QUEENSLAND
COURTS

OFFICE OF THE STATE CORONER

FINDINGS OF INQUEST

CITATION:	**Inquest into the death of Ruby Yan CHEN**
TITLE OF COURT:	Coroners Court
JURISDICTION:	Rockhampton
FILE NO(s):	2012/2810
DELIVERED ON:	12 December 2014
DELIVERED AT:	Mackay
HEARING DATE(s):	16, 17,18 September 2014
FINDINGS OF:	David O'Connell, Central Coroner
CATCHWORDS:	CORONERS: inquest, health care related death, massive air embolism, re-use of partially-used IV bag of Saline during aero-medical retrieval, air entering IV bag during re-spiking procedure.
REPRESENTATION:	
Counsel Assisting:	Mr John Aberdeen
Family of Ruby Chen:	Mr Ben Wessling-Smith instructed by Maurice Blackburn for father Mr Chuan (Charlie) Chen Ms Xinshuan (Cindy) Huang Self represented
Staff of Black Water and Rockhampton Hospitals:	Mr Chris Fitzpatrick instructed by Corrs Chambers Westgarth
Queensland Ambulance:	Ms Melinda Zerner instructed by Minter Ellison
IC Paramedic James McManus:	Mr David Schneidewin instructed by Norton Rose Fullbright Australia

Introduction

[1]. Every day in Australia hospital clinicians and emergency services personnel utilise intravenous saline fluid bags in the treatment of patients[1]. Ordinarily this is a very routine task which presents with very little risk, but like every medical task even the most routine can have tragic consequences.

[2]. One such case is this matter, where a young child undergoing a routine aeromedical transfer between hospitals tragically became involved in the outcome of the simple task of intravenous fluid supply.

[3]. The circumstances of Ruby's case is particularly tragic when she was such a young and healthy[2] little girl but unfortunately, as one medical specialist termed it, in her circumstances the planets tragically aligned.

[4]. This inquest will examine the circumstances of Ruby's death, establish the fundamental cause of her passing, and make recommendations for methods to reduce the risk of such incidents being repeated.

Tasks to be performed

[5]. As I often state my primary task under the Coroners Act 2003 is to make findings as to who the deceased person is, how, when, where, and what, caused them to die[3]. In Ruby's case there is no real contest as to who, when, where, and what caused her to die. The real issue is how she died in the circumstances.

[6]. Accordingly the List of Issues for this Inquest are:-

1. The information required by section 45(2) of the *Coroners Act 2003*, namely: who, how, when, where, and what, caused Ruby's death,

2. How and when did air come to enter the child's bloodstream in such quantity as to cause a fatal air embolism?

3. Whether the medical treatment and care accorded to Ruby Chen at Blackwater Hospital accorded with best practice?

4. Whether the medical treatment and care accorded to Ruby Chen during transport by air from Blackwater Hospital to Rockhampton Hospital accorded with best practice?,

5. Whether the medical treatment and care accorded to Ruby Chen at Rockhampton Hospital accorded with best practice?, and

6. Whether the operation of any infusion pump contributed, either wholly or in part, to the quantity of air which entered Ruby Chen's bloodstream?

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[1] It was described by the medical expert at the inquest that giving intravenous fluids must be one of the commonest healthcare interventions that is done, certainly in hospital (see T2-95 at line 7-8)

[2] Her prior medical background was entirely uneventful and she was rarely ill

[3] Coroners Act 2003 s. 45(2)(a) – (e) inclusive

7. The second task in any inquest is for the coroner to make comments on anything connected with the death investigated at an inquest that relate to public health or safety, the administration of justice, or ways to prevent deaths from happening in similar circumstances in the future[4].

8. The third task is that if I reasonably suspect a person has committed an offence[5], committed official misconduct[6], or contravened a person's professional or trade, standard or obligation[7], then I may refer that information to the appropriate disciplinary body for them to take any action they deem appropriate.

9. In these findings I address these three tasks in their usual order, section 45 Findings, section 46 Coroners Comments, and then section 48 Reporting Offences or Misconduct. I have used headings, for convenience only, for each of these in my findings.

Factual Background and Evidence

10. Ruby Yan Chen[8] was a young child, just a few months short of her 4th birthday. She is the daughter of Chuan Cheng and XinShun Huang[9]. In early[10] August 2012 she was ill for a few days, and in this period her mother prudently took her on two occasions to a local general practitioner where they resided in Blackwater. On the second occasion the decision was made that Ruby be admitted to hospital as her fever was high and she was dehydrated. All of these events which occurred are similar to those faced by many parents when a young child has a fever.

11. Whilst in the Blackwater hospital Ruby was diligently monitored by nursing staff and a doctor and given treatment for her elevated level of dehydration. Essentially the treatment was to keep her under close observation and to increase her level of fluids to help reduce her temperature. This was all entirely appropriate. There is no criticism whatsoever of the steps taken by Ruby's parents, nor of any step in her medical treatment up to approximately the time of her discharge from the Blackwater Hospital for aeromedical transfer to Rockhampton. Effectively the factual background to the matter is not in dispute through to the time Ruby was due to leave Blackwater Hospital.

12. It was due to concern regarding Ruby's medical condition that the Blackwater hospital's medical staff, in consultation with the medical staff of the nearby larger regional hospital, the Rockhampton Base Hospital, decided that it would be prudent for Ruby to be transferred to Rockhampton for her further care. In the circumstances that was an appropriate decision.

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[4] Ibid s.46(1)
[5] Ibid s.48(2)
[6] Ibid s.48(3)
[7] Ibid s.48(4)
[8] Throughout the findings I shall simply refer to her as 'Ruby', rather than Miss Chen.
[9] See exhibit B-1 at page 1, item 3.
[10] Her initial symptoms commenced 2 August 2012

13. The transfer between the hospitals was then to be made by helicopter. In Ruby's condition it was considered a routine aero-medical transfer. Accordingly the Rockhampton-based Capricorn Helicopter Rescue Service[11] and the Queensland Ambulance Service were tasked by Retrieval Services Queensland[12] to collect Ruby in Blackwater and transport her to Rockhampton.

14. The events leading up to the time of Ruby's departure are important for certain background matters which are relevant later in my Findings. These relate to Ruby's then level of dehydration, her high temperature, and the then administration of intravenous fluids to her to improve her condition. As will be seen later the level of fluids provided to her play a critical role in the matter as there was a significant credibility issue to be resolved between the Blackwater medical staff, and the helicopter retrieval staff, being Queensland Ambulance Service paramedics.

15. Accordingly it is necessary that I detail the rehydration regime that Ruby had undergone whilst at the Blackwater Hospital in the time prior to the arrival of the helicopter retrieval team.

16. The Blackwater hospital records provide a very good source of the fluids provided to Ruby. In fact the hospital had a specific record of fluids given to her. These are described as a "24 hour fluid balance chart", and an "Intravenous and subcutaneous fluid order form". Copies of each of these forms were contained in exhibit E2 at annexure SPN-3 and SPN-4[13]. These record Ruby's fluid management as 60mL orally (and an icy pole) plus progressively up to 900 mL intravenously, commencing at 4.00 PM with 400ml/hour, then continuing at 5.00PM with 250mL/hour, and at 6.00 PM at the rate of 250mL/hour.

17. The aeromedical team landed[14] at Blackwater Hospital at a recorded time of 18.42, or 6:42 PM[15]. The paramedics then entered the hospital from the landing area and made their way through from the usual retrieval location (the resuscitation room near the exit) and then through the hospital where they were met by the doctor. They had a short conversation in the hospital, then continued discussing Ruby's condition as they went to see her in her ward room. When at her room, the discussion continued for a short while as certain observations, from the doorway, were made by the paramedics. At that time her IV lines, to which she was still connected, were then requested to be 'taken down', that is removed, as directed by the paramedic. A nurse did this and her fluids then ceased. The doctor agreed with this decision as they considered that Ruby had received sufficient fluids to this time. I am not critical at all of the decision to then cease fluids. All this time would have taken a few minutes and since there is no precise time recorded I conclude that it would have taken a time of

[11] termed 'Rescue 300'
[12] RSQ is a division of Queensland Health which co-ordinates 'rescue' helicopter services, as they are frequently termed by the public, throughout Queensland,
[13] these fluid records were attached to a number of witness statements tendered at the inquest, perhaps due to their importance in recording Ruby's fluid management, or perhaps because of their importance as a contemporaneous record
[14] the moment the retrieval helicopter touched down
[15] See exhibit F3 statement of CJ Manns, helicopter pilot (at line 9, as it is not paragraph numbered), and the QCC records record the time as 18.42.07 (i.e. 6.42pm and 7 seconds)

approximately 8 minutes in total, which is erring on the lower side[16]. Accordingly in that hour since 6.00 PM Ruby had received fluids for about 50 minutes.

18. I find that the fluid records, are an accurate record of the fluid supplied to Ruby whilst she was in the Blackwater Hospital. I note that the fluid order form does contain a slight anomaly where 250 mL/hour was ordered but the volume infused is recorded as just "25". This was readily explained by a nurse who confirmed that the entry of '25' was in her handwriting and she merely was distracted before completing it as '250'.

19. The accurate recording of fluids provided to Ruby are important in two aspects. Firstly, to assist in determining how much fluid had been used from the 1 litre IV saline fluid bag, and secondly, the rate of fluid infused to Ruby to assist in resolving an issue of credibility between the treating doctor at Blackwater Hospital and the lead aeromedical retrieval team flight intensive care paramedic[17]. Throughout these findings it is easier that I simply refer to all the Blackwater hospital clinicians and retrieval personnel by their designation and roles (i.e. doctor, nurse, or paramedic) as it makes it easier in understanding the factual matrix (as opposed to my re-stating their names).

20. At the hospital Ruby's condition was discussed, which in the paramedics' mind confirmed the information that he already knew about her condition. At the hospital fluids being infused to Ruby were done via an infusion pump[18] which was regulating the flow of fluid. The infusion pump has an alarm, and automatic shutdown mode, if it detects any bubbles greater than 50 ul[19]. As this device was unsuitable, due to the limited space in the aeromedical retrieval situation of a helicopter, the paramedic requested the IV line to be taken down and a nurse was asked[20] to provide a new 'giving set'[21] for it. Significantly the partially used IV bag of fluid was kept.

21. Evidence was given that the nurse went with a second paramedic to a room where the giving sets were stored and an appropriate one was chosen. Nothing at all turns on this except to confirm that a new giving set was provided.

22. Most significantly that new giving set was then inserted in the partly exhausted saline IV bag. That is the original spike was removed and line discarded, and a second giving set used in its place. There was much

[16] It is noted that just after the IV line was taken down the paramedic made a telephone call to advise of the Situational Report (the acronym for this call was the 'sit-rep') to the QCC. They recorded that this call occurred at 6.55PM. Ruby departed the hospital building at about 7.00PM, and the helicopter started its engines at 7.04PM, then took off from Blackwater at 7.10PM as the pilot recorded (in accordance with flight regulations)

[17] as it was then termed, now it is termed 'flight critical care paramedic'

[18] This is a device to accurately administer fluids to a patient via an IV line. The pump itself was an 'Alaris' brand, although the paramedic incorrectly referred to it as a 'Baxter' brand infusion pump, merely because he was familiar with that brand name.

[19] dependent upon the air-in-line detection threshold as configured by the user

[20] See exhibit F-1A at paragraphs 59, 65 and 79.

[21] A giving set comprises of a plastic 'spike' that is inserted into the IV bag, and the clear plastic line (which includes the drip chamber, flow regulator roller clamp, one-way valve, and supplementary fluid port), through which the fluid runs, which then connects to the cannula (similar to a needle) inserted in the back of the patient's hand.

conjecture over whether a nurse re-spiked this IV bag, or whether the new giving set was merely provided by a nurse to the paramedics for them to re-spike the IV bag [22]. What is clear is that the original line was removed, and what was clear in evidence was that the lead paramedic primed[23] the new giving set, or line, whilst at the helicopter, because he specifically recalled allowing fluid to drain through the line onto the ground outside the helicopter's door[24]. I will resolve this issue of great significance later in my Findings.

23. What is most relevant is that the same IV bag, now partly exhausted of fluid, was re-spiked. Evidence was given to me that the amount of fluid left in the bag was thought to be about 300 mL[25]. It is a simple mathematical calculation to determine the amount that would likely have been left in the IV bag because the nursing staff had recorded the fluid delivered by that bag since 4.00 PM that day. Utilising the fluid management chart (and knowing the rate was controlled by the infusion pump) it can be seen that in the 2 hours and 50 minutes, that fluid from this IV bag was supplied to Ruby, and there was delivered[26]:-

    a. (400 mL) + (250 mL) + (250 mL x 50/60 (minutes)) + (20mL (priming the line[27])) = 878 mL, and

    b. Certainly there is the possibly of a slight bit more volume consumed (or removed from the IV bag) when a few millilitres of fluid was spilt on the ground whilst the paramedic primed the line.

If I adopt a figure of 885 mL spent from the 1 litre IV fluid bag it shows that there was just 115 mL left[28].

24. I appreciate that my calculations are not 'millilitre precise' but they are a very accurate estimate based on the fluid delivery rates recorded, and the time recorded, by personnel. An amount of 115 mL[29] is significantly different from the suggested volume of 300 mL. This becomes of importance when the fluid delivery rates supplied to Ruby inflight, and the events which occurred inflight during her retrieval, play into significance.

The events in flight

25. The flight from Blackwater to Rockhampton was undertaken at a reduced altitude due to Ruby's diagnosis. Accordingly the helicopter remained

[22] Other differences in recollection of events between persons hold significance, but this one issue weighs most significantly
[23] Priming involves letting fluid run through the line to ensure all air has been expelled from it
[24] See exhibit F-1, paragraph 11 and again in exhibit F-1A at paragraph 109
[25] Paramedic McManus says this was advised to him by RN Nesti see exhibit F-1A at paragraph 80. At no stage did Mr McManus say he assessed the volume remaining even though it is clear he handled the partly consumed bag of fluid.
[26] I leave aside the 20mL of fluid containing the 1 gram of antibiotics delivered to Ruby as it was pushed through the sideline of the IV drip, it is not part of the IV bag's volume
[27] See exhibit F-1A at paragraph 106
[28] or even allowing for the bag holding slightly extra volume, up to 1.1 litres as the evidence suggested some bags do, it leaves only 215 mL left in the bag.
[29] or even 215 mL being the more generous estimate

below 1500 feet of altitude for the entire journey[30]. The flight time was estimated to be about 40 – 50 minutes[31]. Due to the helicopter's configurations, and space in the rear area, the pilot and one paramedic were in the cockpit. The critical care paramedic, Ruby, and her mother were in the rear compartment.

26. Before the flight departed Blackwater, and during the flight, the paramedic stayed in touch with the Queensland Emergency Medicine System Co-ordination Centre, QCC. This centre provides the overview and co-ordination, statewide, for retrieval services, emergency tele-health support, and care, for disaster activities. Part of this service allows paramedics conducting aeromedical retrievals to have the support and assistance of specialist clinicians in Brisbane who provide assistance and guidance. A large number of retrievals are conducted each year[32].

27. The paramedic took appropriate steps to contact the QCC. On the information available to them it was suggested that Ruby continue receiving IV fluid at the rate of 250 mL/hour. Accordingly the paramedic then commenced infusion of saline fluid at this rate utilising the partially used IV fluid bag and new giving set acquired at the hospital[33]. The commencement of fluids did not occur before take-off so that Ruby could settle[34]. I make a number of comments later regarding the reusing of IV fluid, and what became apparent during the inquest being a practice where paramedics, to maintain operational preparedness, will utilise hospital consumables so as not to deplete those in their emergency bags. If during this flight a new IV fluid bag, at the cost of approximately $1.00, was utilised instead of reusing the partly used bag, then young Ruby would be with us today.

28. The records show that Ruby commenced her fluids during retrieval at the rate of 250 mL per hour commencing at about 7.15PM. If there was 300 mL left in the partly used IV fluid bag that would have been sufficient for the entire duration of the flight, indeed sufficient for Ruby to then be transported to the Rockhampton Base Hospital after the flight landed at Rockhampton airport[35].

29. During the flight Ruby's condition deteriorated markedly. The paramedic expressed this to the pilot, and the pilot and the paramedic in the cockpit both discerned the elevated level of concern in the paramedic's voice when he spoke of Ruby's condition deteriorating. Very shortly after Ruby went into seizure, and then cardiac arrest. The time that she went into seizure was about 7 minutes from landing at Rockhampton[36]. The paramedic's level of concern was such that he wished the pilot to land

[30] Evidence of the pilot Mr CJ Manns, exhibit F3 at page 2, line 3
[31] Mr McManus estimated 30-40 minutes, the pilot 50 minutes, the journey being significantly dependant on the prevailing windspeed and direction
[32] Of some 20,500 referrals in the year there were approximately 18,500 aero-medical retrievals completed (T3–32 at lines 24-28)
[33] See exhibit F-1A at paragraph 116
[34] See exhibit F-1A at paragraphs 110 - 119
[35] 300mL allows a window of 70 minutes of fluid delivery at this rate, and there was no administration of fluids by the paramedic prior to take-off
[36] See exhibit F-1A at paragraph 137 and the QAS records record resuscitative procedures commencing at 7.41PM indicating the time of seizure.

immediately. The pilot indicated that they were only a short distance[37] from Rockhampton airport, so continuation of the journey was a better option. There is no criticism whatsoever of the pilot in making this decision.

30. The usual airspeed of the helicopter in its' configuration was about 130 knots[38]. The pilot indicated that he increased[39] the airspeed to approximately 160 knots[40] as the situation was now time critical. The helicopter was observed by paramedics on the ground, who were arranged to meet it, as approaching very rapidly and at a very steep angle. This alerted the paramedics on the ground that the patient must have been in a 'situation critical' position as the pilot was using all means at his disposal in this time critical period. After landing the ground paramedics immediately preceded to the helicopter where they saw the critical care flight paramedic undertaking emergency resuscitation efforts upon Ruby. Ruby was then transported immediately to the Rockhampton Base Hospital arriving at 8.08PM[41]. At hospital she was admitted[42] through the Emergency Department where, despite efforts at resuscitation, she was declared passed away.

Results of Autopsy:

31. Life was officially certified to be extinct at 8.40pm on 9 August, 2012, following the discontinuation of futile cardiopulmonary resuscitation. I shall comment as to the likely moment of Ruby's passing later.

32. An autopsy was conducted by forensic pathologist, Dr Nigel Buxton, at Rockhampton on 13 August 2012. Prior to Dr Buxton conducting the autopsy it is important that I note the investigatory steps taken by the medical staff at the Rockhampton Hospital. The medical staff at the hospital undertook a number of investigations as her passing was considered most unusual and they felt compelled to investigate further to establish the reasons. For this I am most grateful as otherwise unique opportunities to establish her cause of death would have been lost.

33. On the night that Ruby passed away they conducted a chest X-ray which, radiologically, showed evidence[43] of possible air in the chambers of her heart, and the right internal jugular vein. Importantly they continued this investigation the following morning which revealed a clearer picture of a possible air embolism in the chambers of Ruby's heart, and a significant

[37] Estimated as 20 nautical miles see T3-56 line 38
[38] T3-56 line 45
[39] the term used by the pilot in his evidence (T3-58 line 4-5) was that he 'probably wrung a few more herbs out of it', and (T3-57 line2) 'we were rocking along'- neither being an aeronautical term that I am familiar with but it certainly conveyed that he significantly increased engine power to increase his airspeed
[40] T3-56 line 44
[41] See exhibit H-1 page 4 of the entire document
[42] Triaged at 8.09PM see exhibit H-4 page 4
[43] It was noted as unusually lucent or darker, see exhibit G5 at paragraph 15

possible air embolism in the jugular vein. This was very unusual and a very rare finding.

34. The Rockhampton hospital staff notified Dr Buxton of these radiological findings so that Dr Buxton could decide to perform the autopsy in a way to 'capture' those observations. I am indebted to the professionalism and perseverance of the Rockhampton hospital staff and their consultants in undertaking the enquiries that they did, and in notifying the forensic pathologist of their observations so that the autopsy could be conducted in a specific way. This greatly assisted me in finding the cause of death. Without such a collegiate medical effort that opportunity would certainly have been lost.

35. Out of respect to Ruby and her family I do not need to restate the detail of Dr Buxton's full investigations in my Coronial Findings. The autopsy report is exhibit A3 should the specific details of the investigations be relevant for any later purpose. The summary of the forensic pathologists findings are all that is necessary for the purposes of this inquest.

36. Relevantly Dr Buxton found[44]:

    "Air was present within many of the superficial veins covering the surface of the brain, …." …….

    "The heart … revealed copious quantities of air replacing blood in the right atrium and right ventricle …..", and ""Air was present within the aorta and within the superior vena cava". *and*

    "Microbiology testing returned a positive result to influenza A, which simply confirmed earlier diagnosis by the general practitioners that Ruby was suffering from the effects of a simple case of 'the flu'.

37. Dr Buxton's summary and interpretation was that Ruby had died due to a 'massive air embolism'. He noted that:-

    "The febrile convulsion noted in the helicopter is consistent with the clinical presentation of an air embolism. Air embolism in the scenario of this child presentation would suggest the route of administration to be via the intra-venous infusion line. It is probable that the event leading to air entry would have occurred very shortly before the clinical presentation", and "There was no other explanation for intra-venous air entry into the child".

38. In evidence at the inquest Dr Buxton estimated that the quantity of the air present in the heart was approximately 70 mL +/- 10mL[45], which was considered to be a very sizeable quantity for such a young child.

39. Whilst it was established at autopsy that Ruby died due to a massive air embolism, and there is no doubt as to this fact, what caused the massive air embolism remained a mystery until positively identified by Dr McCaffrey just prior to the inquest commencing.

[44] See exhibit A3 at page 2, and 5.
[45] T2-79 at 30-35

40. The precise circumstances of what occurred regarding the IV fluid bag were not entirely clear until further material was available from the parties which, when reviewed by Dr McCaffrey, gave him a 'lightbulb moment' to give insight into what had occurred. Essentially Dr McCaffrey identified that air had not only entered Ruby's circulatory system by the IV line, this was identified as the only way it could have entered her system, importantly the mechanism of how it entered her system was identified. Dr McCaffrey concluded, and I accept on the evidence provided at the inquest, that the amount of air which entered Ruby's system was large, and would have entered over a very short period with the onset from entering her system to her suffering a seizure being very quick and measured in terms of seconds, rather than minutes. Cardiac arrest followed very shortly after.

41. The mechanism by which the air entered Ruby's system is identified as a combination of the re-spiked IV fluid bag, through which the process of re-spiking has allowed air to enter the bag, and then that bag being placed inside an opaque pressure bag which forced the contents of the bag, the saline fluid and air, into the cannula in the back of Ruby's hand. Dr McCaffrey identified that if an infusion pump had been used then once it detected air in the line it would have immediately sounded an audible alarm and shutdown delivery of fluid to the patient. If the saline bag had simply been 'gravity fed' into the patient then once that fluid reached a distance on the giving set just a few centimetres before the patient, then the patient's own venous pressure would have prevented the last amount of fluid from entering the circulatory system. It was only the introduction of the pressure bag, required to be used in the confined space, particularly as to restricted cabin height in a helicopter, which caused the contents of the bag, being both saline fluid and air, to be forced down the giving set, such that when the fluid was exhausted air was pushed by the pressure bag into Ruby's system.

42. Dr McCaffrey described it as an unusual combination of circumstances which he had not encountered before in practice, and he did not consider that any of his fellow clinicians whether experienced, or inexperienced, would have ever witnessed or considered such a situation, but when it was all laid out it all made perfect, logical sense.

43. It was clear from Dr McCaffrey's evidence that the air found in Ruby's system did not enter her circulatory system while she was in Blackwater hospital, nor Rockhampton hospital.

44. The records kept of the aeromedical transfer provide the following relevant details. The patient was loaded at about 7.00 p.m., and a discussion after loading between the paramedic and the QCC occurred at 7.15PM[46]. In that discussion it was determined that further fluids should be given to Ruby as this would assist her then condition. There is no criticism of that diagnosis. As I said earlier if a fresh saline bag had then been used Ruby would not have died. Instead the partly used IV bag was re-connected and fluids then re-commenced being given to Ruby. Significantly the rate of fluids then given was 250 mL/hour. There is no precise time recorded as to when Ruby suffered a seizure during the aero-medical retrieval, but the best estimate given in evidence indicates it

[46] QAS records see exhibit H-1 at page 12 of that exhibit's bundle

was at the time recorded in the QAS chronology, namely 7.39PM[47]. That was approximately 24 minutes after fluids were re-commenced in the helicopter.

45. A simple mathematical equation[48] based on dispensing the remaining fluids from the partly used IV bag at the rate of 250 mL[49] per hour for 24 minutes demonstrates that approximately 100 mL of fluid would have been provided before the fluid simply ran out and air then immediately entered the bloodstream pushed in by the pressure cuff. I note that the paramedic indicated that he ensured, at the commencement of giving fluids in the helicopter, that the rate of 250 mL/hour was achieved. The figure of 100 mL has a remarkable parallel with the range of available fluid in the IV bag calculated in paragraph [23] above.

46. Accordingly I find, in view of Dr McCaffrey's expert evidence, that the air that caused the massive air embolism entered Ruby's system during the aero-medical retrieval, at a time approximately 29 minutes into the flight from Blackwater to Rockhampton (and 24 minutes after fluids were re-commenced in the helicopter). No air entered her system whilst she was at the Blackwater Hospital. This is a significant finding in relation to a number of the list of issues dealt with at the inquest.

47. As to the practise of re-using a partially used saline fluid bag I note that the paramedic's evidence was that kept in his own supplies were at least two 1 litre saline bags, and the helicopter itself, I was advised from the bar table, carries a number of 1 litre bags of saline also. Whilst I mentioned earlier that each saline bag costs roughly $1.00 I should point out that the cost was never a consideration by any party as to the question of the re-using of the partially used saline bag, rather the only consideration was in the paramedic remaining in a 'full state of preparedness of supplies' to immediately respond to the next incident.

48. Of course if the paramedic had used his own supplies during the flight he could have simply restocked those supplies from the helicopter, or when met by the ambulance on the ground. This is without returning to his base station. Although I would remark on this point that, despite whatever practises may have developed, it is not the obligation of hospitals to provide medical supplies to paramedics, within operational limits of course, rather the paramedic should be using the IV fluids and giving sets that they are supplied with, and are familiar with.

Who re-spiked the IV bag?

49. As the expert's evidence clearly found the air that entered Ruby's circulatory system only entered seconds or minutes before she suffered the seizure, I have set out the chronology of these events above. It was very clear on the evidence, and I find accordingly, that the air that entered her system came from the reused IV saline bag. It was clear to me on the

[47] Again see exhibit H-1
[48] (24 mins/60 mins) x 250mL = 100 mL
[49] And the paramedic stated that he was precise about regulating the flow at this rate by constantly adjusting it

evidence, and indeed not refuted by any evidence from any interested party, that the mechanism of how the air entered the IV bag was when it was re-spiked with the new giving set. There was a great deal of evidence provided as to whether this reused IV bag was re-spiked by a nurse at the Blackwater hospital then handed to the paramedic, or re-spiked by the paramedics themselves.

50. It is clear, and I find, that the reused IV bag was not spiked by the doctor, nor any junior nursing staff member, that is an enrolled endorsed nurse, nor any member of the aeromedical retrieval team, leaving aside the lead paramedic. The only persons possibly responsible were a particular registered nurse[50] involved in the patients' care or the lead paramedic[51].

51. The evidence in relation to the re-spiking of the IV bag warrants detailed consideration because of the importance in resolving the conflict in evidence.

52. The Registered Nurses' evidence on this issue was that she went with the retrieval paramedic (distinct from the lead retrieval paramedic) to a stores room across from Ruby's ward room to collect a new giving set. In this stores room was a drawer where new, packaged, giving sets were kept. The registered nurse opened the drawer and the retrieval paramedic selected a suitable new giving set. When she returned to the ward room, she saw that the lead retrieval paramedic was disconnecting the IV line from Ruby, that is the fluid delivery was then being ceased (as the lines were being taken down). The registered nurse recalls there being a very brief discussion with the doctor regarding fluids for Ruby, and at that time the doctor advised her that Ruby had had enough fluids. The doctor in her evidence confirmed regarding Ruby having received sufficient fluids and that the lines could be taken down. I accept that this exchange occurred. At this time the new giving set had not been inserted in the partly used IV bag.

53. The lead paramedic's evidence on this issue confirmed that Ruby's lines were taken down by a nurse, and a new giving set was requested, and that the nurse and the other retrieval paramedic went to a stores room to collect the new set. On the issue of the statement by the doctor that Ruby had received enough fluids the lead paramedic did not agree with that statement, rather he said that what was discussed was that further fluids would be given to Ruby at a certain rate. I shall comment later on the reliability of this recollection of events.

54. Ruby was then taken to the helicopter sitting on her mother's lap in a wheelchair pushed by a paramedic.

55. At the helicopter Ruby and her mother were loaded into the helicopter and the lead paramedic then took some time to ensure that Ruby was comfortable in the unfamiliar environment of the helicopter. Significantly the lead paramedic confirmed that whilst at the helicopter he primed the new giving set and even allowed a little bit of fluid to run through it onto the ground outside the helicopter doors. That of course was an appropriate step and I am certainly not critical of it. At this point it is

[50] RN Sharon Paula Nesti
[51] Paramedic James Dominic William McManus

important to note the conversation or conversations that the lead paramedic had with QCC regarding Ruby's condition and the treatment to be provided to her during retrieval.

56. The lead paramedic did not have a specific recollection of the discussions he had with the QCC, and conceded that the recordings of their discussion would be accurate. The court also had available the contemporaneous notes made by the QCC co-ordinator in Brisbane regarding these discussions. In very short compass the decision was made by the QCC clinicians was that it would be prudent for Ruby to receive further fluids at the rate of 250 mL per hour during retrieval. I am certainly not critical of the decision that was made that she receive further fluids, but I do note that it was at this time, whilst in the helicopter, that the decision was made that Ruby should receive further fluids. I do specifically reject any suggestion that the decision to give Ruby further fluids was in any way a combined decision between the doctor and the lead paramedic.

57. During submissions counsel for the paramedic suggested to me that it would be 'very dangerous'[52] that I find that the paramedic re-spiked the bag as this was submitted to be against the nature of the evidence and the weight to be given to that evidence. Counsel did not detail to me what the specific evidence, or its weight, was that made it so 'very dangerous'.

58. An examination of the reliability, and credibility, of the evidence between the registered nurse, the doctor, and the lead paramedic is of value at this time. I had the benefit of signed statements, and to listening, and observing where present, each of them as they gave evidence. Accordingly I formed certain views. In relation to each of them I found that they gave evidence as best as they were able to recall of the circumstances that occurred, but in areas where they differed I preferred the evidence of the registered nurse and doctor. As examples of the lead paramedic's evidence being not as reliable as others I point to the following aspects of his evidence:-

    a. He claimed in his statement[53] that when he arrived at hospital he noticed that Ruby was attached:-
        i. to a Baxter[54] brand infusion pump (and significantly in his evidence at the inquest he went so far as to say[55] that he believed that the brand name 'Baxter' was written on the infusion pump) and
        ii. to a pressure bag[56] (which he also recalled in his testimony[57]);

[52] T3-99 al lines 7-10, I always find that counsel describing any possible finding that may be contrary to their client's interests as 'very dangerous' to be a curious use of the terminology when it is directed to the bench
[53] Exhibit F-1A
[54] Exhibit F-1A at paragraph 58, and it was clear on the evidence that it was an Alaris brand infusion pump, not a Baxter brand, the paramedic merely stated a brand name he was familiar with
[55] T2-9 at line 5
[56] in hospital Ruby was never attached to a pressure bag, and it was clear on the evidence that a pressure bag is never used with an infusion pump. This was a significant error in recollection.
[57] T2-at lines 23-28

b. that (he) discussed with (the) doctor the rate of infusion (he) intended to run at 60 mL per hour, being similar to what the (doctor) had Ruby running at prior to (his) arrival at the hospital[58];

c. that it was a joint decision, between the paramedic and the doctor, that the paramedic take with him what remained in the IV bag to avoid fluid overload[59]; and

d. that he asked the doctor and a nurse if, in their opinion, Ruby appeared 'pale in comparison to how she presented at the hospital a few days prior', when the correct situation was that Ruby had only presented at hospital that day, and she had never had a prior admission for her condition[60].

59. Each of these are of course, factually incorrect. These are significantly telling errors in the accuracy of the paramedic's recollection of events when I decide the credibility issue between the registered nurse and the paramedic.

60. Whilst appreciating the submission by counsel for the paramedic I do find that, in consideration of all of the evidence, and the reliability and credibility of that evidence, that it was the lead paramedic who re-spiked the partly used IV saline bag. The lead paramedic had no specific recollection of when the new giving set was opened from its' protective packaging, but the irresistible inference is that it was opened from its packaging at, or inside, the helicopter. This of course occurred in the moments just preceding, or immediately prior to, the lead paramedic priming the line. Accordingly it was at this time that the lead paramedic re-spiked the partially used IV bag with the new giving set. He then primed the line before connecting it to the cannula located in the back of Ruby's right-hand.

Coroners Act s. 45: "Coroner's Findings"

61. As I stated in paragraph [5] above, there is no contest over who, when, and where, and what caused Ruby to die. The only real issue is how Ruby died.

Issue 1

62. Issue 1 on the List of Issues for Inquest is that required by section 45 (2) of the Coroners Act 2003, and accordingly I find the following:

[58] Exhibit F-1A at paragraph 86. It was clear on the evidence, indeed recorded on the documented fluid management chart, that Ruby was never receiving fluids at 60 mL/hour, as she received fluid at the rate of 400 mL/hour then 250 mL/hour

[59] Exhibit F-1A, the evidence of the doctor which was clear, and which I accept, was that Ruby had had enough fluids and no further fluids were needed during the approximately 40 to 45 minute flight to Rockhampton hospital

[60] exhibit F – 1A at paragraph 55

a. Who the deceased person is – Ruby Yan Chen[61];

b. How the person died – due to air entering her circulatory system, due to the combination of the re-spiking of a partially used IV saline fluid bag, and the delivery of these fluids by the use of a pressure cuff in the aeromedical retrieval environment;

c. When the person died – 9 August 2012;

d. Where the person died – near Rockhampton, Queensland; and

e. What caused that person to die – massive air embolism.

Issue 2

63. How and when did air come to enter the child's bloodstream in such quantity as to cause a fatal air embolism?

64. In accordance with my findings above, the air entered Ruby's bloodstream during her aeromedical transfer from Blackwater Hospital to Rockhampton Hospital. The air entered in a quantity to cause the fatal air embolism in the minutes just prior to her suffering a seizure which occurred approximately 31 minutes into the flight, which was at approximately 7.41PM, and several minutes prior to landing at Rockhampton.

Issue 3

65. Whether the medical treatment and care accorded to Ruby Chen at Blackwater Hospital accorded with best practice?

66. I find that the medical treatment and care accorded to Ruby at the Blackwater Hospital did accord with best practice. The decision made for Ruby to be transferred to Rockhampton was a prudent step to take in consideration of her then condition[62].

Issue 4

67. Whether the medical treatment and care accorded to Ruby Chen during transport by air from Blackwater Hospital to Rockhampton Hospital accorded with best practice?

68. I find that the medical treatment and care accorded to Ruby during her aeromedical transfer between the hospitals was not in accordance with best practice due to the paramedics' decision to re-use a partially

[61] Personal identification occurred at 10.00pm on 9 August 2012 see exhibit A-1 at page 4
[62] The doctor assessed her condition as serious, and the paramedic, on first observing her at hospital, described her as 'very ill', see exhibit F-1A at paragraph 69

depleted IV saline fluid bag in circumstances where alternate fresh saline bags were available[63].

69. I specifically note that the expert opinion was that in all other respects the paramedic's clinical management of Ruby, and in particular the management of Ruby's attempted resuscitation, was in all respects in accordance with best practice[64].

Issue 5

70. Whether the medical treatment and care accorded to Ruby Chen at Rockhampton Hospital accorded with best practice?

71. The evidence was clear, and uncontroverted, that the medical treatment and care provided to Ruby at the Rockhampton Hospital did accord with best practice. In the express words of the medical expert it was confirmed that the Rockhampton Hospital did everything they could to try to revive Ruby[65]. They could not have done anything more[66].

Issue 6

72. Whether the operation of any infusion pump contributed, either wholly or in part, to the quantity of air which entered Ruby Chen's bloodstream?

73. I find that there is no evidence that any air entered Ruby's circulatory system whilst she was receiving IV fluids in the Blackwater Hospital, which was the only time the delivery of fluids to her occurred with the assistance of an infusion pump. Accordingly the operation of the infusion pump did not contribute, either wholly or in part, to any air entering Ruby Chen's bloodstream.

Additional Issues

74. As the inquest progressed certain practises were canvassed and it is appropriate that I provide my observations on these practises.

75. In evidence it became clear that a practise has developed where paramedics take consumables from hospitals, rather than rely upon their own supplies. Whilst I can understand a paramedics desire to remain in a full state of response preparedness, it is not a desirable practice and should be discouraged (I would not put it so high as to say it should be banned as there would be a number of special circumstances where it may be appropriate to use hospital supplies).

[63] indeed were available from a number of sources, whether that be the paramedic's personal supply, those kept on the helicopter, or even available from the hospital (although as I have stated that is not the preferred option for sourcing supplies)
[64] as Dr McCaffery expressed in his evidence
[65] T2-88 at lines 19-20
[66] T2-88 at lines 5-17

76. One valid reason why it should be discouraged is that paramedics develop familiarity with those items they use most. For instance during evidence when the paramedic was asked to look at something as basic as a giving set it took him quite some time to determine if it was similar to that he used, and of course it had slight differences.

77. I do not raise the issue as a formal recommendation following the inquest, rather I simply note it as an observation.

78. Due to the unusual 'constellation of events', as it was termed, which caused this incident to occur it would be of assistance if a medical expert would take the time to write an education paper for dissemination in medicine journals, or as a practice alert, to convey to medical practitioners the circumstances that occurred in Ruby's case. I appreciate, and thank, Ruby's parents for giving their permission that the circumstances which caused Ruby's death can be shared with medical personnel in an attempt to avoid its repetition.

Coroners Act s. 46: 'Coroners Comments' (Recommendations)

79. This incident does provide the opportunity to recommend important improvements aimed at reducing the risk to patients in similar flight retrieval situations.

80. In accordance with my obligation under the Coroners Act 2003 I now make recommendations that I consider should be implemented.

81. Any recommendation needs to consider certain important aspects, namely that they be sufficiently practical, they are, within reason, cost-effective, and can be achieved utilising, or readily created using, existing technology. If these fundamental aspects can be met there is a greater likelihood that the particular recommendation will be implemented.

82. In consideration of the evidence of this case, and for the reasons I have set out above, I make the following recommendations:-

    a. That IV saline bags are marked in contrasting coloured lettering, for example yellow on black, or red on clear, with the terminology "SINGLE SPIKE ONLY". I note that IV saline bags are already marked, usually in black on clear, or blue on clear, lettering so it should not be difficult, nor expensive, for this to occur. This marking should appear next to the port on the bag to hopefully prevent any repetition of this incident.

    b. Education, and the promotion of, the prohibition on re-spiking of intravenous fluid bags should occur. There was a suggestion that the prohibition on re-spiking of intravenous fluid bags be termed 'Ruby's Rule' as an aid to ensuring that the practice is followed and that the incident never occurs again. If using terminology like this assists then certainly it is to be encouraged[67];

[67] and Ruby's parents have no difficulty with her name being given to this proposed Rule

c. the Queensland Ambulance Service should implement their new clinical practice guideline which they have developed in relation to the priming of giving sets (which I note they had already developed ready for implementation between this incident occurring and the inquest being heard). It is to their credit that they have acted proactively;

d. that aeromedical retrieval services investigate whether it is feasible, and practical, to eliminate the use of opaque pressure cuffs which conceal the fluid level in IV bags. Dependent upon operational requirements, infusion pumps with their system of alarms and safeguards, are the preferable system but there are a number of factors to be investigated to determine if it is feasible to be used[68]. Six months is a sufficient time frame for infusion pumps in the aero-medical environment to be investigated and a decision made[69].

Coroners Act s. 48: 'Reporting Offences or Misconduct'

83. Section 48 of the Coroners Act imposes an obligation to report offences or misconduct.

84. Expert evidence at the inquest on the cause of the incident was given by Dr Kevin McCaffery[70]. As is evident above in my findings I was very impressed by his evidence.

85. Dr McCaffery had the opportunity to review the sworn statements of the persons involved, the medical records, and the autopsy report.

86. He conducted a very thorough examination of the evidence and provided a supplementary report[71] which not only identified how the air entered into Ruby's circulatory system, but he discounted, with explanation, other possibilities[72]. His evidence, essentially, was that:

    a. Ruby died from a massive air embolism manifesting as an acute neurological event;

[68] I note that the Royal Flying Doctor Service does use infusion pumps in aeromedical retrievals, but they do retrievals at a greater altitude, in a pressurised environment, and in the slightly less restrictive environment of an aeroplane as opposed to a helicopter, although it does demonstrate that an infusion pump can be utilised in the aeromedical environment

[69] the representatives of Queensland Health (Rescue Services Queensland) and the Queensland Ambulance Service agreed in evidence that six months was a reasonable timeframe

[70] Dr McCaffery is a Senior Staff Specialist in Paediatric Intensive Care Medicine at the (then named) Royal Children's and Mater Children's Hospitals, Brisbane (now known as the Lady Cilento Children's Hospital)

[71] Exhibit J-3

[72] Dr McCaffery specifically excluded other possibilities, see pages 7 and 8 of his report which was exhibit J-1

b. Cardiopulmonary arrest occurred almost immediately after the first manifestations of neurological abnormality;

c. Her acute deterioration was consistent with a massive air embolism;

d. The chest x-ray findings of intravascular air, and confirmation of this at autopsy, confirms the reason for her death and it was entirely consistent with a massive air embolism;

e. No other pathological process has been identified that accounts for Ruby's neurological symptoms or her subsequent cardiac arrest;

f. The air that entered Ruby's bloodstream entered her circulation system immediately preceding the seizure and cardiac arrest, and this occurred during her aeromedical retrieval;

g. Massive air embolism exhibits as a rapid onset of symptoms, typically from seconds to minutes;

h. That the changing of the giving set, with 'approximately 300 mL' (the paramedic's estimate) of fluid remaining would allow air to enter the IV bag itself[73];

i. That when the IV fluid bag was then inserted into the opaque pressure bag in the aircraft, that pressure bag forced fluid down the line, and when the fluid was expelled, then any remaining air in the IV bag would be forced through the line[74];

j. He replicated the circumstances in a reconstruction which yielded a volume of approximately 100 mL[75] of air reaching the simulated patient;

k. That only through the alignment of a number of contributing factors[76], the changing of infusion sets on a partially empty IV bag, priming the new line, the use of a pressure cuff or bag, the pressure cuff being opaque restricting visual monitoring of the level, the retrieval environment in a helicopter involving low light, noise, stress and cognitive load from other tasks, all these increase the opportunity for error or for missing of subtle signs of air in an IV line;

l. That there was no evidence at any point that the event was the result of malice[77]; and

[73] in his evidence he explained how the vacuum effect of the spent contents of the saline bag would 'suck air in', and gave an example of how this occurs with the familiarly known soft sided plastic sports drinks bottles (see T2-93 at lines 6-18)
[74] This is an important difference to an IV line set up without a pressure bag. Without a pressure bag the IV fluid simply stops in the line, a few centimetres from entering the patient's circulatory system, due to the effect of venous pressure (or meeting pressure equilibrium) holding the last remaining fluid back.
[75] Dr Buxton, forensic pathologist, indicated a 'guesstimate' of 70 mL of air +/- 10 mL as what he observed at autopsy (see T2-79 at 30-35)
[76] Dr McCaffery described it as 'a constellation of factors coming together' see T2-90 at 11 and restated similarly at T2-91 at 40
[77] and it was very evident during the inquest of the emotional difficulties the events caused to those involved

m. that the flight documentation records kept by the retrieval paramedic was in keeping with that of an expert practitioner demonstrating good clinical practice.

87. These are all very relevant observations by the independent medical expert. In addition Dr McCaffery commented that the particular mechanism of how the incident occurred was a surprise to him, and would well be a surprise to most practitioners[78]. Those factors identified by Dr McCaffery are persuasive to me in considering whether any possible 'offence' or 'misconduct' may have occurred in relation to Ruby's death.

88. No party at the inquest suggested that any referral was necessary, but of course ultimately such a decision is mine to make. In the particular circumstances, and on the evidence available, in this inquest, I make no referrals against any person, or entity, under section 48 of the Coroners Act.

Magistrate O'Connell
Central Coroner
Mackay
12 December 2014

[78] See T2-91 at line 26-29 and T2-94 at line 30-37