QUEENSLAND COURTS

OFFICE OF THE STATE CORONER

FINDINGS OF INQUEST

CITATION:	**Inquest into the death of Margaret Allan Johnston**
TITLE OF COURT:	Coroner's Court
JURISDICTION:	Brisbane
FILE NO:	COR 3297/06(3)
DELIVERED ON:	20 November 2009
DELIVERED AT:	Brisbane
HEARING DATE(s):	2/9/08, 28/11/08, 1/12/08 – 5/12/08, 7/08/09, 17/8/09 – 21/08/09, 24/08/09, 25/08/09 and 28/08/09
FINDINGS OF:	Coroner Lock
CATCHWORDS:	CORONERS: Inquest – Insulin, hypoglycaemic brain injury, reliability of immunoassays, medication error or maladministration

REPRESENTATION:

Counsel Assisting:	Mr S Hamlyn-Harris
For St Andrews War Memorial Hospital and its employees:	Mr G Diehm SC and Ms M Callaghan instructed by Blake Dawson
For Dr Hay, Dr Hill, Dr Love and Dr Venkatesh:	Mr A Luchich instructed by Avant
For RN Heelan and RN Moss:	Mr G Rebetzke instructed by Roberts & Kane
For Dr Johnston:	Mr R Perry SC instructed by Spark Helmore
For Mr Johnston and family:	Mr P Clapin of Clapin Lawyers

CORONERS FINDINGS AND DECISION

1. These are my findings in relation to the death of Margaret Allan Johnston who died at the St Andrews War Memorial Hospital on 2 December 2006. These findings seek to explain how the death occurred and consider whether any changes to policies or practices could reduce the likelihood of deaths occurring in similar circumstances in the future. Section 45 of the Coroners Act 2003 ("the Act") provides that when an inquest is held into a death, the Coroner's written findings must be given to the family of the person who died and to each of the persons or organisations granted leave to appear at the inquest. These findings will be distributed in accordance with the requirements of the Act and also placed on the website of the Office of the State Coroner.

The scope of the Coroner's inquiry and findings

2. A Coroner has jurisdiction to inquire into the cause and the circumstances of a reportable death. If possible he/she is required to find:-

(a) whether a death in fact happened;

(b) the identity of the deceased;

(c) when, where and how the death occurred; and

(d) what caused the person to die.

3. There has been considerable litigation concerning the extent of a Coroner's jurisdiction to inquire into the circumstances of a death. The authorities clearly establish that the scope of an inquest goes beyond merely establishing the medical cause of death.

4. An inquest is not a trial between opposing parties but an inquiry into the death. In a leading English case it was described in this way:- *"It is an inquisitorial process, a process of investigation quite unlike a criminal trial where the prosecutor accuses and the accused defends… The function of an inquest is to seek out and record as many of the facts concerning the death as the public interest requires."* [1]

5. The focus is on discovering what happened, not on ascribing guilt, attributing blame or apportioning liability. The purpose is to inform the family and the public of how the death occurred, with a view to reducing the likelihood of similar deaths. As a result, the Act authorises a Coroner to make preventative recommendations concerning public health or safety, the administration of justice or ways to prevent deaths from

[1] *R v South London Coroner; ex parte Thompson* (1982) 126 S.J. 625

happening in similar circumstances in future.[2] However, a Coroner must not include in the findings or any comments or recommendations, statements that a person is or may be guilty of an offence or is or maybe civilly liable for something.[3]

The Admissibility of Evidence and the Standard of Proof

6. Proceedings in a Coroner's court are not bound by the rules of evidence because the Act provides that the court "*may inform itself in any way it considers appropriate."*[4] That does not mean that any and every piece of information, however unreliable, will be admitted into evidence and acted upon. However, it does give a coroner greater scope to receive information that may not be admissible in other proceedings and to have regard to its origin or source when determining what weight should be given to the information.

7. This flexibility has been explained as a consequence of an inquest being a fact-finding exercise rather than a means of apportioning guilt. [5]

8. A coroner should apply the civil standard of proof, namely the balance of probabilities but the approach referred to as the *Briginshaw* sliding scale is applicable.[6] This means that the more significant the issue to be determined, the more serious an allegation or the more inherently unlikely an occurrence, the clearer and more persuasive is the evidence needed for the trier of fact to be sufficiently satisfied that it has been proven to the civil standard.[7] This approach was approved by the Queensland Court of Appeal[8] when specifically dealing with the coronial jurisdiction when it said that the "sliding scale of satisfaction test does not require a tribunal of fact to treat hypotheses that are reasonably available on the evidence as precluding it from reaching the conclusion that a particular fact is more probable than not."[9]

9. It is also clear that a Coroner is obliged to comply with the rules of natural justice and to act judicially.[10] This means that no findings adverse to the interest of any party may be made without that party first being given a right to be heard in opposition to that finding. As *Annetts v McCann*[11] makes clear, that includes being given an

[2] Section 46 of the Act
[3] Sections 45(5) and 46(3) of the Act
[4] Section 35 of the Act
[5] *R v South London Coroner; ex parte Thompson* per Lord Lane CJ, (1982) 126 S.J. 625
[6] *Anderson v Blashki* [1993] 2 VR 89 at 96 per Gobbo J
[7] *Briginshaw v Briginshaw* (1938) 60 CLR 336 at 361 per Sir Owen Dixon J
[8] *Hurley v Clements & Ors* [2009] QCA 167
[9] *Hurley v Clements & Ors* [2009] QCA 167 at paragraph 27
[10] *Harmsworth v State Coroner* [1989] VR 989 at 994 and see a useful discussion of the issue in Freckelton I., "Inquest Law" in *The inquest handbook*, Selby H., Federation Press, 1998 at 13
[11] (1990) 65 ALJR 167 at 168

opportunity to make submissions against findings that might be damaging to the reputation of any individual or organisation.

10. If, from information obtained at an inquest or during the investigation, a Coroner reasonably suspects a person has committed a criminal offence, the Coroner must give the information to the Director of Public Prosecutions in the case of an indictable offence, and to the Chief Executive of the department which administers legislation creating an offence which is not indictable.[12] If, from information obtained at an inquest or during the investigation, a coroner reasonably believes that the information may cause a disciplinary body for a person's profession or trade to inquire into or take steps in relation to the person's conduct, then the coroner may give that information to that body.[13]

The Evidence

Overview

11. Margaret Allan Johnston was admitted to St Andrew's War Memorial Hospital on 2 September 2006, after being referred by her general practitioner with a suspected urinary tract infection ("UTI") and increased confusion.

12. At around 4:00 am on 4 September 2006 she was found by nursing staff to be unresponsive. Blood tests taken at her bedside showed that she had a very low blood glucose level and the clinical signs were consistent with her having suffered from a severe hypoglycaemic event. Subsequent tests revealed that Mrs Johnston had also suffered a series of cerebral strokes. She remained in a coma. Throughout the next three months she only had basic breathing and swallowing functions and after consultation with her family her feeding tube was withdrawn and she passed away on 2 December 2006.

13. An analysis of blood samples taken over the days following her admission revealed that on 3 and 4 September Mrs Johnston had unexplained high levels of insulin in her blood. She was not a diabetic and was not prescribed insulin. Dr De Voss, a pathologist at Queensland Medical Laboratory Pathology ("QML"), was responsible for conducting immunoassays on the blood samples and he discussed the results with Dr Hill, a consultant endocrinologist who was asked by the hospital to examine Mrs Johnston. As a result of the test results and the opinions of Dr De Voss and Dr Hill, combined with the clinical evidence, an initial investigation by the hospital commenced. This concluded that on the evidence available, Mrs Johnston had

[12] Section 48(2) of the Act
[13] Section 48(4) of the Act

probably been administered two separate doses of insulin exogenously (ie., insulin administered via an external source) with one on either the evening of 2 September 2006 or the morning of 3 September 2006 and the second dose on either the evening of 3 September 2006 or the early hours of 4 September 2006.. The hospital administration reported the matter to the police on the evening of 5 September 2006 as it could find no evidence of a medication administration error.

14. An extensive police investigation commenced and numerous statements were taken from security staff, nursing staff, medical staff, Mrs Johnston's family and various experts. Professor Donald Chisholm, an eminent endocrinologist, gave an opinion in December 2006 supporting the view of Dr Hill that exogenous insulin had been administered. Detective Senior Constable Helen Wheatley was the lead police investigator and ultimately a very thorough and extensive report was forwarded to the Coroner. The accepted evidence at the conclusion of the police investigation was that a person or persons unknown had injected Mrs Johnston with either one or two doses of insulin, causing her to suffer a severe episode of hypoglycaemia resulting in irreversible and severe brain damage, which ultimately resulted in her death. No person could be identified as the person likely to be responsible for injecting Mrs Johnston. The only logical possibilities which remained were an accidental administration/medication error by hospital staff or malicious administration by hospital staff or an outsider.

15. An inquest was set down to commence on 2 December 2008 to examine the circumstances surrounding Mrs Johnston's death. In the week before the commencement of the inquest a report from Professor Marks, a Professor of Clinical Biochemistry and world renowned expert in his field, offered a different opinion on the cause of Mrs Johnston's hypoglycaemia. He concluded that sepsis must be considered as a likely cause of hypoglycaemia in her case, and although the possibility that she had been given insulin on one or possibly two occasions could not be excluded with absolute certainty, he considered it to be unlikely. He challenged the reliability of the immunoassay results.

16. The report of Professor Marks was distributed to other expert witnesses. The opinion of Professor Marks was vehemently opposed by most of the medical experts who had provided statements to the investigating police and the Coroner.

17. The inquest had been listed, perhaps optimistically, for one week. As a result of the new evidence from Professor Marks, further evidence was sought. The issue of the

precise nature of the infective process that brought about Mrs Johnston's admission needed to be investigated; along with what was "sepsis" and what was the causal relationship, if any, between sepsis and hypoglycaemia. An opinion from an infective diseases clinician (Associate Professor Allworth) was obtained.

18. Mrs Johnston had also suffered from a series of cerebral strokes (at about the same time as her hypoglycaemia) which would have further compromised her brain function. The significance of this information was not initially evident to me and during the first week I heard some evidence with respect to whether it was the hypoglycaemic event which caused her to suffer irreversible brain damage or whether it was the cerebral strokes or a combination of both. As a result the opinion of Professor Silburn, the neurologist who attended on Mrs Johnston, was sought to examine the relationship, if any, between hypoglycaemia and the onset of her strokes.

19. The respective expert opinions were then tested in a protracted court exercise. The medical issues were complex.

20. There was a significant delay in resuming this inquest after the first week, for all these reasons. This was a particularly unfortunate consequence for the family, causing them significant personal anguish and no doubt considerable further legal expense. As a result it has taken almost a further year to conclude the hearing of the evidence and for this decision to be handed down. It is almost 3 years since Mrs Johnston passed away.

21. I do not intend to set out in detail all the evidence that has been heard in this case. I have been greatly assisted in being provided with written submissions by counsel assisting Mr Hamlyn-Harris, Mr Perry SC representing Dr Johnston and Mr Diehm SC representing the hospital. Their respective oral submissions and that of Mr Rebetzke representing some of the nurses, also assisted. I have concluded, for the reasons that will be provided in my findings, that the opinions of Dr Hill and Professor Chisholm should be preferred to that of Professor Marks. I am satisfied that malicious administration of insulin by someone not connected to the hospital is most unlikely and has been excluded. Logically that only leaves open the other possibilities that there has been an administration/medication error or maladministration by hospital staff. I am unable to identify by whom and when the medication error or administration took place or which of those two possibilities is the most probable. I am cognisant that this is a serious finding to make but that this is the only conclusion

that can be made in accepting that the clinical findings of the morning of 4 September 2006, and subsequently, are consistent with hypoglycaemic brain damage and that the immunoassay results are clearly indicative of exogenous insulin administration.

Social and Medical History

22. Margaret Allan Johnston was aged 82 years. She was married to Richard Johnston. Mrs Johnston was the mother of six children being two sons Craig and Garth and four daughters namely Amy, Sue, Jan and Zea. She has a number of grandchildren. It is evident that they were a close family with many of her children and Mr Johnston being present throughout most of the inquest. Importantly, none of the immediate family was prescribed insulin. Mrs Johnston's daughter Jan was a non-insulin dependent diabetic and this condition was controlled by diet and exercise. No one within the family knows of any person that would want to intentionally harm Mrs Johnston. That possibility is in my view clearly excluded.

23. Mrs Johnston had previously suffered from atrial fibrillation and from angina attacks in 1998. She had suffered a minor cerebral stroke in 1999 from which she appeared to recover well. She had been complaining of some dizziness and light headedness during 2006 but was reported to be independently mobile. She was in relatively good health, albeit frail.

Events of 1 to 6 September 2006

24. On 1 September 2006 Mr Richard Johnston telephoned his son Dr Craig Johnston. He was concerned about the condition of his wife who was confused and irrational. Dr Johnston visited his mother that evening and diagnosed a possible transient ischaemic attack (TIA) or a urinary tract infection, and suggested that she have an early consultation with her GP the next morning. Dr Johnston was telephoned shortly after midday the next day by Mrs Johnston's GP who advised him that he was sending Mrs Johnston to St Andrews Hospital for admission with a provisional diagnosis of UTI. By late that afternoon many members of the family were present at the hospital. Dr Sonya Rose saw Mrs Johnston in the Emergency Department and arranged for her to be admitted to ward 4B. Dr Rose wrote out a medication order for gentamicin, an anti-biotic which is commonly prescribed for treatment of a UTI.

25. Dr James Love saw Mrs Johnston on the ward and diagnosed a possible kidney infection (pyelonephritis) and ordered another dose of gentamicin. Mrs Johnston seemed to be improving but as she continued to be confused, the nursing supervisor organised for her to be 'specialled' overnight. This involves having an assistant in

nursing ("AIN") being present in the patient's room, or in the immediate vicinity, to ensure that the patient did not get out of bed or wander off. At this stage the treatment of Mrs Johnston followed standard good quality medical practice.

26. Dr Craig Johnston is a specialist anaesthetist who works at various hospitals including St Andrews War Memorial Hospital. During the investigation it was revealed that Dr Johnston assisted in the resiting of a cannula in the arm of his mother in the early evening of 2 September 2006. Nothing turns on that incident.

27. On 3 September 2006 Mrs Johnston remained confused. At around 11:00 am she had a short period of unconsciousness when she was being assisted to the toilet. Her pulse was rapid and irregular. Dr Johnston was present and thought that her unconsciousness was probably due to postural hypertension associated with rapid atrial fibrillation and suggested to medical staff that an ECG be performed. An ECG was organised and confirmed that she was suffering from atrial fibrillation. Following standard practice, Dr Love started Mrs Johnston on digoxin.

28. One issue which became quite significant during the course of the inquest was whether or not Mrs Johnston had any breakfast or fruit juice on the morning of 3 September 2006. Dr Johnston stated that he had been told on his arrival at the hospital on 3 September that his mother had eaten breakfast. The progress notes record that Mrs Johnston was given a drink at 5:25 am. The observation charts show that she was sitting in a chair between 7:15 am and 7:45 am, which may be consistent with her having got up to have some breakfast at that time. Endorsed Enrolled Nurse ("EEN") Pierce (who specialled Mrs Johnston between 6:45 am and 3:15 pm on 3 September 2006) noted in her statement that she showered Mrs Johnston "after breakfast". At 9:00 am a blood collector from QML took a sample of blood and noted that it was a "random test". This is consistent with the collector having been told that the patient had eaten something and therefore the sample would not be regarded as a fasting test.

29. EEN Pierce, gave evidence that Mrs Johnston had not eaten any breakfast and was very confused. Dr Johnston recalls that a nurse had told him that his mother had eaten a good breakfast. The importance of this issue will become evident during an analysis of the significance of the results from various immunoassay tests that were later conducted. I am satisfied on the balance of the evidence that Mrs Johnston had taken some fruit juice, and perhaps some breakfast (even if only a small amount), on

the morning of 3 September, and therefore the blood sample taken at 9:00 am was not a fasting analysis.

30. Mrs Johnston continued to be "specialled" throughout her stay on ward 4B. AIN Manisha Smith specialled her from 10:30 pm to 7:00 am on the evenings of 2 and 3 September 2006. She was informed that Mrs Johnston was a falls risk. Other than when she was on a break AIN Smith remained just outside the doorway and completed an observation chart throughout the night. She does not recall anything unusual happening during either of those shifts. At one stage late on the evening of 3 September she recalled that Mrs Johnston was snoring loudly, and thinks this was probably around 11:30 and 11:45 pm, as the observation chart has the words "restless" crossed out and replaced with "sleeping". She recalled asking the Registered Nurse what was the appropriate comment to make in the records and changed it according to that advice. She did not administer any medications and no-one, other than nursing or medical staff, entered the room. She recalls a registered nurse came in to change her drip on the morning of 4 September and that was when the emergency call was made.

31. Registered Nurse ("RN") Kim was working on ward 4B. She worked from 3:00 pm to 10.30 pm on Saturday 2 September and from 8.30 pm on 3 September until 7:00 am on 4 September. In her first statement she noted that she checked Mrs Johnston at about 2:00 am on 4 September but she later stated that it would have been about midnight when she says Mrs Johnston was snoring heavily and loudly. Almost certainly, RN Kim was the nurse who AIN Smith spoke to. RN Kim says she took Mrs Johnston's observations (temperature, blood pressure etc) at midnight which were normal, but which were not noted in the records, despite Mrs Johnston's chart being located with the AIN outside Mrs Johnston's door. At around 4:00 am when RN Kim was doing her next set of observations she thought Mrs Johnston's breathing had changed. Mrs Johnston was incontinent to urine and was unresponsive to voice or pain stimuli. A medical emergency (MERT) was called.

32. Dr Rosemary Hay attended the MERT call at about 4:50 am. She was the Assistant Director of Intensive Care at St Andrews. When she arrived it was obvious to her that Mrs Johnston was in a serious condition. Mrs Johnston was unresponsive and febrile and she had laboured breathing. Mrs Johnston also had decerebrate posturing (hyper extension of all limbs) which is a classic sign of severe neurological impairment. Dr Hay immediately transferred Mrs Johnson to the ICU and asked the QML blood collectors to take a series of tests. She also asked the nurses to do a

bedside glucose test on the last drop of blood in the syringe which the blood collectors had used. Dr Hay was thinking at this stage that Mrs Johnston had had either a stroke or a cerebral infection. She recalls a nurse then informing her that Mrs Johnston's blood glucose was 1.7 mmol/L (millimoles per Litre) which was very low, so Dr Hay immediately ordered 50% dextrose intravenously. This did not wake her. Dr Hay ordered various tests to be performed and was still on duty when the blood results from QML revealed Mrs Johnston's blood glucose level was 0.8 mmol/L. A later c-peptide test result introduced the possibility of exogenous insulin having been administered.

33. Dr Hay was aware that hypoglycaemia can be a consequence of severe sepsis. The only sign which she considered could be consistent with sepsis was Mrs Johnston's fever. Blood cultures had negative growth. A CT scan done that day showed no evidence of a thrombotic stroke but a subsequent CT scan 4 days later showed evidence of a stroke. Dr Hay had no further involvement in her care.

34. Dr Love saw Mrs Johnston in the ICU later the same day and noted Mrs Johnston's extremely low blood sugar level. He had never seen anybody present with a blood sugar level that low. The normal range for blood sugar is between 3.2 - 6 mmol/L. He noted that some medical conditions can cause an extremely low blood sugar level such as insulinoma and those with severe liver or adrenal failure, both of which were absent here. Dr Love considered the first report of Professor Marks and was of the view that it had introduced for him a number of interesting possibilities.

35. Professor Peter Silburn is a consultant neurologist. He was requested to provide a neurological opinion on Mrs Johnston by the ICU. He noted her history and progress notes and reviewed her on 6 September 2006. She had a normal CT scan of the brain. He noted no spontaneous movements and there was symmetrical decerebrate posturing to painful stimuli. Her brain stem reflexes were intact. He felt that she had severe diffuse brain dysfunction and damage. He felt her prognosis for useful recovery was poor but felt a repeat brain scan was necessary. The repeat CT scan demonstrated a right occipito-parietal ischaemic infarct which he felt was in the branch of the right middle cerebral artery. There was documented evidence on CT scanning of the brain of a recent cerebral infarction on a background of prior global CNS disturbance. He felt that Mrs Johnston had a very poor prognosis for useful recovery. I will refer to Professor Silburn's evidence later in this decision.

36. Dr Peter Lavercombe was the Director of the Intensive Care Unit. When he first examined Mrs Johnston he concluded that she had "assumed sepsis" because of her confusion, and cerebral posturing indicating a significant brain injury. He commenced a number of procedures and ordered further tests. He was notified of abnormal insulin results and then organised for other blood samples taken on 2 and 3 September to be tested for insulin and c-peptide. Dr Hill advised him that the results were consistent with exogenous injection of insulin. Dr Lavercombe contacted senior hospital administration and the family. He noted that the evidence supported a conclusion that two doses of insulin had been given, one on Saturday night and one on Sunday night. Dr Lavercombe looked for other causes of the increased insulin levels and caused some tests to be performed to see if Mrs Johnston had an insulin secreting tumour, which tests proved negative. Subsequent CT scans showed a stroke and an MRI on 11 September 2006 showed multiple recent strokes.

37. Dr Lavercombe had read Professor Marks' first report and disagreed with the propositions he was advancing.

38. Dr Peter Hill, an endocrinologist, saw Mrs Johnston on the afternoon of 4 September 2006. As a result of the results from the pathology tests performed by Dr De Voss; the clinical record; and his examination, Dr Hill came to a conclusion that she had been injected with insulin on two occasions. Dr Hill remained of this view in the course of his evidence and vehemently disagreed with the propositions put forward by Professor Marks in his report.

Blood Glucose, Insulin, C-Peptide, Hypoglycaemia

39. Professor Marks is a Doctor of Medicine, a fellow of the Royal Colleges of Physicians of London and Edinburgh, a fellow of the Royal College of Pathologists and a member of the Academy of Experts. He has carried out extensive work on disorders of carbohydrate metabolism, especially on hypoglycaemia, and has published extensively on the subject. He is the author of the book "Insulin Murders"' published in 2007. He has not been involved in clinical practice for many years. Professor Marks gives some helpful definitions in relation to the complex medical issues that this case revolves around. Although other experts do not agree with his ultimate conclusions, they have no disagreement with his summary of the some of the medical issues and it is on that basis that I intend to quote heavily from his reports for this part of the decision.[14]

[14] The following paragraphs rely on pages 4 to 9 of his first report which is exhibit G13

40. Professor Marks states that hypoglycaemia is a description applied to an abnormally low blood glucose concentration. The physiological consequences of a fall in blood glucose concentrations to below about 4mmol/L, is that the secretion of endogenous insulin by the pancreas ceases. This results in the activation of the autonomic nervous system with the promotion of sweating by the parasympathetic nerves and release of adrenaline by the sympathetic nerves, which together produce some of the characteristic symptoms and signs of hypoglycaemia. With severe hypoglycaemia, consciousness can be lost when the blood glucose level falls below 2.5mmol/L in younger people, and below 3mmol/L in older people. Consciousness can usually be restored in a person suffering from hypoglycaemic coma by giving them an intravenous injection of glucose, provided they have not been comatose for longer than about six hours. Prolonged hypoglycaemia with a blood glucose concentration below about 1.5mmol/L can cause permanent and irreversible brain damage.

41. Glucose is the only sugar that circulates in the blood and can be measured accurately in most clinical laboratories. Less accurate, but immediate, results can be obtained at the bedside using point of care instruments.

42. Insulin is a protein produced in the pancreas in response to a rise in blood glucose levels. It works on the tissues in the body to reduce the concentration of glucose. In healthy people its release is tightly controlled. Insulin secretion is switched on when the blood glucose concentration rises as glucose is absorbed into the blood circulation after a meal. It is switched off as blood glucose concentration falls, and stops altogether once the blood glucose concentration has fallen to about 4mmol/L (although the exact level is variable from person to person).

43. Insulin is made in the cells of the pancreas by the splitting of pro-insulin at two places to yield one molecule of insulin and one molecule of c-peptide.

44. Insulin ordinarily disappears from the blood about six times faster than c-peptide so that in a steady fasting state, when little change in their concentration is occurring, there are about six times as many molecules of c-peptide in the blood as there are of insulin.

45. During hypoglycaemia, endogenous insulin, c-peptide and pro-insulin release stops, and their concentrations drop to very low or undetectable levels. When the cause of hypoglycaemia is exogenous insulin, the insulin levels will be abnormally high but there will be a low c-peptide. When hypoglycaemia is produced by something other

than insulin (eg. an insulinoma), the concentration of insulin, c-peptide and pro-insulin are inappropriately high and easily measurable. In all cases the blood glucose level will be low.

Immunoassays Tests

46. Dr Kerry De Voss was involved in coordinating and performing a number of pathology tests from various blood samples taken from Mrs Johnston. He also organised tests to be performed by Mr John Galligan at the Royal Brisbane Hospital pathology department to check on his results. These results were very similar to his. Samples were also sent to the Sullivan Nicolaides laboratory ("SNL"). Dr De Voss received the test results from SNL over the telephone, but did not receive formal written test results from SNL or specifically record them. He recalls that they were consistent with the other results and he would have noted them if they were different. All three laboratories used different assay methods, and he was of the view that if all three were consistent then it would be pretty remote that they were all in error.

47. In addition to running a dilution or linearity check, Dr De Voss also ran three additional tests on Mrs Johnston's samples. One test involved heat treating the sample and rerunning the tests. An additional test was a procedure known as human sera dilutions on suspect immunoassay results. This involved mixing Mrs Johnston's blood with blood from another patient and rerunning the tests. The third additional test was a procedure known as a heterophillic Ab Procedure (also known as a heterophillic anti-mouse antibody). This involved mixing Mrs Johnston's blood with blood from an animal and again rerunning the tests. He did not specifically record or write down the results of the additional tests in his workbook. However, he stated they had those results been different from the original results, he would have noted them and informed Dr Hill and Detective Wheatley.

48. Dr De Voss also noted that in this case the laboratories had an advantage of being able to test various blood samples taken over a timed sequence before, at the time of and after the hypoglycaemic event. For instance, the results for Mrs Johnston's blood sugar, insulin and c-peptide on 2 September 2006 on admission, and when she was not having a hypoglycaemic event, are consistent with normal blood sugars, insulin and c-peptide levels. The results of 4 September were supportive of her clinical state of unconsciousness, decerebrate posturing and low blood sugar. Results after 4 September were consistent with the known clinical treatment being provided to Mrs Johnston. Combined with the extra tests Dr De Voss performed, and the fact that 3

different laboratories using different assays had consistent results, meant that he was satisfied that all possible causes of interference had been excluded.

49. Dr De Voss stated that if insulin injection was considered to be the likely explanation, then it was more likely that Mrs Johnston received two injections and not just one. He opined that if Mrs Johnson had received only one large injection on 3 September 2006, she would not have been able to wake spontaneously at lunch that day after being asleep the previous two hours, unless any insulin given had been a mixture of rapid and long acting insulin. Dr De Voss stated that a single injection of long lasting insulin would not explain her blood results on 4 September 2006.

50. The report of Professor Marks brought into question the reliability of immunoassays. One issue raised was the possibility of the presence of substances in the patient's serum which "interferes" with one or more steps in the assay. The other issue raised was cross reactivity. Mr Galligan is the supervising scientist of chemical pathology at Royal Brisbane Hospital. Mr Galligan stated that it would be highly unlikely that three tests would get the same results if there was some cross reaction with something else. As with many things in science, Mr Galligan could not absolutely rule out that there may have been cross-reactivity across the three tests, but still thought it unlikely. Mr Galligan also pointed out that if there was interference in the test of 4 September, one might also think that there would also be interference with tests on each of the other days, and that did not occur in this instance. Both Dr De Voss and Mr Galligan could not rule out the possibility that there could be interference with the insulin result as a result of infection, but their expectation would have been that the infection would have to have been a very severe infection for products to be produced that would interfere in the assay.

The Evidence of Professor Chisholm and Dr Hill

51. Dr Hill provided a useful summary of the test results in his statement and his table and Professor Marks' table were referred to often in evidence and it is helpful to set them out.

Dr Hill's Table

Date	Time	Glucose mmol/L	Insulin mU/L	C-Peptide nmol/L	Comments
2/9	1420	5.8	10	0.8	On admission to hospital
3/9	0900	3.1	125	0.8	Most likely after breakfast

4/9	0525	0.8 [1.7 at bedside test]	190	<0.1	Found unconscious
4/9	1435	6.1	49	0.1	In ICU on 10% dextrose drip
5/9	0530	6.8	58	0.34	In ICU
6/9	0510	10.7	58	2.9	In ICU

52. Professor Marks also compiled a table of the results as below. He converted the insulin and c-peptide concentrations to molar (SI) units and the second laboratory results are in brackets. He noted that the differences between the two laboratories were sufficiently small to treat them as having no significance but this did not make them necessarily correct.

Professor Marks' Table

Date & time collected	Glucose mmol/L	Potassium mmol/L	Cpeptide pmol/L	Insulin pmol/L	Proinsulin pmol/L	Albumin	Comments
01/08/06 09.30h	5.4	4.3				41	
02/09/06 @14.20h	5.8	4.3	800 (900)	70 (56)	19.6	42	
03/09/06 09.00	3.1	4.5	800 (960)	875 (721)	22.6	37	Gentamicin 0.7mg/L Cortisol=450nmol/L
04/09/06 @05.25h	0.8	4.4	Undetectable (undetectable)	1330 (1092)	17.6	37	Cortisol=2030nmol Medicine chart iv cortisol at 08.00h
04/09/06 14.35h	6.1	3.9	100 (80)	343 (308)	13.4	29	Albumex 250ml infused
05/09/06 05.30h	6.8	4.6	300 (469)	413 (364)	19	32	Gentamicin 0.9mg/L
06/09/06 @05.10h	10.7	4.0	2900	406		31	

06/09/06 @16.05		3.4					
07/09/06 @05.10h	7.2	3.6	1600	203		32	
08/09/06 @05.00h	8	3.9	2700	378		30	
09/09/06 @10.45h	8.8	5.0				28	
10/09/06 @06.00h	8.3	4.8				28	
11/09/06 @05.40	8.3	4.5				26	

53. Whatever table is used, the test results indicate that on 2 September 2006 Mrs Johnston had a normal blood glucose level associated with normal c-peptide and insulin levels. Using the unit value as they came from the laboratory (Dr Hill's table), at 9:00 am on 3 September she had a low blood sugar of 3.1 mmol/L, an elevated insulin level and a low c-peptide. On 4 September 2006 she had a very low blood sugar of 0.8mmol/L, very high insulin and a very low c-peptide. Dr Hill and Professor Chisholm are of the opinion that this set of results, combined with her clinical picture, was clearly indicative of exogenous insulin administration.

54. Professor Chisholm is an eminent endocrinologist and Professor of Endocrinology at the Garvan Institute of Medical Research, St Vincent's Hospital, Sydney. He was the Head of Clinical Diabetes Research, Diabetes and Metabolism at the Institute at the time of preparing his reports. He remained in clinical practice and research up to two years ago and is still involved in research. In his second report[15] Professor Chisholm noted that Mrs Johnston had a mild degree of hypoglycaemia on 3 September 2006 with a low blood sugar, a quite high insulin level and a relatively low c-peptide level. He stated that these results were not very conclusive and could perhaps be related to a downswing in the blood sugar after earlier food administration.

55. Professor Chisholm stated that the results from 4 September were more clear-cut. There was a very high insulin level, very low c-peptide and very low glucose levels. Professor Chisholm was of the opinion that a low blood glucose level due to low nutrition, illness (such as septicaemia), endocrine hypofunction etc would have been associated with a very low insulin level. The very low c-peptide level associated with

[15] Exhibit C2

the very low blood glucose level indicates that the insulin in the bloodstream was exogenous (produced within the body) rather than endogenous. Endogenous insulin release is associated with the simultaneous release of c-peptide which has a longer half life in the circulation. Professor Chisholm also noted that according to the bedside testing chart the blood glucose level fell again to a level of 2.8 at about 10:00 am despite the fact that intravenous glucose and dextrose, together with hydrocortisone (which also has a substantial effect on raising blood glucose levels) had been given. He was of the view that this would not have happened if the low glucose level had been due to poor nutrition or severe illness.

56. Professor Chisholm was of the opinion that if Mrs Johnson had been given a single injection of intermediate acting insulin sometime during the night of 3 September or early hours of 4 September this would fit well with the low blood glucose level at 5:25 am and recurrent low blood glucose level around 10:00 am. An injection of quick acting insulin could possibly also cover this timeframe but only if given within a couple of hours before 5:00 am.

57. Professor Chisholm noted that the results which were not fully consistent with a diagnosis of hypoglycaemia due to exogenous insulin, were the pro-insulin levels. All experts agree about that. Professor Chisholm notes that the pro-insulin level was tested by a laboratory in Sydney which was the only laboratory in Australia testing it. Pro-insulin assays were done relatively infrequently and low normal levels are close to the level of sensitivity of the assays. There is evidence that there may have been a small degree of cross-reactivity of insulin in the assay and in fact this particular assay is no longer available or being used. Much evidence was heard about the pro-insulin levels and the assays performed but I am satisfied that the pro-insulin results are unreliable because of the nature of the assay tests, and can be excluded from consideration. It does not necessarily follow that the immunoassays for insulin and c-peptide are also invalid or unreliable.

58. Although Professor Chisholm opined that Mrs Johnston had severe hypoglycaemia produced by exogenous insulin, he considered that it was difficult to know how much this contributed to her overall illness and eventual demise. In general, a coma due to hypoglycaemia is immediately reversed by intravenous glucose. However, when hypoglycaemia is severe and prolonged, or where it is superimposed on another cause of brain malfunction, the coma may be more prolonged or even irreversible. Professor Chisholm noted that Mrs Johnston was admitted in a confusional state indicating some type of brain malfunction prior to the hypoglycaemia, and of course it

is now known that Mrs Johnston suffered from a number of cerebral strokes at around the same time.

59. Professor Chisholm agrees that immunoassays for insulin and c-peptide can be affected by septicaemia or other severe illness, but errors of this type would generally be only of a moderate magnitude. He stated that there might be a 25% error in the insulin assay rather than the usual 10% or so, but the insulin and c-peptide results on the sample of 4 September were extremely high and low respectively and which he did not believe could be attributed to the vagaries of the immunoassay procedure.

60. Professor Chisholm noted that the insulin and c-peptide levels on 2 September were as expected. The levels from 5 to 8 September did fluctuate, however he noted that she was receiving intravenous glucose which would have caused significant fluctuations in her blood glucose level and corresponding fluctuations in insulin and c-peptide levels. He did not think that those results were surprising.

61. Professor Chisholm was of the view that the amount of insulin administered was probably in the usual therapeutic range for people with diabetes rather than in the range of an overdose. He did say that it would usually take a large dose of insulin to induce hypoglycaemia sufficient to cause a coma however this would not be the case in an ill and malnourished patient such as Mrs Johnston. He stated in his evidence that he would have thought a dose of 40 to 50 units of intermediate insulin would be needed, but for the reasons given by him and Professor Marks, this is an uncertain calculation. Mixitard 30/70 has a 70% intermediate and 30% quick acting component, which would fit the profile. The amount given to the only diabetic patient on the ward was 18 units in the morning at 7:00 am and 10 units at night at 5:00 pm. Professor Chisholm agreed that giving Mrs Johnston 10 units at 5:00 pm on 3 September would not achieve the result found the next morning. It would have to have been a significantly larger dose given much later in the night.[16]

62. Dr Hill, also, was of the opinion that the results of 3 and 4 September 2006 were consistent with exogenous administration of insulin on two separate occasions. He did not think that the results could be explained by a single administration of exogenous insulin before 9:00 am on 3 September 2006. He said that the simple reason was that if it was sufficient to cause the condition that ultimately occurred over the night of 3 September and the morning of 4 September, then Mrs Johnston would have gone into a hypoglycaemic state earlier on 3 September and at least by

[16] Page 55 of transcript from 21 August 2009 14-55

lunchtime or soon after. He opined that the results of 3 September, where the blood glucose level was not as low and the c-peptide was detectable, could be explained by the fact that the sample taken at the time was not a fasting test. If she had anything to eat that morning, even a juice, her blood sugar could have gone up a little, which would have been enough to stimulate some insulin secretion. This would result in some measurable c-peptide, but with the insulin level still very disproportionate to the c-peptide level. For the reasons espoused by Professor Chisholm, Dr Hill also agrees that the pro-insulin assay results are incorrect.

63. Dr Hill also thought that the doses given to Mrs Johnston were pharmacological doses. He opines that the dose given before 9:00 am on 3 September 2006 was such that Mrs Johnston was able to remain conscious. On the second occasion it may well have precipitated a stroke and that was the reason why, when she was given dextrose, she did not recover because she had "stroked out".

64. Dr Hill was of the view that it was much more likely that the doses of insulin were a medication error in which a dose of insulin that was intended for someone else had been given. He agreed with Professor Marks that this was not necessarily an overdose and this would explain some of the test results. In order to cause neurological damage to be caused normally a lot of insulin is required and the person needs to be profoundly hypoglycaemic for a prolonged period of time. Dr Hill said that if Mrs Johnston had had a stroke then this was an alternative explanation for what occurred. What qualifies as a "pharmacological dose" varies between people. Dr Hill said that is not possible to say what type of insulin was used and what the dose was.

Infection/Sepsis related hypoglycaemia

65. Professor Marks in his first report came to a conclusion that sepsis must be considered a likely cause of hypoglycaemia in Mrs Johnston's case. In his second report he noted that infection related hypoglycaemia remained a possibility if the insulin and c-peptide results were discounted.

66. On the issue of sepsis Dr Hill stated that whilst Mrs Johnston had a fever, none of the blood cultures showed that she had an infection. He also was of the view that according to the literature he could not see that sepsis was a major player to the extent that it would cause a person such as Mrs Johnston, to become hypoglycaemic. He noted, consistently with other witnesses, that most patients who are septic have a high sugar level and not a low sugar level. To have a low sugar

level Dr Hill felt that you had to be critically very unwell to the extent of having a major system shutdown.

67. Associate Professor Tony Allworth is a highly qualified consultant physician in infectious diseases and an Associate Professor at the University of Queensland. Associate Professor Allworth was requested by the Coroner to provide a report.[17] He noted that both sepsis and septicaemia are poorly defined terms. He described sepsis as the clinical manifestation of an inflammatory state that is suspected or proven to be due to an infection (usually but not exclusively bacterial). Septicaemia was also a poorly defined term, referring to the presence of pathogenic organisms, usually bacterial, in the blood associated with manifestations of sepsis. The likelihood of organ failure or metabolic abnormalities such as hyper or hypoglycaemia increases as the severity of the manifestations of the inflammation progress. The clinical signs of sepsis are variable, but the classical hallmark is of fever, although it is not invariably present. The patient may have either warm or cool peripheries, a fast heart rate and an altered mental state. Low blood pressure is a feature of more advanced sepsis. Laboratory indices commonly, but not reliably, demonstrate an elevation of specific white blood cells and in more advanced cases then there may be abnormalities of liver and renal function.

68. Associate Professor Allworth stated that there was evidence from the medical records and statements of witnesses that Mrs Johnston was suffering from an infective illness on presentation to hospital. The indications of this were her confusion and fever. The source of the infection at that time, and subsequently, remained obscure. Whilst a clinical diagnosis of UTI was made, the urine culture performed on the day of admission was contaminated with skin cells and did not grow any significant organisms, thus precluding a clear diagnosis of UTI. Mrs Johnston was treated with intravenous ampicillin and gentamicin which were appropriate antibiotics and there was some evidence that she improved in her clinical state. When Mrs Johnston was found in the early hours of the morning of 4 September there were clinical signs of infection including that of high fever and non-responsiveness (also explainable by the hypoglycaemia) and there was a subsequent development of low blood pressure requiring treatment. However, as Mrs Johnston had possibly been unconscious for some hours, Associate Professor Allworth opined that these features could have been due to pneumonia or other complications of unconsciousness, rather than her original infection.

[17] Which is exhibit C3

69. Associate Professor Allworth also noted that whilst hypoglycaemia is a recognised complication of sepsis, particularly in the elderly, it is rare. The most common reaction to sepsis is hyperglycaemia (high blood sugar). He said that it would be unusual to see a patient with the severity of hypoglycaemia as with Mrs Johnston due to sepsis alone. Finally, he stated that the presence of sepsis would not explain the discrepancy between the levels of insulin and of c-peptide. He agreed that this was an issue that would need to be addressed by an endocrinologist.

70. Associate Professor Allworth stated in his evidence that based on the limited reports in the medical literature, multi-organ failure was not a pre-requisite for hypoglycaemia consequent on an infection, but that the patients would have overt signs of sepsis as distinct from subtle signs of sepsis.

71. Associate Professor Allworth said that in his clinical experience and based on the limited literature, if there is potentially a link between sepsis or infection and hypoglycaemia, and on the basis of the proposed mechanism linking the two, the expectation is to find low insulin levels not high insulin levels, as was the case with Mrs Johnston. He stated that the proposed mechanism suggested in most of the literature is of a peripheral utilisation of glucose by the tissues so that in general terms when the glucose levels falls, he would expect insulin levels to fall also. This mechanism was also the one that Professor Marks suggested in his first report.[18]

72. Associate Professor Allworth was asked about the relationship between sepsis and atrial fibrillation and agreed that there could be a connection. He also stated that in terms of infection this can be a trigger for atrial fibrillation, either in the presence or absence of underlying heart disease, but more commonly in the presence of underlying heart disease.

73. Dr Henderson, who is both an intensivist and cardiologist, stated that there were rare cases noted in the literature of elderly people who develop hypoglycaemia from sepsis but the cases of sepsis were severe. He noted that Mrs Johnston had some coronary atherosclerosis and hypertension and would be predisposed to atrial fibrillation. He was also of the view that hypoglycaemia would predispose someone to atrial fibrillation even more. He agrees with Professor Silburn when he said that hypoglycaemia can induce atrial fibrillation.

[18] Exhibit G13, page 25, paragraph 89

The Evidence of Professor Marks

74. Professor Marks is undoubtedly a world renowned expert. In his first report he came to a conclusion that sepsis must be considered a likely cause of hypoglycaemia in Mrs Johnston's case. In his second report he noted that infection related hypoglycaemia remained a possibility, if the insulin and c-peptide results were discounted.

75. Professor Marks stated in his second report[19] that "*exogenous insulin cannot be excluded as a possible explanation for the clinical picture and result of the laboratory tests but only if some of the, c-peptide and proinsulin results are discounted as being inaccurate*." Further "*infection-related hypoglycaemia remains a possibility but again only if the insulin, c-peptide and proinsulin results are discounted*". In the conclusion of his second report, at page 20, he stated that he "*admits to not knowing exactly why Mrs Johnston became hypoglycaemic. I believe that a natural cause is more likely than deliberate poisoning with insulin and about as likely as accidental poisoning with insulin. Both are possible but I have seen no evidence, apart from plasma insulin immunoassay results that may themselves be wrong, to support my conclusions."* It is clear that Professor Marks has moderated his opinion on that stated in his first report. In fairness to Professor Marks, in his evidence he said that he may have worded that paragraph too strongly in favour of possible accidental insulin administration.

76. The reliability of the immunoassays was a subject of significant evidence. Professor Marks was critical of the reliability of the immunoassays and particularly had regard to the c-peptide reading for the morning of 3 September. The problem with his evidence is that he did not think that was necessarily true of the test results when Mrs Johnston was first admitted, as they were what would have been expected. The results for 3 September were difficult for him to reconcile because if the cause was exogenous insulin then he thinks the c-peptide level was wrong and if it was due to sepsis, then both the insulin and c-peptide levels were wrong. Professor Marks conceded that but for the c-peptide result on 3 September 2006 he would have concluded that Mrs Johnston was administered insulin exogenously. When asked about the readings for 4, 5, and 6 September he said they were more difficult to reconcile because there was nothing that was glaringly wrong and they all became perfectly normal by 6 September.

[19] At pages 6 – 7 in exhibit G16

77. At one stage he also stated that as a tool in clinical management immunoassays were right 99.99% of the time.[20] I accept this statement was made in the context of, and at the end of, a rather long and at times rambling discussion about potential issues concerning immunoassays, and where he relied on matters raised particularly in his own paper "*False Positive Immunoassay Results*"[21]. He stated that the issue of cross-reactivity would not apply to these particular assays but it was more the issue of interference in the assay producing a wrong signal. His paper stated that over a whole range of immunoassays, 8.7% of the results were considered to be false positives. It was interesting to see that in relation to the tests for insulin and c-peptide set out in that paper there were no false positives mentioned and his answer to a question by me about that was unclear.

78. I accept that there is a scientific basis for an assertion that interference is a potential source of error in immunoassays. Dr De Voss agrees. However in this case, and for the reasons that have been given by Dr De Voss in his evidence, the possibility of the immunoassay results being unreliable has been minimised such that I can be confident to a high standard of proof that unreliability can be excluded. Here there were three laboratories producing similar results with different assay processes over a timed series of blood samples. Dr De Voss conducted a further series of three tests involving the mixing of normal patient serum, heat treatment, and absorption against an animal panel. Of further significance are the test results on 5 and 6 September. If there were anti-bodies that were interfering with the results of 3 and 4 September it is apparent that they would have also been present on 2, 5 and 6 September, as Dr De Voss stated that the anti-bodies would persist in circulation for months. This proposition was supported by Professor Chisholm in his evidence when he said an antibody *"would not appear for 24 hours on 3 and 4 September and disappear for the rest of the time."*[22]

79. On the issue of an infective process interfering with the assay, Mr Galligan also stated that he would have expected there to be a high rate of infection for there to be a generation of by-products that might interfere with the assay. Dr De Voss noted that Mrs Johnston had numerous blood cultures taken and other organisms tested. A microscopic examination of her admission urine showed a number of white cells, a number of red cells and a number of epithelial cells. Put together, there was no evidence of a true infection. Her white cell count was only mildly up on her normal

[20] Page 64 from the transcript from 20 August 2009
[21] Exhibit G20
[22] Page 37 from the transcript from 21 August 2009

levels and did not indicate a tremendous infection but something in the order of a sore throat.

80. Accepting that there is nothing that is absolute in science, for my purposes this evidence is very significant and Professor Marks' evidence, notwithstanding his high profile in his profession, did not stand up to scrutiny. When you consider the clinical picture on 2 September and Mrs Johnston's test results; and then look at the clinical picture on 4 September and the results; they are consistent with hypoglycaemia induced by exogenous insulin. Professor Chisholm said of the results from 4 September 2006 that he could not conceive of that happening except in the presence of insulin and were only consistent with the administration of an excessive amount of exogenous insulin. Professor Chisholm stated that a patient who had poor nutrition, frailty and septicaemia would be associated with a low insulin level. When such a patient was given the amount of glucose together with cortisone as was given to Mrs Johnston, and which both raise blood sugar, he would have expected the blood sugars to have remained normal for the next number of hours or at least mildly elevated. In fact what happened with Mrs Johnston was that the blood sugar levels dropped to 2.8 and Professor Chisholm said he could not conceive of that happening except in the presence of an excessive amount of insulin.[23]

81. As to the level of insulin Professor Chisholm did not think it was a very high dose, perhaps in the order of 40 to 50 units, which he said was in a therapeutic range.

82. Professor Marks was also taken to excerpts from his book " Insulin Murders" in relation to his suggestion that only severe infection can cause hypoglycaemia. Professor Marks stated that he had changed his opinion since writing the book and was now of the view that even minor infections can be involved. He had noted the evidence of other witnesses who had not diagnosed that Mrs Johnston was suffering from sepsis or a severe infection. Professor Marks referred to two papers in the medical literature, one by Alamgir[24] and one by Birkman which he said supported this proposition. Under cross examination he conceded that in the Alamgir article the one patient that had died had presented with sepsis from E. Coli which was sufficient to cause the death with an incidental finding of low blood glucose.

83. The conclusion I have drawn from this analysis of the respective expert opinions is to find in favour of the view of Professor Chisholm and Dr Hill and other experts, as

[23] Pages 38 – 39 of the transcript from 21 August 2009
[24] Exhibit G18 "Prognostic Value of Low Blood Glucose at the Presentation of E. Coli Bacterium", The American Journal of Medicine 2006, 119, 952-957

distinct from Professor Marks. One starts at the clinical finding in the early hours of 4 September which is supportive of severe hypoglycaemia from which Mrs Johnston could not be revived. She had a very low blood glucose level and decerebrate bilateral posturing. The immunoassays results support that this was due to exogenous insulin. Professor Marks has not convinced me that the immunoassay tests are unreliable. Professor Mark's proposition relies on the results being unreliable. His proposition also relies on rather tenuous evidence which supports that minor infections can cause low blood sugar sufficient to cause hypoglycaemia. It is uncontested that hypoglycaemia caused by infective processes are rare. To find in favour of Professor Marks' propositions I would have to:

I. discount the evidence of Professor Chisholm and Dr Hill;
II. find that this is one of the rare instances that 3 different immunoassays are unreliable;
III. find that this is one of those rare cases where hypoglycaemia was caused by sepsis/infection;
IV. also find that the relatively moderate infective process for which Mrs Johnston was being treated was sufficient to bring about this rare result; and
V. ignore the evidence of a number of expert medical witnesses who thought a much greater infective process was necessary.

I cannot do so and do not therefore favour Professor Marks' view.

Hypoglycaemia, Stroke and brain damage

84. Mrs Johnston was in a hypoglycaemic coma when found on 4 September 2006. Professor Silburn thought that her clinical signs then were in keeping with a global issue in the brain and not focal deficit that could be expected with a stroke. A very large stroke can cause a global non-responsiveness, but there was no evidence of a mid-line shift that would be expected if that was the case. Evidence of such a large stroke was not seen on the scans and there was no evidence at autopsy that she suffered a deep brain stem stroke. Low blood sugar in an elderly woman who was not diabetic would account for the clinical signs.

85. Later radiological studies showed that Mrs Johnston suffered from one significant and one smaller stroke. Stroke and hypoglycaemic brain damage are caused by quite different mechanisms. In hypoglycaemia the low blood sugar in the brain causes it to be damaged diffusely because energy to feed the brain is reduced to an unacceptable level. Professor Silburn described stroke as a clinical syndrome characterised by acute loss of focal brain function lasting more than 24 hours. There are two main causes. The first is due to a spontaneous haemorrhage into or over the

brain substance (haemorrhagic stroke). The second is due to an inadequate blood supply to a part of the brain as result of low blood flow, thrombosis or embolism and usually associated with disease of the blood vessels, heart or blood (ischaemic or thrombotic stroke).

86. A CT scan of Mrs Johnston's brain on 4 September 2006 was normal. This is not an unusual finding in relation to hypoglycaemia in the first 24 hours and also is the case in relation to ischaemic or thrombotic strokes (as distinct from haemorrhagic strokes where the bleeding will be seen on the scan almost immediately). Professor Silburn noted that this scan was compatible with a person of Mrs Johnston's age and co-existent vascular risk factors of long-term hypertension with a history of a previous transient ischaemic attack. There was no evidence of an acute stroke.

87. When Professor Silburn examined Mrs Johnston on 6 September 2006, he felt that there was a diffuse brain injury, but there was also some laterality to the symptoms he observed and which placed one hemisphere slightly different. So despite a CT scan being normal he felt that there was something else happening on one side of the brain.

88. The brain scan on 8 September 2006 was considered by Professor Silburn as being abnormal with a well demarcated area of hypodensity consistent with an infarct in the distribution of a branch of the right middle cerebral artery.

89. The MRI scan performed on 11 September 2006 demonstrated bilateral cerebral infarction. Professor Silburn interpreted the MRI as showing evidence of stroke in the right middle cerebral artery as may be seen in an embolic event and significant small vessel ischaemia both old and new. There was also an unusual appearance of increased cortical grey matter signal, not in a vascular distribution, sparing the underlying white-matter which can be seen in hypoglycaemia.

90. Professor Silburn felt that Mrs Johnston's presentation was related to a combination of severe hypoglycaemia with cerebral dysfunction plus a recent stroke with the initial bilaterality of her signs being more in keeping with the initial prolonged hypoglycaemia.

91. Professor Silburn considered that Mrs Johnston had a high risk of stroke with the co-existent vascular risk factors and the brief period of atrial fibrillation which she suffered early in the admission. Atrial fibrillation is a known potential cause of embolic

stroke. Hypoglycaemia can cause focal and diffuse cerebral dysfunction, but it is not a necessary or sufficient condition to cause a stroke. However Professor Silburn was of the view that the episode of hypoglycaemia significantly contributed to Mrs Johnston's demise on the basis of the severe hypoglycaemia effect on cerebral dysfunction and cardiac dysfunction. The severe hypoglycaemia would induce neuronal metabolic dysfunction and potentially increase the susceptibility to neuronal damage. He thought that given Mrs Johnston's presentation it was highly unlikely that the diffuse brain damage was due to any other potential cause, including the level of infection found in Mrs Johnston. The level and magnitude of the change on the morning of 4 September did not fit with her condition earlier during her admission. His understanding was there would have to be severe sepsis and multi-organ failure to produce hypoglycaemia to the level found here. He was adamant that the strokes also did not cause her death, rather it was a combination of factors.

92. Professor Silburn was unable to be definitive about when the first stroke occurred. He was of the view that her unresponsiveness on 4 September 2006 was not due to a stroke alone, but by the time he saw her two days later, the stroke had occurred.

Autopsy Examination and Neuropathology

93. Dr Ong conducted the autopsy examination and Dr Tannenburg provided a neuropathology report on a macroscopic and microscopic examination of the brain.

94. Dr Ong found no evidence of insulinoma, despite a thorough dissection of the gastrointestinal tract. He found the presence of pulmonary thromboembolism in Mrs Johnston's right lung, the source of which appeared to be from the deep veins of the left calf. Extensive pneumonia was present in both lungs. Significant coronary atherosclerosis in the left anterior descending artery, consistent with a history of angina was found.

95. The brain showed evidence of old infarction and changes of Alzheimer's disease which were associated with age. Features of Parkinson's disease were also present. Dr Ong noted that the neuropathology examination found no unequivocal changes of hypoglycaemia damage.

96. In his first autopsy report Dr Ong found the cause of death to be complications arising from hypoglycaemic brain damage. After considering the various expert reports, and in particular the opinion of Professor Silburn, he added a further summary to his report with substantially the same cause of death, but adding coronary

atherosclerosis as a significant factor. Dr Ong concluded from Mrs Johnston's clinical history and the post-mortem examination, that her cause of death was from multiple complications (including pneumonia, Pulmonary thromboembolism, dehydration) due to brain damage, which was secondary to hypoglycaemia.

97. Although there was no physical evidence at the post-mortem examination of hypoglycaemic brain damage, both Dr Ong and Dr Tannenburg considered the physical and clinical history when reaching their conclusions. Dr Ong said that if hypoglycaemic brain damage was being considered to be a cause of death he would have expected signs of that found on the autopsy examination. Dr Ong said hypoglycaemia potentially contributed to Mrs Johnston's death by rendering her brain more susceptible to other forms of insult, which in this case were the strokes. There were some hypoglycaemic insult to the brain but not enough to cause direct damage that a pathologist could find when examining the brain macroscopically or microscopically.

98. Dr Tannenburg is a highly qualified neuropathologist. He was referred specifically to the evidence of Professor Silburn and the reference in his own report to his comment that 'unequivocal changes of a hypoglycaemic damage to the brain are not observed.' He explained that hypoglycaemia produces, in its pure form, a diffuse pattern of brain damage affecting many areas of the brain, including the cerebral cortex, brain stem and cerebellum. There are other types of diffuse cerebral damage that do not give this specific pattern. In this case he also found other patterns of damage including an area of infarction on the right side of the brain and on the left side there was a smaller area of damage in the arterial boundary zone. There was a diffuse brain damage present in this case but it was spotty and fairly mild and affected the deep grey matter structures of the brain in the basal ganglia and the thalamus. Dr Tannenburg said that this pattern is fairly non-specific and may indicate a cardiac genesis or an arterial genesis as a cause.

99. Importantly, Dr Tanneburg said that the pure pattern of hypoglycaemic brain damage is seen in only about 20% of cases. More often than not a mixed pattern which looks a little bit like hypoxia with little areas of infarction in the cortex similar to this particular case is observed. He also said that in this case there was a period of survival of some three months, during which time the brain undergoes a sequence of healing and repair.

100. The importance of this evidence is that in not finding physical evidence of hypoglycaemic damage at the post-mortem examination by no means establishes that this did not occur. There is ample other evidence, particularly from Professor Silburn, that Mrs Johnston did suffer from a hypoglycaemic event sufficient to place her in a coma which he was able to observe. However his evidence and that of other experts were uncertain as to the extent to which her death resulted from that event, the strokes or a combination of both. I favour Professor Silburn's view that when he examined Mrs Johnston, both had occurred, and that both conditions were significant and contributory to her inability to revive and her subsequent death.

Access to Insulin

101. Mr Gath was the pharmacist manager providing pharmacy services to the hospital. On 5 September 2006 he was requested by the hospital administration to produce a report detailing the insulin which had been dispensed from the pharmacy over the previous weekend. The report showed that the pharmacy had provided insulin to a patient on ward 4B on 30 August 2006. There was no other insulin dispensed on the ward in the preceding few weeks. He also did a visual inspection of Ward 4B and found insulin for that patient[25] in the bottom of the refrigerator in the first medication room. The insulin stock was soluble insulin Mixitard 30/70. He also found a vial of insulin Protophane 3m penfill and an open file of Actrapid soluble insulin. He did not find the insulin that was dispensed on 30 August. He then went to this patient's bedside locker and found an opened vial of Mixitard 30/70 which had a date of having been opened on 16 August. He later concluded that this vial came with the patient from the Wesley Hospital where a vial was dispensed to the patient on16 August.

102. Mr Gath also checked the medication room at the neuroscience end of ward 4B and checked the contents of that refrigerator. Here he found that an open vial of Actrapid soluble insulin and an opened a pack of Mixitard 30/70 penfill insulin. He was then told by RN Liebke that she had found a vial on the bench in the rehabilitation medication room. This vial had been labelled open however it did not have a patient's name on the vial so she put into a sharps bin.

103. Mr Gath stated that there was a problem in 2006 that it was not uncommon to find insulin in medication refrigerators which should not have been there.

[25] The name of that patient will remain confidential for privacy reasons but the inquest had regard to his medical records as part of the investigation

104. RN Liebke was tasked along with the Assistant Director of Nursing, Judy Dodd to check for insulin on ward 4B. They found insulin belonging to the patients in the neuroscience ward as already has been indicated. They also found a single vial of Mixitard 30/70 in the neuroscience treatment room belonging to another patient. Insulin was also found in the rehab treatment room refrigerator belonging to the patient in room 15A.

105. On 5 September 2006 RN Liebke was tidying the rehabilitation treatment room when she located a vial of 10 ml Mixitard 30/70 insulin (this vial is the same as described in paragraph 102 of these findings). This vial was located in a plastic tub on the bench and had written on it as having been opened and with a date she does not recall. It had no patient identifying names on it. She placed this in a sharps container. The sharp container was later taken to the hospital administration. RN Liebke identified the vial as the one shown in Exhibit B2A[26]. However as pointed out by Mr Perry in his written submissions[27] the box and vial found by Mr Gath and shown in Exhibit B2 as belonging to the other patient is a different vial. The box is labelled as having been dispensed by St Andrews on 30 August 2006 but it is not the same vial as found by RN Liebke. The importance of this evidence is that the other patient was clearly receiving his insulin as was noted on the medical records. There was a vial opened which appears to be a 3ml vial and which is labelled for that patient. The vial that should have been with the box was not that vial. It is likely that the vial that was originally in the box is the one found by RN Liebke on 5 September.

106. The sharps container was subsequently examined by Police at my request. A vial of Mixitard 30/70 was found with a label stating it was opened on 31 August 2006. In my view it is clear that the vial which was found by RN Liebke was a vial supplied by the pharmacy on 30 August and opened on 31 August 2006. This is the vial which is shown in photograph 17 of exhibit B2A and was identified as such by RN Liebke in her evidence. Clearly it has had some of the insulin removed. The evidence indicates that some 0.8 – 0.9mL's (80 – 90 units) have been withdrawn from this vial[28] and it is my finding that this is a vial which has more probably been the source of the insulin which was given to Mrs Johnston. Professor Chisholm gave evidence of a likely dose of between 40 to 50 units and this is consistent with two doses having been withdrawn.

[26] Photograph 17 shows it clearly
[27] At paragraph 20
[28] Statement of Donna Maree Stewart, exhibit D63B

107. The evidence supports a finding that there was insulin available on the ward and certainly a vial of insulin was found in a place where best practice and policy would suggest it should not have been.

108. I do not intend to set out the evidence of the many nursing and security staff who gave evidence in this case. There are also numerous statements of witnesses which have been considered by me, including witnesses who have not been called to give evidence. Swipe cards were required to access the medication rooms. However, the evidence heard at the inquest suggests that their use was loosely controlled and there were supplies of cards left in nursing station drawers for use by agency nurses, and for use by enrolled nurses and AIN's who did not have access for medication reasons but may have required access for other materials. At the time, record keeping for their use and access was largely absent. That has since been tightened by the Hospital.[29]

109. RN Vitelli was recorded in the medical notes as having been the checking nurse for Ampicillin which was to be given to Mrs Johnston with a time of 6:00 am on 4 September. At that time Mrs Johnston had been transferred to the ICU. The practice as described by RN Vitelli seemed to be that medications that were required to be checked for a number of patients were checked at some time early in the shift and possibly well before administration. RN Kim confirmed the practice. RN Kim also did not document the observations she said she made at around midnight which was a time when Mrs Johnston had been heard by her and AIN Smith as snoring loudly. I was not altogether impressed with the evidence of Nurse Kim, and the medication practice she adopted and the lack of observation recording was not indicative of best nursing practices.

110. This evidence was illuminating, and as the inquest later heard was a complete surprise to RN Hambrecht, the Director of Nursing, who did not consider it to be best practice at all. I will deal with that later but the medication practice identified, did set up a greater potential for error occurring.

111. It is evident that access to the wards generally was open during the day. At night there were some restrictions with the front door locked and lifts closed down but certainly it was possible for someone off the street to have access to the wards if they had that intent. I am not critical of that aspect of security as hospital wards should be open for easy access by a patient's family, subject to sensible

[29] Attachment 6 to the statement of Ms Hambrecht, Director of Nursing, exhibit D25B

precautions being taken, and a balance needs to be made on having too much security as appropriate to the risks that are to be managed. The risk of someone coming off the street to act maliciously is no doubt there, but historically it would be said to be an unlikely event and was being managed and monitored.

112. It is unlikely that in this instance some third party has simply come in to the hospital with an intent to do harm to someone, accessed a medication room and found some insulin and then taken the risk of passing the nurse's stations and in particular the person who was specialling Mrs Johnston to give her an injection of insulin. If the intent had been to do serious harm then it is likely a much higher dose would have been given and on one occasion. This possibility is logically excluded for these reasons.

113. The only other conclusions available are of accidental administration/medication error or malicious administration by hospital staff. It is noted that there is an absence of documentation about medication of insulin which it seems historically would usually be found if it was an error. The fact that it may have occurred twice makes it even more unlikely. The fact that historically if there had been an accident this would have been identified by the staff member concerned was also mentioned. It is noteworthy that if an accidental medication error occurred and was realised by the person concerned, the remedy is simple, quick and effective if done in time. It is difficult to conceive that someone within the hospital would have maliciously administered insulin but that possibility remains open.

114. Although these are serious findings to make, it is clear to me that there has been an administration of insulin on probably two occasions, but certainly once, as suggested by Dr Hill and Professor Chisholm. The doses given were high but within a range of therapeutic doses of Mixitard 30/70. The dosage is inconsistent with a malicious administration if it was for the purposes of causing death or permanent injury and leans to a medication error. However, the state of the evidence is such that it is not possible for me to be conclusive to the requisite standard of proof one way or the other. Both are open. It is not possible to identify who may have given the injections or with sufficient preciseness as to time to identify a particular person or a shift that may have been involved.

Hospital Investigation and the timeliness of notification to Police

115. I do not intend to set out in any detail the evidence that was heard in relation to this issue. The Police were called at about 6.30 pm on 5 September. By around 9:00

am on that day Dr Lavercombe and Dr Hill were fairly clear that they thought it was an exogenous injection of insulin that was involved. Further investigations by the pharmacy took place. Dr Lavercombe expressed a view to the Director of Medical Services, Dr Brandon by 11:00 am. Dr Lavercombe was unable to exclude medication error absolutely but had done so to a sufficient extent to think that police should be called to undertake a more rigorous investigation. A meeting of the Hospital executive was held at 2:00 pm and a decision was made to interview staff and RN Rossmuller, the hospital's Risk and Quality Manager, and the hospital solicitor spoke with them. This was to again check that there had not been a medication error. Their conclusion was that medication error was still unlikely and then the police were called.

116. Certainly in a case like this the earlier that police are called, the less opportunity there is to lose any forensic evidence. An example of what could happen is exemplified by RN Liebke discarding an insulin vial into a sharps bin. She herself understood how important that was shortly after and mentioned how embarrassed she was and although the evidence was not lost altogether, it could have been.

117. Nevertheless, I do not intend to be critical of the hospital on this point. They undertook a number of preliminary investigations which seemed to be appropriate and made the decision in a reasonably expeditious fashion. It is arguable they could have rung the police earlier that day and perhaps before any staff were interviewed but it was a decision based on legal advice. The interviews were conducted quickly and in a planned manner. There was no hesitation after they were completed.

118. There have been no doubt lessons learnt. Internal investigations as to critical incidents are part of most hospital policies. The cut off point is usually where an issue of "blameworthiness" is identified, and certainly a possible criminal incident would be encompassed by that concept. A medication error may be a critical incident but of itself would not necessarily be considered a "blameworthy" or more serious act.

119. Dr Brandon advised that his research and that of hospital lawyers had not been able to identify a national policy or guideline for notification of police in the event of staff having grounds to suspect criminal conduct had occurred. The Queensland Health Policy[30] is not much more advanced on this particular issue. It sets out as a

[30] Queensland Health Critical Incident Management Standard 2008

Severity Assessment Code 1, an event where death or likely permanent harm is not reasonably expected and results from incorrect management of medications. This event requires notification to management of the District. Where the act is determined to be "Blameworthy"[31] any Root Cause Analysis ("RCA") process stops. If there is a death then it would be reportable to the Coroner, but there appears to be no other process set out in that policy that determines when the Police should be called, if there is not a death or what happens when the RCA is stopped.

120. Dr Brandon stated that from his perspective he would seek legal advice about the incident to guide them through the legal process. He agreed that in using lawyers from the hospital's panel there may be the possibility of a conflict of interest and that someone more independent may be appropriate in those circumstance. As a matter of wider policy a recommendation that an independent person or body be established to make appropriate decisions is unlikely to be accepted due to a variety of reasons and in any event may not have been able to produce a much different result in this case.

121. One criteria is to consider the seriousness of the end result as being the trigger but that leaves out causation. Serious consequences related to health care occur daily but that may not necessarily mean someone is to blame either civilly or criminally. RCA processes are better suited to those incidents than a police investigation. The trigger that possibly should be considered as a policy in the wider health area is that the police be called where there is an incident, such as incorrect management of medications, which has caused a possible permanent injury or death and where some blameworthiness, including possible criminal consequences, are being considered. Such an event should be reported to an appropriate senior staff member such as the Director of Medical Services. If the preliminary evidence supports that a blameworthy act has taken place, then police should be called. There is still somewhat of a judgment call to be made as to what constitutes or is likely to constitute such an act, but at least the process is known and established and may result in an earlier investigation taking place. If the police investigation does not establish evidence to support a criminal charge, then the investigation reverts to the hospital to be completed as a RCA.

Changes to Hospital Policies

122. I have considered the policies of St Andrews Hospital. RN Hambrecht, detailed those in her statement. After the events of September 2006 the hospital reviewed

[31] Defined in the *Standard and in the Health and Other Amendment Act* 2007 as an intentional unsafe act, or deliberate patient abuse or conduct that constitutes a criminal act.

its security and swipe card access and developed a new policy which tightens medication room and swipe cards access[32]. Ms Hambrecht stated that there is now over 90% compliance. Since the policy was implemented each ward has 5 swipe cards allocated for agency staff and it has been over 12 months since a card has had to be replaced or deactivated.

123. The hospital also developed a new policy for Dispensing of Medication on Discharge[33] as some of the insulin found on the ward belonged to another patient who had been discharged. The hospital pharmacy is now owned and run by the hospital which controls this process. The policy appears to be appropriate.

124. The practice of preparing medication well in advance and cross checking of medication was one which caught RN Hambrecht by surprise when she first heard about it in evidence. There was some justified criticism that the hospital was unaware of the practice and that it was still unaware 2 years later until it came out in evidence. The existing policy was revised in January 2009[34] which sets out "*that the person who prepares the drug and checks the expiry date must be the person who administers the drug*". RN Hambrecht stated that this was with the intention that it would be given when it is prescribed. I am not altogether sure whether that clearly sets out the principle that it is not best practice to prepare or check medications some time in advance of administration and perhaps that could be made clearer. Ultimately the policy is important but of greater importance is the message that is disseminated and the auditing to ensure compliance. I understand that the intent of the policy has been raised at ward meetings and is audited by after-hours coordinators.

Findings required by section 45

125. I am required to find, as far as is possible, who the deceased was, when and where she died, what caused the death and how she came by her death. As a result of considering all of the material contained in the exhibits and the evidence given by the witnesses I am able to make the following findings in relation to the death of Mrs Johnston:

(a) The identity of the deceased was Margaret Allan Johnston
(b) The place of death was St Andrews War Memorial Hospital, 457 Wickham Terrace, Brisbane

[32] Attachment 6 to the statement of Ms Hambrecht, Director of Nursing, exhibit D25B
[33] Attachment 10 to the statement of Ms Hambrecht, Director of Nursing, exhibit D25B
[34] Clause 4.5.2 in attachment 13 to the statement of Ms Hambrecht, Director of Nursing, exhibit D25B

(c) The date of death was 2 December 2006.

(d) Mrs Johnston died as a result of a combination of hypoglycaemic brain damage and cerebral vascular accident. The hypoglycaemic brain damage occurred as a result of the administration of two doses of insulin, one on either the evening of 2 September or the morning of 3 September and one on either the evening of 3 September 2006 or the early hours of 4 September. Either coincidentally or because of the insult to her brain from the hypoglycaemic damage Mrs Johnston suffered two cerebral strokes. Mrs Johnston would have been predisposed to cerebral infarcts given her past medical history and clinical presentation. It is not possible to be precise about the extent of the effect of either of these events towards her ultimate demise. In any event, her hypoglycaemic brain damage would have been a significant factor in her failure to revive.

126. The formal cause of death was:

1(a). Complications from hypoglycaemic brain damage and cerebral vascular accident.

Other significant conditions

2. Coronary atherosclerosis

Concerns, Comments and Recommendations

127. Section 46 of the Act provides that a Coroner may comment on anything connected with a death that relates to public health or safety, the administration of justice or ways to prevent deaths from happening in similar circumstances in the future. St Andrews War Memorial Hospital has reviewed and amended many of its written polices as a result of the death of Mrs Johnston and should be commended for taking that action. It is more important that the policies are adequately audited for compliance and that staff understand the intent behind such policies.

128. I recommend the hospital clarify the intent behind the amendment to its policy Medication – Prescribing, Dispensing, Checking, Administration, Documentation and Storage General Guidelines, clause 4.5.2, as it is not immediately clear to me how that addresses the criticised practice that was identified.

129. I also recommend that the hospital adopt a policy which provides that any adverse event which is identified as may be constituting a blameworthy act such as an intentional unsafe act, or deliberate patient abuse or conduct that constitutes a

criminal act, and which may result in death or permanent injury, be reported immediately to a senior person (such as the Director of Medical Services), who, if satisfied that the incident meets that criteria, will immediately report the incident to the police.

Finally, I offer my condolences to Mr Johnston and the family of Mrs Johnston for their loss. I now close this inquest.

John Lock
Brisbane Coroner
20 November 2009