Images performed immediately after the procedure did not demonstrate any definite evidence of any free fluid in the region of the liver biopsy."*

79. Associate Professor Cameron says he viewed the entire ultrasound record and did not see any evidence of bleeding.

80. Dr Kumbla also gave evidence that she viewed the entire record. However, she did not report it until after she would have known about Alyssa's subsequent deterioration.

81. Further, Melissa Cunningham was the sonographer who is noted on the report as performing the post-operative ultrasound. Ms Cunningham provided a statement and was cross-examined as part of the coronial investigation of Alyssa's death.

82. Ms Cunningham graduated at the end of 2005 but she had prior experience as a radiographer.

83. Ms Cunningham told the Court that the sonographer decides which images to retain.

84. Therefore, I am not convinced that that all the images of the post-operative ultrasound would have been available for Dr Kumbla's review at 5.04pm on 16 March 2006. Accordingly, Associate Professor Cameron's opinion is the only evidence I can accept of Alyssa's complete pre and post-operative ultrasounds. He is not a radiologist.

85. Both Dr Kumbla and Counsel for Southern Health say that it is possible, even probable, that Ms Cunningham did not perform Alyssa's post-operative ultrasound.

86. They are supported by Ms Cunningham's evidence:

- She does not remember working with Associate Professor Cameron in the Endoscopy Suite and it was rare for her to be called out of the radiology unit to assist with ultrasounds.

- She has no independent memory of Alyssa's case and she does not remember ever being called to perform an ultrasound for a paediatric liver biopsy.

- She did not usually work with babies under general anaesthetic.

- She does not remember ever performing an ultrasound on a baby under general anaesthetic.

- She does not recall a conversation with Associate Professor Cameron or Dr Kumbla.

87. Accordingly, I find that Ms Cunningham did not perform the post-operative ultrasound at 11.30am on 16 March 2006. Further, I am unable to say who performed the post-operative ultrasound or who decided to retain only a single cameo image of the post-operative ultrasound.

88. The single cameo image of Alyssa's post-operative ultrasound has also been reviewed by Professor Michael Ditchfield, the Head of Paediatric Imaging at Southern Health, and Dr O'Donnell.

89. Professor Ditchfield and Dr O'Donnell both confirm that they can see a thin echogenic structure transversing the liver and they both presumed this indicated the needle track mark. This retained cameo image did not show the portal vein or any other large blood vessel. Further, it did not show any bleeding in the visible part of the biopsy tract.

90. Therefore, from the information available to me, I find that there was no heavy or aggressive bleeding from the biopsy needle tract when the post-operative ultrasound was performed at about 11.30am on 16 March 2006.

91. Dr O'Donnell explained that heavy bleeding would be detectable immediately if the biopsy needle had entered an artery.

92. Accordingly, I find that the bleeding subsequently found in Alyssa's biopsy tract probably did not arise from an arterial bleed. Therefore, it remained undetected and, probably, undetectable

when the post-operative ultrasound was performed within five minutes of completion of the liver biopsy at 11.32am on 16 March 2006.

93. Clinical data suggests that Alyssa's condition began to deteriorate soon after she returned to Ward 42N at 12.35pm and certainly by 1.30pm on 16 March 2006. Therefore, a further post-operative ultrasound after one or two hours would have detected the bleed and allowed timely intervention.

94. Southern Health has now included routine post procedure ultrasound scans two hours after all paediatric liver biopsies commencing December 2010. Therefore, I make no recommendations on this issue.

95. By 2011, Dr O'Donnell and Counsel for Southern Health, John Snowdon, both told the Court that nearly all paediatric liver biopsies are performed by interventional radiologists in radiology suites under real-time continuous ultrasound guidance. Therefore I make no recommendation in relation to the need for continuous ultrasound guidance of paediatric liver biopsies.

96. Dr O'Donnell also told the Court that image-guidance was already considered to be necessary for paediatric percutaneous liver biopsies in 2006.[18]

97. However, there is no evidence before me to support the possibility that Associate Professor Cameron used continuous ultrasound guidance when he performed Alyssa's liver biopsy.

98. Rather, I have formed the view that Associate Professor Cameron and Dr Kembla used the term "ultrasound guidance' to mean pre-procedural and post-operative ultrasounds.

99. I also find that Associate Professor Cameron performed the liver biopsy using pre-procedural ultrasound guidance and post-procedure ultrasound check for bleeding. However, he did not use real time ultrasound during the biopsy procedure.

100. At 2.35pm on 16 March 2006, Alyssa suffered a cardiac arrest. At 3.35pm, an urgent ultrasound was performed. I am unable to explain the delay of one hour between Alyssa's cardiac arrest and the urgent ultrasound performed to determine the cause of her deterioration. A more comprehensive set of images was retained from this procedure.

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[18] JG Amaral, J Scwartz, P Chait, M Temple, P John, C Smith, G Taylor & B Connolly, "Sonographically guided percutaneous liver biopsy in infants: a retrospective review", (2006) 187 AJR W644.

101. The 3.37pm ultrasound was reported as showing that Alyssa had extensive fluid in the peritoneum which was presumed to be blood, an organising haematoma around the liver and active bleeding from the biopsy tract.

102. Dr O'Donnell also interpreted the images of the 3.37pm ultrasound. He said that the tract of blood arose from an intra-hepatic structure which seems to be 1.5-1.8cm deep. He also told the Court:

> *"The tract in the liver is extending down to and entering that portal vein branch...*
>
> *What I can say is that* (the tract) *is at least 15 to 18 millimetres from the surface of the liver to the portal vein branch."*

103. Dr O'Donnell also said the tract of blood from the liver edge to the large major blood vessel, which may have been the portal vein, is only part of the tract that is outlined with blood and blood flow. The actual needle tract could be longer. It is consistent with the tract of a needle with a 2cm throw.

104. As well, Dr O'Donnell said that he could see a large mass with blood flowing into it that did not extend beyond the surface of the liver. It looked like a haematoma.

105. Therefore, I find that Alyssa was bleeding from an injury to a portal vein branch that occurred during the liver biopsy performed by Associate Professor Cameron using a with a 2cm throw at about 11.30am on 16 March 2006.

106. This injury was and remains a well-documented specific risk associated with paediatric percutaenous liver biopsies.

107. I also find it very unlikely that Associate Professor Cameron would have penetrated Alyssa's portal vein if he had used continuous ultrasound guidance when he performed her liver biopsy. Alternatively, he would have been aware immediately that he had injured the portal vein and had an opportunity to remediate the bleeding in a timely manner.

Post-operative observation of paediatric liver biopsy patients

108. The Royal Children's Hospital Liver Biopsy Clinical Path required and continues to require post-operative nursing observations include temperature, pulse, respiration, blood pressure and biopsy site checks.[19]

109. At 12.35pm on 16 March 2006, Alyssa was transferred to the recovery room prior to return to the ward. At 12.00pm, the gastroenterology resident, Dr Christie-Johnson, reviewed her. At 12.05pm, she woke up from her anaesthetic.

110. Alyssa's medical records indicate that, consistent with Associate Professor Cameron's orders, her observations were recorded every 10 to 15 minutes in the recovery room. However, none of these recorded observations included a blood pressure assessment.

111. Bettina Ketts was the nursing manager of the Endoscopy Unit in March 2006. Ms Ketts was not on duty that day and she was not involved in her care. However, in a statement, she said that:

- Nil orally was routinely imposed after a procedure;
- Blood sugars were not routinely checked;
- It was not anaesthetic practice to record paediatric blood pressure before, during or after their procedures.

112. In assessing a small child at risk of bleeding, Ms Ketts told the Court:

> *"The signs that I'd be looking for in a child would be a rapid pulse or heart rate, increased respiration rate, pallor or paleness, lethargy. But certainly it wouldn't - I wouldn't be looking for blood pressure; it would be a more latent sign."*

113. This practice is inconsistent with the requirements of the Royal Children's Hospital Liver Biopsy Clinical Path.

114. Ms Ketts also explained that anaesthetic can influence blood pressure and that it is always difficult to take a meaningful blood pressure in children when they are moving. She had no other explanation for the Southern Health practice of not taking paediatric blood pressure before, during or after their procedures.

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[19] Royal Children's Hospital, Melbourne Australia, "Liver Biopsy Clinical Path", Medical Checklist Liver Biopsy 2.doc last updated May 2003.

115. However, Ms Ketts told the Court, this practice has now changed. Blood pressure is now routinely taken in children as part of their post operative observations.

116. At 12.35pm on 16 March 2006, Alyssa returned to Ward 42N. Lena Lim and Belinda Fox were the nurses caring for her.

117. From 12.45pm to 2.05pm, nursing staff took observations at intervals ranging from 15 to 35 minutes. In that period:

- Alyssa's respiratory rate declined to 38 breaths per minute;
- Her pulse varied from 127 to 149 beats per minute;
- Her temperature rose to 37 degrees C;
- Her pulse varied from 127 to 149 beats per minute;
- Her oxygen saturations declined to 80% on room air (noted as not a good reading).

118. No blood pressure measurements were recorded.

119. Gina Ruwoldt was a Registered Division 1 Nurse Unit Manager working on Ward 42N on 16 March 2006. She told the Court:

> *"Well, I'd be concerned because there's obviously gaps where her vital signs weren't recorded properly. The temperature hasn't been taken since 1.30. I guess that's only an hour, isn't it? And there's nothing to say if they attempted to record a blood pressure or not...."*

120. Ms Ruwoldt also said that it was not normal practice to make 15 minute observations on the ward. However, if it was otherwise ordered she would expect the readings to be done and recorded.

121. Therefore, it is clear that the expectations of Associate Professor Cameron and the Nurse Unit Manager about the content and frequency of post-operative observations were inconsistent with those of the nursing staff in the Endoscopy Suite and Ward 42N at Southern Health.
Recommendation 7

122. The new Southern Health Paediatrics - Pre and Post Liver Biopsy Protocol[20] requires post-anaesthetic observations to include blood pressure. Further, I note Ms Ketts' and Ms Ruwoldt's efforts to improve compliance. Therefore, I make no further recommendation on this issue.

123. At 1.00pm, Ms Lim told Associate Professor Cameron she could not obtain Alyssa's blood pressure reading. His understanding was that this failure to obtain a blood pressure reading was a technical problem and he told Ms Fox to keep trying. Associate Professor Cameron then left the hospital and responsibility for Alyssa's management fell to his registrar, Dr Nunan.

124. This was the first time Dr Nunan had managed a baby who had undergone a liver biopsy. She had seen one or two previous paediatric liver biopsy procedures but she does not remember ever having to review them on the ward.

125. Further, Ms Fox remained unable to obtain a blood pressure reading. At 2.05pm, Dr Nunan told Ms Fox not to worry because Alyssa's heart rate remained stable and she looked well. Rather, Dr Nunan ordered intravenous maintenance fluids.

126. In evidence, Dr Nunan also said that she had asked the nursing staff to attempt to obtain Alyssa's blood pressure using a manual blood pressure machine because, particularly in a child that is not able to be cooperative, it is usually the more accurate. She was unaware that nursing staff could not find a manual blood pressure machine on the ward. Ward 42N now has two manual blood pressure machines.

127. However, Ms Lim and Ms Fox told the Court that none of the four electronic blood pressure monitors available was recording proper measurements and Ms Fox could not find a manual sphygmomanometer on the ward.

128. Ms Lim also told the Court she had no trouble performing an adequate blood pressure measurement at 8.50am during Alyssa's pre-operative assessment. She used one of the electronic blood pressure machines on the ward fitted with an infant cuff.

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[20] Southern Health, "Paediatrics - Pre and Post Liver Biopsy Protocol", Clinical Protocols and Guidelines, CP-PD09, Version 1.4, September 2006.

129. Further, subsequent testing of the blood pressure machines on Ward 42N indicated that all four non-invasive machines were working on 16 March 2006 and that the other three children on the ward all had blood pressure readings recorded in the medical records that day.

130. Therefore, any practical investigation of the problem at the time would have demonstrated that failure to detect Alyssa's blood pressure was not just caused by a technical incapacity to obtain the blood pressure measurements. This would have led to investigation of why Alyssa's blood pressure was too low to be detected using the electronic blood pressure equipment available.

131. Accordingly, from information that could have been ascertained at the time, I have formed the view that, by 12.45pm on 16 March 2006, Alyssa's blood pressure had deteriorated from 63/47mmHg, when Ms Lim last assessed it at 8.50am, to the point where it was unable to be measured by an electronic blood pressure machine.

132. In the absence of any other explanation, I must assume that Alyssa's low blood pressure occurred as a consequence of the liver biopsy procedure.

133. Associate Professor Margaret McEniery provided an expert opinion for the Court. She is in the faculty of Nursing at the University of Newcastle and has clinical experience in paediatric and surgical wards.

134. Associate Professor McEniery says the four traditional vital signs have been shown to be limited in detecting important physiological changes. Similarly, studies addressing the measurement of indirect blood pressure suggest the readings do not always accurately reflect the haemodynamic status of critically ill patients.

135. Further, Mr Joseph Cramieri was the after-hours on-call paediatric surgeon on 16 March 2006. He is a general paediatric surgeon who works at the Monash Medical Centre and the Royal Children's Hospital. Mr Cramieri told the Court:

> *"...at my level of training I almost never used the machinery itself, so it would be difficult for me to comment on that. I think in broad principle it can be very difficult to obtain blood pressures on small babies, but I would also say as a surgeon that I would always see blood pressure as a secondary thing to the pulse rate, because we know that the blood pressure is unreliable in these circumstances, we know that babies are very*

resilient to blood pressure losses, and in fact babies can maintain their blood pressure.. until they have lost a significant amount of blood."

136. However, both these opinions address the situation where blood pressure is artificially high and this disguises the patient's deteriorating condition. They do not address or explain the circumstances that arise where the blood pressure is already so low as to be unmeasurable using electronic equipment.

137. In the context of nursing staff being very concerned about Alyssa, Associate Professor Cameron attributed their inability to obtain a blood pressure measurement to technical difficulty with taking paediatric blood pressures.

138. Normal parameters for heart rate for an infant up to six months of age is from 100 to 160 beats per minute. The criteria for a medical emergency team call is a heart rate of greater than 180 beats per minute.

139. A pulse oximeter is used to monitor patients' heart rate and blood oxygen saturation levels. Associate Professor McEniery said that pulse oximetry is essential for detecting deterioration in critical physiological functions that might otherwise be missed using blood pressure monitoring or subjective observations of the patient.

140. A detector is attached to a finger or toe and the real time readings are displayed on a screen. However, there is no provision for saving this trace for future analysis. Therefore, the Court and other professionals seeking to retrospectively review a patient's status are limited to the memories of medical officers and nurses and notes of their observations at specific times.

Recommendation 8

141. At 12.45pm, Ms Lim was able to record Alyssa's heart rate as 145 beats per minute and oxygen saturation as 100% on room air. She told the Court these readings were within normal limits and she was not worried about Alyssa's condition at that time.

142. However, by 1.30pm, nursing staff were unable to obtain an adequate trace using two different pulse oximeter machines using a probe attached to Alyssa's foot. Ms Winterscheidt stated:

"During the period we tried to obtain saturations and pulse readings on the oximeter. I obtained a second oximeter with a trace line that was hard to determine, where the

initial unit had a good trace. The second machine showed the readings we were getting were not a good trace".

143. At 1.30pm, Ms Fox recorded Alyssa's pulse to be 127 beats per minute and her oxygen saturation was 97% and noted to be "not a good reading". These readings are lower than previously but remained within normal range. However, Ms Fox also recorded that Alyssa looked quite pale and called Dr Nunan.

144. At 1.50pm, despite nursing opinion of observations that it was not a good trace over more than 20 minutes and two oximetry machines, Dr Nunan relied on her relatively short observation of Alyssa's real time trace from the pulse oximeter to advise Ms Fox not to worry about difficulty with obtaining a blood pressure because the heart rate was normal and she looked well.

145. Dr Nunan also told the Court that she was concerned about Alyssa but comforted by having seen normal oxygen saturation levels recorded. Therefore she dismissed the low readings as instrument error:

"The fact that I could see normal ones really reassured me. And coupled with that at that stage her airway and breathing seemed perfectly adequate to me, so I wasn't concerned - I couldn't think of a reason why the oxygen levels in the blood would be low at that point, given all of that."

146. Again, Associate Professor Cameron and Dr Nunan both attributed nursing staff concerns about their inability to obtain adequate pulse oximetry readings to instrument error. Their opinions may have reflected the shorter periods of time they observed Alyssa and their inexperience with adverse outcomes following paediatric liver biopsies.

147. In the absence of any other explanation, I must assume that Alyssa's inadequate pulse oximetry trace after 1.30pm on 16 March 2006 reflected deterioration in the signals projected by her pulse and oxygen saturation levels attributable to the liver biopsy procedure.

148. By 2.05pm, Alyssa's oxygen saturation had fallen to 80% and her pulse oximetry trace remained variable. Dr Christie-Johnson called Dr Nunan.

149. Dr Nunan requested a blood sugar reading. She told the Court that her medical training reinforced the ABCD mantra for assessing unexplained deterioration in young children:

"Airway, Breathing, Cardiac and Don't forget the glucose."

150. Alyssa's blood glucose level was low but it responded positively to a bolus of dextrose and Dr Nunan ordered another attempt to breast feed. Alyssa took a few sucks and then became lethargic. Her oxygen saturation was around 90-93% on room air and there was still only a faint trace on the oximeter.

151. At about 2.15pm, Dr Nunan contacted Associate Professor Cameron. She told him that there were concerns about Alyssa. She did not think it was a bleeding problem but rather a respiratory problem and hypoglycaemia.

152. Associate Professor McEniery asks the same question that I ask:

> *"What effect did the registrar's opinion that the problem was not a surgical or bleeding problem but rather a respiratory or hypoglycaemia problem have on their response and the outcome for Alyssa?"*

153. I note that Associate Professor Cameron accepted Dr Nunan's advice on this issue.

154. Even in 2010, Associate Professor Cameron told the Court:

> *"I would have to defer to those who were there and were making the other observations."*
>
> He also said:
>
> "I *think some of the changes that were happening around about the 2 o'clock mark were because of the low blood sugar, which was identified and rectified."*

155. Therefore, I have formed the view that Associate Professor Cameron's interpretation of the information provided to him by his registrar influenced his opinion and continues to influence his belief that Alyssa's deterioration occurred rapidly, over a matter of minutes.

156. I also believe that this interpretation delayed an appropriate response to the other indicators consistent with a slow post-operative haemorrhage which, if accepted as a differential diagnosis, commenced before Alyssa returned to Ward 24N at 12.35pm on 16 March 2006.

157. Severe bleeding is a known high risk factor for paediatric liver biopsy. However, Associate Professor Cameron had only one experience of severe bleeding from a liver biopsy. Dr Nunan

had no prior exposure to post-operative management of paediatric liver biopsies. Alyssa's blood sugar level had been restored but her pulse oximetry readings remained variable.

158. In these circumstances, I have formed the view that Associate Professor Cameron should have been more sceptical about Dr Nunan's capacity to appropriately assess Alyssa and consider alternative explanations of her condition.

159. Alyssa's condition continued to deteriorate. At 2.35pm, she sustained a cardiac arrest. At 3.35pm, an ultrasound showed a large mass in or close to the liver consistent with a haematoma under the liver capsule. She was still actively bleeding around the biopsy site. There was no evidence of an accumulation in the peritoneum.

160. I am unable to explain the delay of one hour in obtaining an emergency ultrasound except to note that Alyssa's catastrophic failure occurred at about the time for shift changeover in the hospital.

161. Mr Cramieri told the Court he first saw Alyssa at about 5pm:

> *"I guess with the history of having had a liver biopsy with a child that was unstable and with a child who had a very distended abdomen, the likely conclusion was that this was bleeding that was the cause of the problem."*

162. At 6.30pm, Mr Cramieri performed an emergency laparotomy. He explained that the two hour delay in commencing surgery was spent attempting to stabilise Alyssa's haematology to give her a better chance of survival.

163. Mr Cramieri also said he found:

> *"The thing that I note at the time is the major bleeding I saw really seemed to be coming from the hole, not from that area, basically."*

164. Mr Cramieri also found the hepatic capsule was disrupted in the area around the puncture site:

> *"I have distinct memory of it, and I could see the puncture site, but what I could see along the side of the lobe of the liver coming towards me as I look up, was really the capsule almost billowing a little bit, with the bleeding. So it was clear that it wasn't adherent to the surface of the liver, which is what I would have expected. So I did note that at the time"*

165. He also told the Court:

> *"...this certainly raised the possibility that in fact Alyssa had initially developed a subcapsular haematoma following the initial biopsy which may have initially controlled her bleeding but then subsequently ruptured because of the ongoing ooze... it's actively controlling the bleeding, as long as the capsule doesn't give way."*

166. Mr Cramieri formed the view that the bleeding had been into a subcapsular haematoma and then, secondarily and catastrophically, into the abdominal cavity when the haematoma ruptured at 2.35pm.

167. Further, in evidence, Associate Professor Cameron described Alyssa's deterioration as:

> *"Certainly a catastrophic event, and by all reports something happened very suddenly over what seems to have been a matter of minutes rather than a longer period of time."*

168. Dr O'Donnell's interpretation of the ultrasound images taken at 3.35pm is also consistent with a haematoma accumulating within the hepatic capsule.

169. However, Dr O'Donnell's finding that the hepatic capsule remained intact and there was no bleeding in the peritoneum at 3.35pm is inconsistent with Mr Cramieri's theory that rupture of the hepatic capsule precipitated Alyssa's cardiac failure at 2.35pm. It is also inconsistent with the possibility that the capsule rupture was caused by resuscitation efforts at 2.35pm.

170. Rather, Dr O'Donnell's finding that the hepatic capsule remained intact and there was no bleeding in the peritoneum is consistent with a slow deterioration leading to Alyssa's cardiac arrest at 2.35pm.

171. Accordingly, I find that rupture of Alyssa's hepatic capsule did not occur until after her ultrasound at 3.35pm.

172. Therefore, I do not accept that Alyssa's acute deterioration at 2.35pm was attributable to rupture of the subcapsular haematoma. Rather, at this time the haematoma remained encompassed by the hepatic capsule.

173. I note that signs and symptoms of cardiovascular failure that are easily discerned in adults may remain subtle in children and that children are more susceptible than adults to hypoperfusion.[21]

174. The full extent of the haemorrhage was also partly disguised by the effect of its containment within the liver capsule until at least 3.35pm. I also note that the liver capsule would have provided some back pressure on the haemorrhage while it remained intact and, accordingly, it would have reduced the rate of blood loss from the circulation.

175. Neither Associate Professor Cameron nor Nurse Unit Manager Gina Ruwoldt were aware of similar cases involving subcapsular haematoma. Both specialise in paediatric medicine.

176. However, the professional literature reports that small subcapsular haematomas are not uncommon after adult liver biopsy and these can occur in patients without any other symptoms. Larger subcapsular haematomas can also occur but these cause pain, tachycardia, hypotension and delayed changes in blood composition. They can usually be managed conservatively.[22]

177. I also note that, by the time Mr Cramieri saw Alyssa's injury at 6.30pm, her clotting factors were significantly distorted by resuscitation fluids. By then, her INR was 2.2 which is well out of normal range.

178. Therefore, the heavy bleeding he saw by the end of his first attempt at resuscitation surgery may not have reflected the rate of blood loss throughout the afternoon.

179. Accordingly, I do not accept that Alyssa's deterioration and cardiac failure at 2.35pm was catastrophic or occurred over a matter of minutes. Rather, it seems to me that Alyssa's cardiac failure was the culmination of a slowly developing situation over at least two hours that was causing concern to the nursing staff in Ward 42 N and was communicated to medical staff.

180. However, in the absence of objective evidence from blood pressure monitors and pulse oximetry, Alyssa's medical staff failed to properly respond to the possibility that her blood

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[21] CA McKiernan & SA Lieberman, "Circulatory Shock in Children: An Overview", Pediatr. Rev. 26 (2005) 451-460.

[22] AO Bravo, SG Sheth & S Chopra, "Liver Biopsy" (2001) 344 N. Engl. J. Med. 495.

pressure was low or seriously consider the possibility that her decline was associated with slow bleeding attributable to penetration of the portal vein.

181. One question that arises from this interpretation is: Why did Alyssa's heart rate remain low when the normal response to haemorrhage is for the heart rate to increase?

182. Professor Michael South is a general paediatrician and intensive care specialist at the Royal Children's Hospital. He was in Court supporting Dr Nunan and offered his opinion about the cause of Alyssa's unexpected low heart rate.

183. Professor South says that a baby as sick as Alyssa would be expected to have a heart rate greater than 170 beats per minute rather than 127 to 149 beats per minute observed by Dr Nunan.

184. In Professor South's opinion, this inconsistency between Dr Nunan's observations of Alyssa's heart rate and her apparent continuing haemorrhage may be explained by vagus nerve stimulation. He also said this phenomonen has long been recognised as a potentially confounding clinical sign in adults with traumatic liver injury including liver and kidney biopsy.[23]

185. Professor South told the Court:

> *"In the liver it's possible that a haematoma forming under the capsule of the liver could be stretching the liver capsule and this can stimulate one of the nerves that supplies the liver to actually slow the heart rate down...*
>
> *So that may be what was going on here. The bleeding, which would normally have a tendency to make the heart rate go up, could have been being counteracted by this stimulation to the vagus nerve, which was also slowing it down."*

[23] Professor South cited: EL Eliason, "Surgical emergencies in the Abdomen", Philadelphia Academy of Surgery, 2 February 1925; LH Blumgart & T Vajbrabukka, "Injuries to the Liver: Analysis of 30 cases", (1972) BMJ 158; AJM Mathieson, "Closed Abdominal Injury", BMJ 1962 749; AJ Graham, "Subcutaneous Rupture of the Liver", Chicago medical Society 2 November 1926;JM Bordas, C Bru & M Bruguera, "Hypotension and Bradycardia after Liver Biopsy" Lancet (1974875; LR Bigongiari, "Vagal Pseudohaemorrhage after percutaneous Biopsy", 15 Investigative radiology (1980) 350; LR Bigongiari, MA Linshaw, FB Stapleton & JW Weigel, 1 Urol.Radiol. (1980) 217

186. The fact that the phenomenon is not well known in children or taught to paediatricians suggests to me that it is a possible but speculative explanation of Alyssa's apparently normal heart rate.

187. Further, Professor South explained his theory in the context of peritoneal accumulation by 2.30pm when we know Alyssa's haemorrhage was contained in the hepatic capsule until at least 3.35pm when the ultrasound occurred.

188. Accordingly, I am unable to accept that vagus nerve stimulation explains Dr Nunan's observations that Alyssa maintained a stable, normal heart rate. Rather, in the context of nursing staff reporting an inadequate and faint oximetry trace, it seems to me that I cannot assume that her heart rate remained either stable or normal for any extended period of time after 1.30pm on 16 March 2006.

189. Mr Cramieri identified bleeding from a bleeding site around the biopsy wound in Alyssa's liver. He controlled this bleeding with a single suture to the biopsy site.

190. Associate Professor Cameron told the Court:

> *"If it was thought to be a bleeding problem the two instructions would have been to call the surgeons, there was a surgical registrar already there, and to give fluids and to get the blood transfusion going, if we thought that was the problem. And again, to stress, blood was standing by and being cross-matched because I would not go ahead with a liver biopsy unless it was."*

191. Accordingly, I find that there was a much better chance that Alyssa would have recovered, if surgical intervention had occurred and her bleeding site had been identified and secured when she first deteriorated at about 1.30pm or at any other time earlier than 6.30pm on 16 March 2006.

192. During surgery, Mr Cramieri also found bleeding from the raw part of the liver was not significant at first observation:

> *"I remember just as we were closing the abdomen we did definitely start to see both oozing from around the wound, which I hadn't seen when we were starting."*

193. This observation supports the possibility that Alyssa's hepatic capsule ruptured during or immediately prior to Mr Cramieri's intervention.

194. On the other hand, Mr Cramieri told the Court that, although it was possible, he did not believe that he had ruptured the hepatic capsule when he was entering the abdomen or retracting the liver.

195. Mr Cramieri was unable to control the ooze that continued to issue from the surface of Alyssa's liver. He attributed this uncontrollable lesion involving most of the surface of Alyssa's liver to the effect of the accumulated blood within the hepatic capsule. I have no reason to doubt his interpretation.

196. I am also unable to say whether citrin deficiency is associated with changes in the liver surface or cell composition that could have made it susceptible to the effect of accumulation of a haematoma under the liver capsule.

197. Rather, I find that this lesion would also have been less likely to occur or be so severe if surgical intervention had occurred when Alyssa first deteriorated at about 1.30pm rather than 6.30pm on 16 March 2006.

198. Therefore, I find that early diagnosis of penetration of the portal vein during liver biopsy would probably have prevented Alyssa's death.

RECOMMENDATIONS

Pursuant to section 72(2) of the **Coroners Act 2008**, I make the following recommendation(s) connected with the death:

1. Royal Australasian College of Physicians Paediatrics & Child Health Division and the Royal Australian College of General Practitioners advise paediatricians and general practitioners that all babies who present with unresolved conjugated jaundice at about eight weeks, particularly those for whom liver biopsy is being considered, should undergo further plasma amino acid screening to exclude the possibility that their symptoms are associated with Type II citrullinaemia.

2. Victorian Clinical Genetics Services establish genetic screening for babies who would otherwise undergo liver biopsies and have characteristics associated with increased likelihood of citrin deficiency.

3. Victorian Clinical Genetics Services provide genetic screening for parents of children who have been identified as carriers of citrin deficiency.

4. Royal Children's Hospital review their protocols in the light of changes introduced by Southern Health Pre and Post Liver Biopsy Protocol into their protocol in September 2006 and September 2008.

5. Southern Health continue to actively promote a ward culture of accessing protocols when patients are booked for rarely performed procedures including awareness of their Paediatrics - Pre and Post Liver Biopsy Protocol.

6. Southern Health retain digital images of all ultrasound radiology of paediatric procedures.

7. Southern Health host a discussion between senior nursing staff in the Endoscopy Suite and Ward 42N and paediatric radiologists and gastroenterologists who perform endoscopy procedures to clarify and specify the content and frequency of standard post-operative observations.

8. Southern Health explore the possibility of introducing permanent recording pulse oximeters in Ward 42N and the Endoscopy Suite.

I direct that a copy of this finding be provided to the following:

Minister for Health
Victorian Clinical Genetics Services
Royal Australasian College of Physicians Paediatrics & Child Health Division
Royal Australian College of General Practitioners
Chief Executive Officer, Royal Children's Hospital

Signature:

DR JANE HENDTLASS
CORONER
Date: 13/12/12