Scottish Parliament Region: Lothian

Case 200402209: Lothian NHS Board

Summary of Investigation

Category

Health: Hospital; Neuroradiology

Overview

Mr C was admitted to the Western General Hospital, Edinburgh, after suffering a brain haemorrhage. On the following day, during the Consultant Neuroradiologist's attempt to clot the blood vessels, the catheter ruptured and glue escaped which caused Mr C to have a stroke.

Specific complaints and conclusions

The complaints which have been investigated are that:

(a) the cause of the rupture was that the syringe containing the glue was pushed too hard, causing too much pressure on the catheter (*not upheld*);
(b) the risk of the catheter breaking and the risk associated with the use of that particular catheter were not disclosed to Mr C (*partially upheld*);
(c) Mr C was not informed of alternative treatments available to him (*upheld*);
(d) Mr C was not allowed a cooling off period to make a decision about treatment (*upheld*);
(e) Mr C's consent to the procedure was inadequately documented (*upheld*);
(f) the incident was not properly recorded or investigated (*not upheld*);
(g) the explanation of what had happened given to Mr C and his wife was inadequate (*no finding*); and
(h) Lothian NHS Board (the Board) whitewashed the incident (*not upheld*).

Redress and recommendations

The Ombudsman recommends that the Board:

(i) provide her with details of the outcome of their review of their current consent policy, taking into account 'A Good Practice Guide on Consent for Health Professionals in NHS Scotland' issued by the Scottish Executive[1]

[1] On 3 September 2007 Scottish Ministers formally adopted the title Scottish Government to replace the term Scottish Executive. The latter term is used in this report as it applied at the time of the events to which the report relates.

on 16 June 2006, especially for neurosurgical and radiological interventions;

(ii) advise her of the outcome of their review of their Incident/Near Miss Reporting and Investigation procedure;

(iii) take steps to ensure that where explanations are given in situations such as this they are properly recorded; and

(iv) apologise to Mr C for the shortcomings identified in this report.

The Board have accepted the recommendations and will act on them accordingly.

Main Investigation Report

Introduction

1. Mr C had been suffering from headache, nausea and neck stiffness for some eight days, when he was admitted to Stirling Royal Infirmary. CT scanning disclosed a brain haemorrhage and Mr C was transferred to the Western General Hospital (the Hospital) the same day, where a cerebral angiogram revealed an arteriovenous malformation (AVM) on the right side of his brain. He was discharged home and arrangements were made to re-admit him. On 19 November 2002, two Consultant Neuroradiologists attempted to clot the blood vessels using 'glue' (embolisation procedure) dispensed through an Ultraflow catheter. During the procedure, the catheter ruptured and glue blocked the right vertebral and right posterior cerebellar arteries. This caused Mr C to have a stroke two days later, involving sensory changes on one side of his face and body, swallowing difficulties and dizziness.

2. On 4 May 2003, Mr C complained to Lothian NHS Board (the Board), raising many areas of concern to him. The patient liaison officer responded to Mr C's complaint but he remained dissatisfied with the response and requested Independent Review2. The Convener passed this back for local resolution and a meeting was held in Mr C's house. Mr C criticised the accuracy of the Board's report of the meeting and again asked for Independent Review, submitting a 13-page letter itemising his concerns.

3. The Convener agreed that an Independent Review should be arranged and sought advice from two neuroradiologists and a neurosurgeon from outwith NHS Lothian. This took some time and Mr C complained about the delay, although the Convener's office had warned Mr C that such a delay was likely, due to the difficulty of obtaining advice from specialists in neuroradiology who were impartial. Mr C agreed to the terms of reference for the Independent Review Panel (IRP) but also said that he wished all of the matters in his 13-page submission to be considered.

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[2] Independent Review was part of the NHS complaints procedure at that time. A Convener, usually a non-executive director of the NHS Board concerned, dealt with requests for Independent Review. The procedure changed in April 2005 and Independent Reviews are no longer held.

4. The Independent Review was held on 9 January 2005 and a draft report sent to Mr C on 15 February 2005. Mr C responded with a letter criticising the report's accuracy and thoroughness and making his own recommendations. The Convener consulted his IRP colleagues but decided that no changes were required.

5. Mr C submitted his complaint to the Ombudsman on 8 March 2005 and I very much regret that, for a variety of reasons, our consideration of this complaint has taken much longer than it should have done. For that I apologise sincerely, both to Mr C and to the Board.

6. The complaints from Mr C which I have investigated are that:

(a) the cause of the rupture was that the syringe containing the glue was pushed too hard, causing too much pressure on the catheter;
(b) the risk of the catheter breaking and the risk associated with the use of that particular catheter were not disclosed to Mr C;
(c) Mr C was not informed of alternative treatments available to him;
(d) Mr C was not allowed a cooling off period to make a decision about treatment;
(e) Mr C's consent to the procedure was inadequately documented;
(f) the incident was not properly recorded or investigated;
(g) the explanation of what had happened given to Mr C and his wife was inadequate; and
(h) the Board whitewashed the incident.

7. In his complaint to the Ombudsman, Mr C was critical of the NHS complaints process. He expressed his dissatisfaction over the way his concerns were dealt with and, in particular, the delays in dealing with his complaints. However, in April 2005, the NHS complaints process completely changed, partly to progress complaints more quickly. In view of this, I considered there was no added value in investigating Mr C's specific concerns about how his complaints were handled.

8. In his letter to the Convener dated 15 February 2005, Mr C asked that all of his concerns were dealt with. After taking advice I am satisfied, however, that Mr C's concerns about other matters raised in that letter, including his concerns about the nursing staff and ward cleanliness, were sufficiently dealt with at local resolution level by the Board. I, therefore, did not investigate those matters.

Investigation

9. In order to investigate Mr C's complaints I had access to the documents sent by him, Mr C's clinical records and the correspondence in connection with his complaint. I have obtained advice from a clinical adviser to the Ombudsman (the Adviser) and from a nursing adviser (the Nursing Adviser). My findings are based on the advice I have received.

10. I have not included in this report every detail investigated but I am satisfied that no matter of significance has been overlooked. An explanation of the abbreviations used in this report is contained in Annex 1. A glossary of the medical terms used in this report can be found in Annex 2. Mr C and the Board were given an opportunity to comment on a draft of this report.

(a) The cause of the rupture was that the syringe containing the glue was pushed too hard, causing too much pressure on the catheter

11. Mr C's procedure was carried out by two Consultant Neuroradiologists, one operated the catheter (Consultant 1), the other acted as his assistant by inserting the catheter (Consultant 2). Mr C said that the expert report obtained by the Board concluded that the catheter ruptured because it was over pressurised. Mr C considered that could only happen in one way and that was that Consultant 1 put too much pressure on the syringe supplying the catheter with glue. He concluded that the cause was, therefore, human error.

12. The Board arranged for the catheter to be sent for examination by a Medical Device Consultant. In his report, this expert explained the procedure for using the catheter. He said that, in order to administer substances through the catheter in a reasonable time, it is necessary to apply rather high pressures to the syringe. The expert said that he could find no manufacturing defect in the catheter. He said that the rupture had been caused by excess pressure but he suggested two possible reasons for that: either that premature polymerisation occurred and caused blockage of the catheter; or the catheter became kinked. The expert said that premature polymerisation can occur even when the preparation of the glue is done correctly. Kinks are sometimes not seen under fluoroscopic imaging. He could not tell whether the rupture had occurred before or after polymerisation of the glue so he could not say which of these scenarios was the more likely. The expert said that his findings did not point to the cause of the rupture being poor performance on the part of the neuroradiologists who performed the procedure.

13. The IRP said that the rupture of the catheter was a recognised and rare complication of the procedure. They agreed that the catheter had ruptured during the procedure but accepted the view of the expert who wrote the report.

(a) Conclusion

14. Mr C, the Board and the expert all agreed that the catheter ruptured and that the rupture was caused by the pressure inside the catheter. The expert considered, however, that the build up of pressure was caused either through the catheter becoming blocked or kinked. I note that the expert specifically said that his findings could not prove a bad performance by the neuroradiologist who carried out the procedure. Having considered the matter carefully, I have not seen evidence that the rupture was caused by human error. In all of the circumstances, I do not uphold this complaint.

(b) The risk of the catheter breaking and the risk associated with the use of that particular catheter were not disclosed to Mr C

15. Mr C obtained information from the internet, which indicated that there had been previous problems with other catheters rupturing during procedures and they had been withdrawn from use in other countries. He considered that he should, therefore, have been told of the risk associated with that particular catheter.

16. The Board have advised me that the effects of catheter rupture are covered under the risks of stroke when obtaining consent. They have commented that it is probably the least common of all of the causes of stroke which include thrombosis, air embolus and dissection. They said that during consent the risk of stroke was explained, however, there was no record of the discussion or that potential complications were explained when consent was obtained. There were diagrams drawn on the back of the consent form which the Board stated clearly indicated that there had been a detailed discussion of the technique, as well as associated risk of stroke. However, at a meeting in Mr C's house on 7 December 2003, attended by Mr and Mrs C, Consultant 1 and two other senior members of the Board, Consultant 1 agreed that he had not mentioned the possibility of the catheter rupturing to Mr C as he considered that the risks were too low. (I have been provided with the minute of this meeting.)

17. As part of the IRP, two neuroradiology assessors who were independent of the Board reviewed this issue and wrote a report. They said that catheters involved in rupture incidents (Flowrider HPC) had been withdrawn by the manufacturers during 2000 and early 2002. The upgraded model, MTI Ultraflow HPC, had been used by the Hospital since early 2002 without incident. The Ultraflow catheter is one of the most commonly used microcatheters for glue embolisation of AVM. It was one of two catheters available at that time. The Assessors had contacted the manufacturers of the catheter, who said they had withdrawn the Flowrider catheter from the market after they introduced Ultraflow. The design of the Ultraflow catheter is completely different from the Flowrider catheter and is not a modification of the latter. They confirmed that the Ultraflow catheter had never been withdrawn from any market in the world.

18. The IRP considered the Assessors' report. They concluded it was unnecessary to disclose to Mr C problems associated with equipment which had been withdrawn approximately a year prior to his operation.

19. The Adviser noted that the Consultants involved in Mr C's operation said at the IRP that they would not have given details to a patient about problems with a catheter they had stopped using. Although they themselves had not had any problems with the catheter used in Mr C's procedure, they would mention the rare complication of rupture and glue leakage. In the Adviser's opinion, that is a reasonable position.

(b) Conclusion

20. It is vital that patients receive sufficient information to allow them to make an informed choice before undergoing any procedure. It is clear from the evidence that an earlier catheter involved in rupture incidents had been withdrawn from the market and the catheter used in Mr C's procedure was a model of a different design. Information relating to the earlier model would, therefore, not be relevant and it would not be necessary to give this information to Mr C. The Neuroradiology Assessors confirmed that the catheter used in Mr C's procedure had not been withdrawn from any market. Consultant 1 and Consultant 2 said that, although they themselves had not had any problems with the catheter used in Mr C's procedure, they would mention the rare complication of rupture. The advice I have received is that it would be reasonable for the risk of the catheter rupturing to be mentioned. While the Board have referred to the diagram on the back of the consent form as demonstrating that the potential complications were explained, Consultant 1

said at the meeting in Mr C's house on 7 December 2003, that he had not mentioned the possibility of the catheter rupturing to Mr C as he considered that the risks were too low. Taking all this into account, and given the lack of an actual record of what was discussed when consent was obtained, I have decided to partially uphold this complaint, to the extent that Mr C should have been told about the possibility that the catheter could break but was not. I am also concerned about the lack of an actual record of what was discussed and the Ombudsman, therefore, has the following recommendations to make.

(b) Recommendation

21. The Ombudsman recommends that the Board;

(i) apologise to Mr C for the shortcomings identified; and

(ii) review their current protocols for consent and recording of consent in line with 'A Good Practice Guide on Consent for Health Professionals in NHS Scotland' issued by the Scottish Executive on 16 June 2006, especially for neurosurgical and radiological interventions and inform the Ombudsman of the outcome of this review. (please also refer to paragraphs 39 to 41.)

(c) Mr C was not informed of alternative treatments available to him

22. Mr C's discharge letter from his previous stay in the Hospital stated that he would be re-admitted in six weeks time for super-selective angiography, prior to a decision being made about further management. (Super-selective angiography is used to determine if a patient is suitable for embolisation.)

23. Mr C said that when he was re-admitted to the Hospital he understood that he was being admitted for further investigation of his condition, prior to a decision being made about his treatment. After admission, he was asked to consent to the embolisation procedure. The other options for his treatment, surgery, stereo-tactic radiosurgery or doing nothing, were not mentioned to him. He, therefore, did not have the opportunity to choose his treatment. Mr C had subsequently successfully undergone stereo-tactic radiosurgery in September 2003 in Sheffield.

24. As stated in paragraph 16, there is no written record of what was discussed when Mr C was asked to consent to the embolisation procedure, although Consultant 1 had drawn some diagrams on the back of the form.

25. At the IRP meeting, Consultant 1 said that it was his normal practice to cover the various options but as Mr C had been referred to him by a

neurosurgeon he may not have mentioned surgery as an option in this case. There was limited discussion of radiotherapy. Consultant 1 said that embolisation was his preferred option.

26. Consultant 2 said that all patients now pass through a multi-disciplinary clinic where the various options are discussed. That procedure, however, did not exist at the time of Mr C's treatment.

27. The Adviser said that Consultant 1 should have discussed all of the treatment options with Mr C and recorded what he told him. In his view, the entries in the nursing records did not demonstrate this.

28. The IRP said it was not clear whether alternative treatments were covered in any detail. When responding to my draft report, the Board pointed to an entry in the nursing notes dated 9 September 2002, which was prior to Mr C's initial discharge. The entry reads 'Angiogram today showing AVM. Spoken to by Registrar this evening (Dr …) regarding possible treatments'. In the Board's view this showed that Mr C was spoken to about his treatment options which they said were further discussed at an x-ray meeting the following day. An entry in the nursing records for 10 September reads 'to be discussed at x-ray meeting re treatment plan'.

29. A guide to consent to examination, investigation, treatment or operation published by the Scottish Health Department in 1992 states that:

> 'Patients are entitled to receive sufficient information in a way that they can understand about the proposed procedure, the possible alternatives and any substantial risks so that they can make a balanced judgement.'

(c) Conclusion

30. The advice I have received is that Consultant 1 should have discussed all of the treatment options with Mr C, including the likely consequences of doing nothing but Consultant 1 does not recall doing this. While the nursing notes record that Mr C was spoken to regarding possible treatments, there is no record of what Mr C was actually told. In all of the circumstances, I uphold this complaint. I note, however, that all patients now pass through a multi-disciplinary clinic where the various options are discussed with them and the recommendation at (b) is also relevant. The Ombudsman, therefore, has no further recommendations to make.

(d) Mr C was not allowed a cooling off period to make a decision about treatment

31. Mr C said that, when he was re-admitted to the Hospital, he expected to have tests. Instead, Consultant 1 met him with a pen and a consent form for the embolisation procedure. Mr C thought that he should have had a cooling off period to consider the procedure.

32. The Consultant Neurosurgeon, who is independent of the Board and who wrote a report for the IRP, said that he would have emphasised to Mr C that there was no urgency to make a decision but that the decision should be taken within weeks rather than months.

33. The Adviser said that it may have been the case that Consultant 1 and Consultant 2 wanted to get on with Mr C's treatment but, as it was not clear that they had discussed all the treatment options with Mr C and recorded this, in his view they had clearly cut short the usual two-stage procedure. The Adviser said that Mr C should have been given at least a day or two to think about it, as there is generally no urgency for the procedure to take place. That is the usual practice among specialists in the field of arteriovenous malformation (AVM).

34. When responding to my draft report, the Board advised that Mr C was initially admitted on 8 September 2002. They commented that, after a discussion concerning the treatment options (see paragraph 27), Mr C was readmitted six weeks later on 18 November 2002 for selective angiography. The Board, therefore, contended that Mr C had a six-week cooling off period.

(d) Conclusion

35. Mr C's procedure was not done on an emergency basis and the advice I have received is that Mr C should have been given enough time to consider matters. While the Board contend that Mr C was advised of the treatment options, there is no record of what Mr C was actually told and the Adviser's view is that that the consultants cut short the two stage process. I have to be guided by the advice I receive and on this basis I uphold this complaint. I note, however, that all patients now discuss treatment at the multi-disciplinary clinic prior to being admitted which means that there is, now, a cooling off period. The Ombudsman, therefore, has no recommendations.

(e) Mr C's consent to the procedure was inadequately documented

36. Mr C said that it was unacceptable that there were no written notes of the meeting he had with Consultant 1 when his consent was obtained prior to the embolisation procedure. He found it very difficult to accept that a Consultant Neuroradiologist would not write anything down.

37. At the IRP, Consultant 1 said that his current practice had changed, in that appropriate notes were now recorded on patient records.

38. The IRP said that it was regrettable that there was no record of what was said at the meeting. It recommended that standard practice includes appropriate notes and explanations on the consent form. The Adviser said that Consultant 1 should have recorded what he told Mr C but he did not.

39. When commenting on the draft report, the Board stated that the consent procedure was documented in line with guidelines at the time and in line with the neurosurgical consent as practiced in the Department of Clinical Neurosurgery in 2002. While they noted the recommendations in the draft report, they had been compliant with the main recommendations in the 2006 guidelines (see paragraph 21) for some time. Their current policy document was due to be reviewed and they provided me with a copy of their current policy. They were concerned that, although events had occurred in 2002, they were being judged against a more recent document which included significant changes in practice.

(e) Conclusion

40. I require to be guided by the advice I have received and I, therefore, uphold this complaint although I note that Consultant 1 has now changed his practice. I am satisfied that the advice I received in relation to this issue was based on what the Adviser considered to be a reasonable standard at that time, however, I am pleased to note the work that has been done by the Board on their consent policy.

(e) Recommendation

41. The Ombudsman recommends that the Board provide her with details of the outcome of their review of their current consent policy. (This takes into account the recommendation at paragraph 21)

(f) The incident was not properly recorded or investigated

42. Mr C said that the Incident Report Form was not completed until 22 November 2002, three days after the event. In response to his original complaint, the General Manager said on 17 July 2003 that the cause had not been determined. It was not until 4 June 2004 that the expert provided the report on the catheter (paragraph 12 refers).

43. The IRP accepted that the investigation had not proceeded with the urgency appropriate to such an incident. It recommended that Incident Report Forms be completed timeously.

44. The Chief Executive said that Mr C's condition was evolving following the rupture of the catheter and to have completed the Incident Report Form earlier would have led to an erroneous picture, underplaying the importance of the incident. A full report of the incident was sent to Scottish Healthcare Supplies on 25 November 2002, who replied on 28 November 2002 that they did not intend to investigate. The Board were unable to persuade Scottish Healthcare Supplies to undertake any further investigation and, therefore, made their own arrangements to commission an independent expert to report on the catheter.

45. When the Board commented on a draft of this report they provided me with correspondence in connection with the ruptured catheter. Scottish Healthcare Supplies acknowledged receipt of the adverse incident report on 28 November 2002 but said that they did not intend to mount a full investigation at that time. They said that the incident would, however, be recorded and reported to the manufacturer/supplier. They said that they would continue to monitor the situation and would appreciate being informed of any recurrence of the problem. Scottish Healthcare Supplies later said that they would investigate the matter and started to do so on 5 December 2002 but, on 28 April 2003, Scottish Healthcare Supplies decided not to pursue the matter further as they were unable to reach a conclusion and an independent testing house could not be found to test the device. Consultant 1 gave Scottish Healthcare Supplies details of the independent tester but the matter was not pursued.

46. The Board also commented that the Board's Incident/Near Miss Reporting and Investigation Procedure was revised in June 2004 and had a review date for June 2007. The procedure does not specify a specific time frame in which an incident report should be completed but does state that this should happen

'as soon as possible'. The Board also provided details of the procedures as contained in this policy document.

47. I asked the Ombudsman's Nursing Adviser to consider this issue. She has indicated that, as the situation was evolving, it was reasonable to wait before filling in the Incident Report Form, providing that was done as soon as the situation became clear.

(f) Conclusion

48. It is clear from the evidence that the Incident Report Form was not completed until 22 November 2002. The advice I have received, however, is that was reasonable in the circumstances of this case. From the correspondence supplied by the Board, it is clear that attempts were made to have the reason for the rupture investigated to a conclusion by Scottish Healthcare Supplies but those attempts were not successful. The Board then commissioned the expert's report. I accept that it was reasonable to wait to see the results of the Scottish Healthcare Supplies investigation before commissioning the expert's report. I, therefore, do not uphold this complaint.

(f) Recommendation

49. The Ombudsman recommends that the Board advise her of the outcome of their review of their Incident/Near Miss Reporting and Investigation procedure.

(g) The explanation of what had happened given to Mr C and his wife was inadequate

50. Mr C said that both Consultant 1 and Consultant 2 had not been available to speak to his wife in the hours between his procedure and the stroke occurring and the explanation given to him had been inadequate.

51. In the initial response to his complaint, the General Manager said that Consultant 2 would have been very willing to speak to Mr C's wife but when he attended Mr C she was not there. A specific request was made for a meeting on 20 November but unfortunately when the neuroradiologist saw Mr C his wife was not present.

52. When commenting on the draft report, the Board made reference to three entries in the clinical records which record communication surrounding this as detailed below:

- 19/11/02 (day of the procedure) Consultant 1 will see patient at 17:20
- 20/11/02 Mr C has forgotten what doctors told him yesterday
- 20/11/02 Consultant 2 'Explained technical complication again in simple terms'

53. They advised that every attempt was made to explain to Mr C and his wife what happened and there was no attempt at any time to hide that there had been a technical problem.

54. The Adviser said that, while Consultant 2 recorded on 20 November 2002 that he had 'explained technical complication again today in simple terms', he had not made any record of any previous discussion. Nor was it clear from the recorded entries above what Mr C was told at the time. In the first response from the Board, it was stated that Consultant 2 had explained to Mr C and that was recorded in the notes but the Adviser could not find such information in either the medical or the nursing notes. The Adviser said that it was not clear what Mr C was told after the event.

(g) Conclusion

55. It is important that full explanations are given, especially if something unexpected in the delivery of care and treatment has happened. While I am satisfied that there is no evidence to suggest that the Board at any time attempted to hide that there had been a technical problem, clearly Mr C was not satisfied with the explanation he received. There is evidence of explanations being provided in the records but because these explanations were not fully recorded I am unable to make a finding on the adequacy of these explanations.

(g) Recommendation

56. The Ombudsman recommends that the Board take steps to ensure that where explanations are given in situations such as this they are properly recorded.

(h) The Board whitewashed the incident

57. Mr C said that he regarded the way that his complaints were dealt with as a cover-up. He regarded the IRP as a whitewash. I, therefore, asked the Adviser to consider this when giving me advice on the medical aspects of the complaint.

58. The Adviser said that the IRP was conducted according to national guidelines and its conclusions were reasonable. It was also reasonable that the IRP confined itself to the terms of reference which Mr C agreed, as the other matters raised by Mr C had been dealt with already. The Adviser said that it would have been helpful to have clarified with Mr C in advance that the IRP would only look at those issues. The Adviser said that there is no evidence that the Board or the doctors involved tried to cover up either the procedure or their actions afterwards.

(h) Conclusion

59. The IRP's findings were similar to what I found in investigating Mr C's complaints. I, therefore, cannot find other than that the IRP carried out their task appropriately. I do not uphold this complaint.

60. The Board have accepted the recommendations and will act on them accordingly. The Ombudsman asks that the Board notify her when the recommendations have been implemented.

Annex 1

Explanation of abbreviations used

Mr C	The complainant
The Hospital	Western General Hospital
AVM	Arteriovenous malformation
The Board	Lothian NHS Board
IRP	Independent Review Panel
The Adviser	Clinical Adviser to the Ombudsman
The Nursing Adviser	Nursing Adviser to the Ombudsman
Consultant 1	The Consultant Neuroradiologist who operated the catheter
Consultant 2	The Consultant Neuroradiologist who inserted the catheter

Annex 2

Glossary of terms

Arteriovenous malformation (AVM)	A tangle of abnormal blood vessels liable to rupture and cause haemorrhage
Catheter	A tube for moving fluid in the body
Cerebellar	Part of the brain concerned primarily with motor function, the control of muscle tone and the maintenance of balance
Cerebral angiogram	A diagnostic procedure to visualise blood vessels in the head following introduction of a contrast material into an artery
Embolisation	Clotting
Fluoroscopic imaging	An x-ray procedure that makes it possible to see internal organs in motion
Glue	Embolisation fluid, in this case Glubran -2
Polymerisation	Hardening
Scottish Healthcare Supplies	A Division of the Common Services Agency
Stereo-tactic radiosurgery	Treatment with focused radiation
Stroke	A condition due to the lack of oxygen to the brain
Super-selective angiography	A radiographic technique used to image blood vessels in the brain where a radio-opaque (shows up on x-ray) contrast material is injected into a blood vessel for the purpose of identifying its anatomy on x-ray