IST-3 Perfusion and angiography studies: Image acquisition and analysis protocol.

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Version: 4

Aim:

To determine whether imaging "mismatch" should be used to decide whether patients should receive rt-PA or not we will :
a) establish a core of interested physicians and radiologists in IST-3 to guide the proposed advanced imaging substudy, inform and participate in the analysis and prepare manuscripts for publication and presentation, and
b) address the following questions:

i) do acute ischaemic stroke patients with imaging evidence of tissue at risk (mismatch) on either CT with CTP or MR DWI/PWI, have a) less infarct growth and b) better functional outcome if treated with rt-PA than do patients without mismatch?

ii) which perfusion parameter (cerebral blood flow, cerebral blood volume or mean transit time), processing method (qualitative, quantitative) and threshold best predicts a) infarct growth at 24 hours and b) poor functional outcome at six months?

iii) can we clarify what imaging features on plain CT or MR DWI differentiate viable from non-viable tissue?

Ultimately we will contribute the IST-3 perfusion data to the Stroke Imaging Repository (STIR), an international multicentre project which aims to standardise stroke perfusion imaging.

Methods:

1) Acquisition

   Due to the diverse range of scanners involved in the IST3 perfusion sub-study, it will not be possible to completely harmonise the acquisition parameters used for the individual patient examinations. However, certain guidelines and operating procedures can be identified that will ensure that the data collected can be post processed in a standard way. These recommendations are drawn from those published as a result of consultation between leading stroke research centres and included groups in America, Europe and Japan[1], modified by experience in IST-3 centres participating in related multicentre acute stroke imaging studies, and knowledge of key factors determining image quality.[2] These recommendations are reproduced from the cited reference in tables 1 - 3 below. It would be desirable to use the same modality for both pre-randomisation and follow-up imaging from the same subject. However if for technical or practical reasons this is not possible, mixed CT and MR acquisitions (eg CT pre-randomisation and MR follow-up) are acceptable.

   In addition to the diffusion/perfusion MRI or perfusion CT series, any structural MRI (GRE, T2, FLAIR) or CT (spiral CT, etc) sequences acquired at the same time should be included. These are used for registration between time points and as independent indications of final lesion extent. For CT, spiral CT is to be preferred over CT MPR data or sequential axial CT acquisitions with thick slices. Suggested spiral CT acquisition parameters are given in Table 4.

   If angiography (either MR or CT) have also been acquired, these should be submitted as well. In the case of the structural and angiographic series, the manufactures default settings usually produce usable data – as an example, in Table 5 we have included some of the acquisition parameters used for CTA and MRA in the Neuroradiology Department at our hospital.

2) Submission

   The individual IST3 centres involved in the perfusion sub-study are already submitting imaging and other data via the various submission processes available. We require original electronic DICOM (scanner output) data in order to process the perfusion and angiographic data. The preferred electronic image data transfer mechanisms include CD, web upload, and FTP. Sending as an email attachment is possible but NOT optimal. Otherwise no change to these mechanisms is required to handle the increased volume of data represented by the perfusion or DWI or angiographic data. The IST-3 imaging

technician can advise if there are any concerns (eleni.sakka@ed.ac.uk)

3) Collation
The main IST3 image data management system will be used to identify appropriate DICOM studies as they pass through the existing anonymisation processes. These examinations will then be passed onto a separate data management system which will be used to handle the data of the perfusion sub-study. As part of the transfer process, a database is populated in order to track the individual examinations within the study and their stage in processing. Periodically, the meta-data stored in the database will be used to query the main IST3 archive in order to identify any DICOM studies containing perfusion/diffusion series that may not have been transferred.

4) Analysis
Direct comparison of perfusion parametric maps produced using manufactures proprietary software between centres is problematic. However, in the current study these issues are addressed by standardising central processing and by using time based measures of cerebral perfusion such as Time to Peak (TTP), which may be more reproducible as well as correlating with outcome.[3,4] However a main aim of the IST-3 perfusion analysis is to explore use of a range of perfusion parameters including further validation of parameters found to identify salvageable tissue accurately in previous studies (systematic review ongoing). See Table 6 for draft list of parameters to be tested, pending final results of systematic review of perfusion imaging in stroke and full discussion amongst the IST-3 Perfusion and Angiography Studies Steering Group (Appendix 1). See Appendix 2 for full list of definitions of lesions.

The primary processing of the data (to produce calculated perfusion/diffusion maps and measure lesion volumes) will be carried out using applications from the FMRIB software library (FSL) suite (FMRIB, Oxford, UK,[5,6]), the Perfusion Mismatch Analyser (PMA) (ASIST, Japan,[7,8]) and existing in-house software. Secondary analysis required to answer the scientific question (Regions of interest, Volumes, etc) will be produced using Analyze (http://www.analyzedirect.com/) but will be stored in published formats (DICOM, NIFTI) or text documents encoded using ISO/IEC 646 as appropriate.

Analysis of diffusion/perfusion or CTP mismatch/deficit will also be performed by visual assessment to apply categorical scoring methods including the IST-3, 1/3 MCA and ASPECTS rating scales as per IST-3 extended scan reading proforma (see Appendix 3). This complements the information detected by measuring lesion volumes, is directly translatable to routine clinical practice, and will distinguish lesion volume increase due to increase in lesion extent from that due to increased swelling without any increase in extent. The angiographic images will be coded for the presence, location and degree of arterial occlusion using the Mori and TIMI scores.[9,10]

5) Persistence
Access to all the computer and storage systems used in the analysis and storage of the data are controlled by appropriate authority and authorisation systems, including anonymisation. The storage systems upon which the data are stored have high levels of redundancy to improve service continuity and are automatically backed up nightly to allow service recovery in the event of accidental or catastrophic loss. MD5 based checksums will be employed to ensure the integrity of the data and to log changes to files within the system. After completion of the project the data will be retained in their original form indefinitely using secure off site storage operated by University of Edinburgh Computing Service.

6) Publication
All papers will be published in the name of the IST-3 Collaborative Group, Perfusion and Angiography Imaging Study Subgroup (Appendix 1). The raw data and processed data from the IST3 perfusion project will be made available upon written (email) request to researchers or other appropriate individuals. These data will be published using electronic transfer mechanisms available within the Department of Clinical Neuroscience, the University of Edinburgh or any mechanism provided by the funder. These data will not be made available on physical media such as DVD. The availability of the data will be publicised via the IST3 newsletter/website, University of Edinburgh collections catalogue, the SINAPSE collaboration (www.sinapse.ac.uk), the STIR collaboration and any mechanisms provided by the funding body. Any such data made available will be fully, ambiguously and irreversibly rendered anonymous. All publications resulting from the analysis of the data collected will also be deposited with the publications archive.

Table 1. Recommended Acquisition Protocols for Perfusion-Weighted (PWI) MR Imaging

PWI	
Sequence	Single-shot gradient-echo echoplanar imaging
TR	TR = 1500 to 2000 ms
TE	TE=35 to 45 ms @ 1.5T TE=25 to 30 ms @ 3T
Flip angle	flip angle α =60 to 90° @ 1.5T, 60° @ 3.0T
Baseline	At least 10-12 Baseline images (please note the first few images prior to steady state are discarded)
Coverage	**At least 12 slices, with same slice thickness and gap as DWI, increase TR and slice gap to achieve reasonable coverage.**

Table 2. Recommended Acquisition Protocols for Diffusion-Weighted (DWI) MR Imaging

DWI	
Sequence	Single-shot spin-echo echoplanar imaging
TR	Should be at least 4000 ms (but can be larger)
TE	**Minimum achievable**
Diffusion weighting (b values)	**b=0 and 1000 sec/mm^2**
Coverage	**At least 10-12 slices, with same slice thickness and gap as PWI.**

Table 3. Recommended Acquisition Protocol for Perfusion-CT (PCT)

CTP	
Acquisition Rate	**1 image per second, (ideally at one source rotation per second)**
Total Acquisition Time	40 to 60 seconds
Base Line Period	**5-10 volumes should be acquired prior to contrast arrival**
Kvp and	**80 kVp (not 120 kVp)**
mAs	**100 mAs or higher**
Contrast Volume	**35-50 mL (with saline flush)**
Delivery Rate	**4-6 mL per second**
Coverage	As dictated by configuration of hardware

Table 4. Example Acquisition Protocol for Spiral CT

Spiral CT	
Kvp	120
mAs	310
slice collimation	0.75 mm
pitch	0.65
Gantry Rotation	Maximum
Table feed speed	less than 7.5mm per gantry rotation

Table 5. Suggested Acquisition Protocol for CT angiography (CTA) and MR angiography (MRA)

CTA	
Kvp	100
mAs	120
Contrast (volume/type/rate)	50ml Omnipaque 300 at 4ml/sec
Flush (volume/type/rate)	40ml saline at 4ml/sec
delay	15secs
coverage	circle of Willis (upwards)
slice collimation	0.75mm
pitch	1.25

MRA	
Sequence	3D TOF 2 slab HR
TR (ms)	23
TE (ms)	2.7
Flip angle	20°
Locs / slab	32
Slice thickness	1.6
Slice gap	0
Matrix	320 x 224
Φ FOV	1
FOV	16
Slice orient^{n}	Straight axial
Tscan	5:46

Table 6. Draft list of parameters to be assessed in central offline analysis (to be further refined in light of ongoing systematic review of perfusion imaging in stroke and on discussion with the IST-3 Perfusion and Angiography Studies Steering Group).

MR perfusion[4]	**CT perfusion**
Raw data	Raw data
rCBF	rCBF
rCBV	rCBV
rMTT (first moment)	rMTT (1.45)[11]
TTP (various thresholds)	TTP (1.4 wrt normal side)
Tmax plus 2 s as per EPITHET[13]	
Tmax plus 4 s as per EPITHET[13]	
ATF	ATF
CBFq	CBFq (including 12.7 mL/100 g/min)[12]
CBVq	CBVq (including < 2.2 mL/100g)[12]
MTTq	MTTq

7) References

1 - Max Wintermark, Gregory W. Albers, Andrei V. Alexandrov, Jeffry R. Alger, Roland Bammer, Jean-Claude Baron, Stephen Davis, Bart M. Demaerschalk, Colin P. Derdeyn, Geoffrey A. Donnan, James D. Eastwood, Jochen B. Fiebach, Marc Fisher, Karen L. Furie, Gregory V. Goldmakher, Werner Hacke, Chelsea S. Kidwell, Stephan P. Kloska, Martin Köhrmann, Walter Koroshetz, Ting-Yim Lee, Kennedy R. Lees, Michael H. Lev, David S. Liebeskind, Leif Ostergaard, William J. Powers, James Provenzale, Peter Schellinger, Robert Silbergleit, Alma Gregory Sorensen, Joanna Wardlaw, Ona Wu, and Steven Warach. Acute Stroke Imaging Research Roadmap. Stroke, 2008; 39: 1621 - 1628.

2 – Konstas AA, et al. Theoretical basis and technical implications of CT perfusion in acute ischaemic stroke, Part 1: Theoretical Basi. AJNR 2009;30:662-668.

3 - Takasawa P, et al. How reliable is perfusion MR in acute stroke?: Validation and determination of the penumbra threshold against quantitative PET. Stroke, Mar 2008; 39: 870 - 877.

4 - Kane I, Carpenter T, Chappell F, Rivers C, Armitage P, Sandercock P, Wardlaw J. Comparison of 10 different magnetic resonance perfusion imaging processing methods in acute ischemic stroke. Effect on lesion size, proportion of patients with diffusion/perfusion mismatch, clinical scores, and radiologic outcomes. *Stroke* 2007;**38**:3158-64.

5 - S.M. Smith, M. Jenkinson, M.W. Woolrich, C.F. Beckmann, T.E.J. Behrens, H. Johansen-Berg, P.R. Bannister, M. De Luca, I. Drobnjak, D.E. Flitney, R. Niazy, J. Saunders, J. Vickers, Y. Zhang, N. De Stefano, J.M. Brady, and P.M. Matthews. Advances in functional and structural MR image analysis and implementation as FSL. NeuroImage, 23(S1):208-219, 2004.

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7 - http://www.ajnr.org/cgi/content/abstract/ajnr.A1274v1

8 - Sasaki M, Yamada K, Watanabe Y, et al. Radiology 2008; 249: 624-630

9 – TIMI score *NEJM 1985;312:932-6*

10 – Mori score *Stroke 1988;19:802-812*

11 - Wintermark M, Flanders AE, Velthuis B, Meuli R, van Leeuwen M, Goldsher D, Pineda C, Serena J, van der Schaaf I, Waaijer A, Anderson J, Nesbit G, Gabriely I, Medina V, Quiles A, Pohlman S, Quist M, Schnyder P, Bogousslavsky J, Dillon WP, Pedraza S. Perfusion-CT assessment of infarct core and penumbra: receiver operating characteristic curve analysis in 130 patients suspected of acute hemispheric stroke. Stroke. 2006;37:979 –985.

12 - Schaefer PW, Roccatagliata L, Ledezma C, et al. First-pass quantitative CT perfusion identifies thresholds for salvageable penumbra in acute stroke patients treated with intra-arterial therapy. AJNR Am J Neuroradiol 2006; 27 :20 –25

13 - Davis SM, Donnan G, Parsons MW, Levi C, Butcher KS, Peeters A, Barber PA, Bladin C, De Silva DA, Byrnes G, Chalk JB, Fink JN, Kimber TE, Schultz D, Hand PJ, Frayne J, Hankey G, Muir K, Gerraty R, Tress BM, Desmond PM, for the EPIC Investigators. Effects of alteplase beyond 3 h after stroke in the Echoplanar Imaging Thrombolytic Evaluation Trial (EPITHET): a placebo-controlled radomised trial. *Lancet Neurol* 2008;**7**:299-309.

Appendix 1: IST-3 Perfusion and Angiography Imaging Studies Steering Group

JM Wardlaw :	IST-3 Imaging lead; Steering Committee Member; expert Image reading panel
PAG Sandercock :	IST-3 Co PI
RI Lindley :	IST-3 Co PI
V Murray:	IST-3 Sweden lead
Andre Peeters:	IST-3 Belgium lead; IST-3 Expert Image Reading Panel; EPITHET investigator
Mark Parsons:	IST-3 Australia centre lead; EPITHET investigator
Adam Kobayashi:	IST-3 Poland centre lead
R von Kummer :	IST-3 Expert Image Reading Panel
Anders von Heijn :	IST-3 Expert Image Reading Panel
Max Wintermark :	STIR PI
Geoff Donnan :	EPITHET Co PI
Steve Davis :	EPITHET Co PI
David Perry	IT manager, IST-3 programmer, SIRS programmer
T Carpenter :	IST-3 Perfusion imaging image analyst; STIR Investigator
F Chappell :	IST-3 Perfusion imaging statistical analyst
Eleni Sakka	IST-3 Image data management technician

Other IST-3 Trials office staff as per main protocol.

Appendix 2. Definitions

Definitions (note variables defined by both categorical and continuous methods:

CT lesion (baseline and 24 hr) -	Categorical – score on: IST-3; ASPECTS; (1/3 MCA)
	continuous – volume: visual outline; (query explore Hounsfield unit threshold on baseline scan and +6 HU on follow-up scan to delineate lesion extent)
DWI lesion (baseline) -	categorical – score on: IST-3; ASPECTS; (1/3 MCA)
	continuous – volume; visual outline
	ADC – less than 550 x 10^{-9} mm^2 per second threshold (Siemonson/Kidwell/Fiehler); (650 x 10^{-9} mm^2 per second threshold, pending results of in house study)
Lesion growth -	subjective (categorical) – difference in score between time points: IST-3; ASPECTS; (1/3 MCA)
	continuous – difference in lesion volume from baseline CT or DWI and 24 hr CT/MR.
Lesion swelling (24 hr) -	IST-3 scale (absolute and change from baseline)
Final infarct size (24 hours) -	T2/FLAIR/CT volume outline traced by visual assessment (not threshold)
	categorical – score on: IST-3; ASPECTS; (1/3 MCA)
PWI lesion (at baseline) -	MR – rCBF, rCBV, rMTT (first moment), TTP, Tmax (2 and 4 second threshold as per EPITHET)
	CT – CBV (less than 2 ml/100g), rMTT (1.45), TTP (1.4 wrt normal side), CBF (un thresholded)
	categorical estimate of above lesion sizes by ASPECTS, IST3, 1/3 MCA
	continuous: volume tracing according to above parameters and thresholds
'tissue at risk' -	refers to at risk but salvageable tissue, equating to other terms such as "penumbra" and "mismatch". Prefer, in the present context, to use "tissue at risk" as this is modality independent and more encompassing than either of the other two terms. The primary definition on MR is a ratio of perfusion to diffusion lesion volume of 1.2 (primary in EPITHET, DIFFUSE, and other studies); consider testing ratio of 2 also (secondary analysis in EPITHET).
	CT: difference between rMTT and CBV on thresholds defined above
Vessel patency:	defined on MRA or CTA by TIMI and Mori scores.
Reperfusion:	Improvement of one point or more on the TIMI score and/ or reduction in extent of perfusion lesion of 20% or more by volume or 1 point or more ASPECTS (or 1 category or more on IST-3 scores).

Note: results of systematic review to identify other thresholds awaited.

Appendix 3 Extended scan reading forms

IST-3 Perfusion and Angiography Studies

CT image interpretation form

PATIENT ID:

DATE OF READING: **DATE OF SCAN:**

SCAN QUALITY: Good ☐ Moderate ☐ Poor ☐ **Comment:**

READER ID:

TYPE OF SCAN:
(tick all that apply) **CT Plain:** ☐ **CTP:** ☐ **CTA:** ☐

TYPE OF PERFUSION AVAILABLE: **MTT:** ☐ **CBV:** ☐ **TMAX:** ☐

CBF: ☐ **TTP:** ☐ **Other:** ☐

Please tick Yes or No. Please do not leave blanks. Thank you.

1.	Are all the scan sequences completely normal?	**Y** ☐	**N** ☐	***If YES stop here***
2.	**Ischaemic Changes** Is there any sign of acute ischaemic change on any sequence? If in doubt as to whether acute or old, code as acute.	**Y** ☐	**N** ☐	***If No go to Q.7***
3.	Which side of the brain shows ischaemic change?	**R** ☐	**L** ☐	***Tick R and L if both***
4.	Classify signs of ischaemic change in the main lesions (if more than one recent lesion). (**see examples)**	**Y**	**N**	
	a) Loss of grey/white matter cortex definition.	☐	☐	**N/A**
	b) Loss of basal ganglia outline.	☐	☐	☐
	c) Hypodensity present (i.e. more than in a or b so that the lesion appears less dense than white matter).	☐	☐	

d) PWI lesion visible.
(tick one box for each row that applies). The 20% refers to volume.

	N	<20%<CT	Same as CT	>20%>CT
CBF	☐	☐	☐	☐
CBV	☐	☐	☐	☐
MTT	☐	☐	☐	☐
Raw data	☐	☐	☐	☐
TTP	☐	☐	☐	☐
Tmax	☐	☐	☐	☐
ATF	☐	☐	☐	☐
Other (blank to fill in parameters) _____	☐	☐	☐	☐
_____	☐	☐	☐	☐
_____	☐	☐	☐	☐
_____	☐	☐	☐	☐

5. Classify site and size of ischaemic lesion on plain CT **(see examples)**

a) site (enter most appropriate code in box)

1° ☐

2° ☐

M =MCA* = any lesion in the MCA territory
AS =Infarct of up to half of ACA territory
AL =Infarct of more than half of ACA territory
PS =Infarct of up to half of PCA territory
PL =Infarct of more than half of PCA territory
MAS=M+AS*
MAL=M+AL*
MPS=M+PS*
MPL=M+PL*
MAP=Infarct of whole MCA, ACA and PCA territories
L =Lacune*
B =Borderzone*
C =Cerebellum*
S =Brainstem*
CS =Cerebellum and brainstem

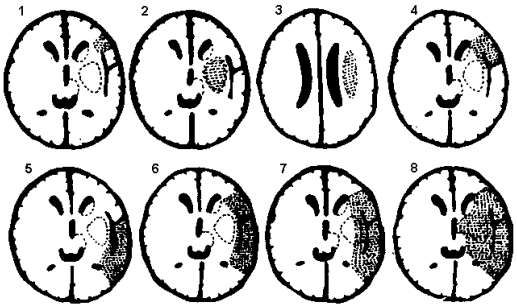
* code sub-territory sites in b

b) sub-territory sites

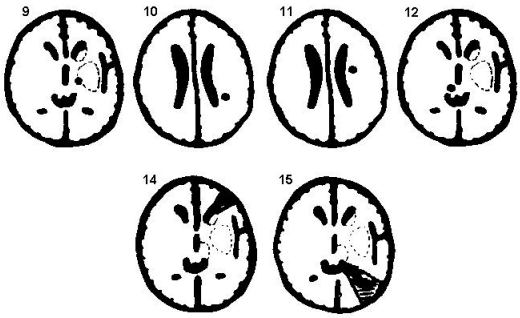
1° ☐

2° ☐

MCA sub-territory codes
1=small cortical infarct
2=basal ganglia infarct (>2x2x2cm)
3= infarct of white matter lateral to the lateral ventricle (>2x2x2cm)
4=infarct of anterior half of peripheral MCA territory
5=infarct of the posterior half of peripheral MCA territory
6=infarct of the whole of peripheral MCA territory
7=6+infarct of lateral part of basal ganglia
8=infarct of whole of MCA territory



Lacunar/Borderzone sub-territory codes
9=lacune in internal capsule/lentiform
10=lacune in internal border zone
11=lacune in centrum semiovale
12=lacune in thalamus
13=lacune in brainstem, inc. pons (not shown)
14=anterior (mainly) border zone
15=posterior (mainly) border zone



Cerebellum sub-territory codes
16=small cortical (not shown)
17=<1/2 hemisphere (medium) (not shown)
18=>1/2 hemisphere (not shown)

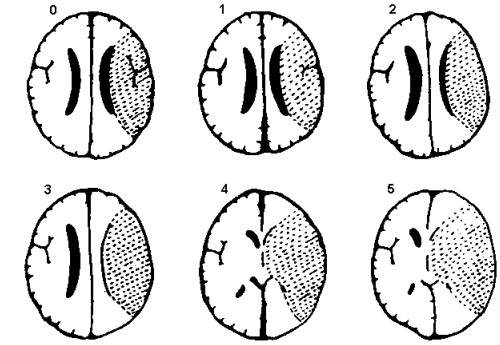
Brainstem sub-territory codes
11=small, i.e.<1/2 medulla (not shown)
12=extensive, i.e. pons + medulla (not shown)

c) degree of mass effect on plain CT

1° ☐

2° ☐

Mass effect grading
0=no swelling
1=effacement of the sulci overlying the infarct
2=1+minor effacement of adjacent lateral ventricle
3=1+complete effacement of lateral ventricle
4=1+effacement of the lateral and third ventricle
5=4+shift of the midline away from the side of the ventricle
6=5+effacement of the basal cisterns

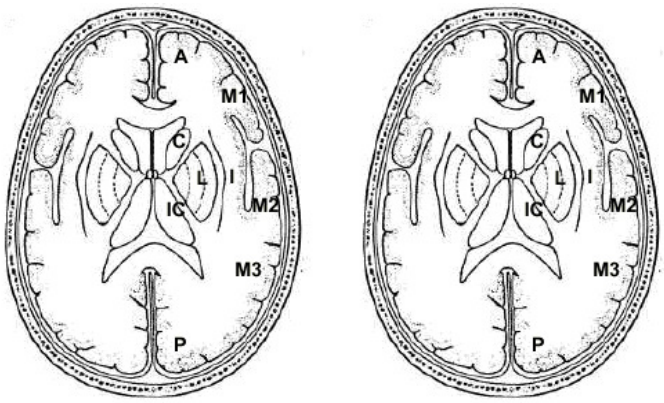


6. ASPECT Score lesion:

Please enter '1' for all abnormal areas, '0' for normal areas, 'U' for unscoreable areas*

	Plain CT		Raw PWI data	MTT	CBF	CBV
	Swelling	**Hypoattenuation**				
N/A	☐	☐	☐	☐	☐	☐
Caudate (C)	☐	☐	☐	☐	☐	☐
Lentiform (L)	☐	☐	☐	☐	☐	☐
Insula (I)	☐	☐	☐	☐	☐	☐
Internal Capsule (IC)	☐	☐	☐	☐	☐	☐
MCA1 (M1)	☐	☐	☐	☐	☐	☐
MCA2 (M2)	☐	☐	☐	☐	☐	☐
MCA3 (M3)	☐	☐	☐	☐	☐	☐
MCA4 (M4)	☐	☐	☐	☐	☐	☐
MCA5 (M5)	☐	☐	☐	☐	☐	☐
MCA6 (M6)	☐	☐	☐	☐	☐	☐
A	☐	☐	☐	☐	☐	☐
P	☐	☐	☐	☐	☐	☐

***'unscoreable' = areas not included on CTP**



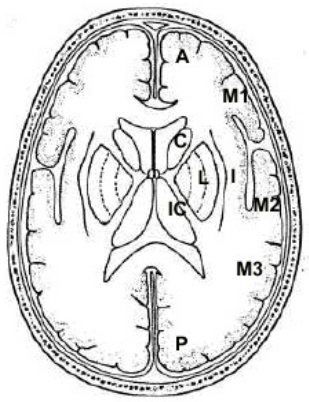
6 continued – additional PWI parameter scores

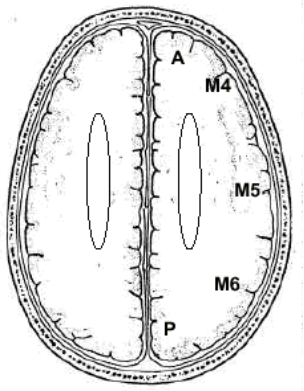
6. ASPECT Score lesion:

Please enter '1' for all abnormal areas, '0' for normal areas, 'U' for unscoreable areas*

	TTP	Tmax	ATF	Other:	Other:	Other:
N/A	☐	☐	☐	☐	☐	☐
Caudate (C)	☐	☐	☐	☐	☐	☐
Lentiform (L)	☐	☐	☐	☐	☐	☐
Insula (I)	☐	☐	☐	☐	☐	☐
Internal Capsule (IC)	☐	☐	☐	☐	☐	☐
MCA1 (M1)	☐	☐	☐	☐	☐	☐
MCA2 (M2)	☐	☐	☐	☐	☐	☐
MCA3 (M3)	☐	☐	☐	☐	☐	☐
MCA4 (M4)	☐	☐	☐	☐	☐	☐
MCA5 (M5)	☐	☐	☐	☐	☐	☐
MCA6 (M6)	☐	☐	☐	☐	☐	☐
A	☐	☐	☐	☐	☐	☐
P	☐	☐	☐	☐	☐	☐

***'unscoreable' = areas not included on CTP**





7. CT hyperattenuated/Abnormal Vessel Sign

	Y	N
a) Is there a hyperattenuated artery (i.e. acutely occluded) on plain CT	☐	☐
b) Is there an occluded artery on CTA?	☐	☐

c) Name abnormal artery. If 'Y' to either a) or b), indicate which artery(ies). List most important (largest) abnormal artery first (1) and least important (smallest) last (3) if more than one.

1. ☐
2. ☐
3. ☐

1) ICA
2) MCA main stem
3) MCA Sylvian branch
4) PCA
5) ACA
6) 1+2+3
7) 1+2
8) 2+3

8. If abnormal artery on CTA, indicate the degree of obstruction:

a) TIMI score for abnormal artery: ☐

NEJM 1985;312:932-6

Grade	Criteria on arteriography
0	No flow/patency
1	Minimal flow/patency
2	Partial flow/patency
3	Complete flow/patency

b) MORI score for abnormal artery ☐

Stroke 1988;19:802-812

Grade	Criteria on arteriography
0	No flow/patency
1	Minimal flow/patency
2	Flow/patency of less than 50% of the territory of the occluded artery
3	Flow/patency of more than 50% of the territory of the occluded artery
4	Complete flow/patency

9. Haemorrhagic Changes *

Is there any haemorrhage anywhere? Y ☐ N ☐ ***If No go to Q.11***

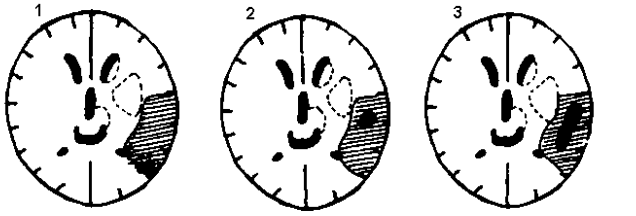
10. Classify haemorrhage (if more than one haemorrhage, tick all present – indicate order of significance) :

Order (insert 1 (most important), 2, 3 (least important) to indicate your estimate of the order of clinical importance)

Size of Haematoma (tick box for max diam.):

	Y	N	Order	<3cm	3-5cm	5-8cm	>8cm
a) petechial haemorrhage (example 1 or 2 below)	☐	☐	☐	☐	☐	☐	☐
b) significant haemorrhagic transformation of infarct (i.e. underlying infarct still visible) (example 3 below)	☐	☐	☐	☐	☐	☐	☐
c) parenchymal haematoma (i.e. no infarct visible)	☐	☐	☐	☐	☐	☐	☐
d) parenchymal haematoma clearly remote from infarct	☐	☐	☐	☐	☐	☐	☐
e) subdural haematoma	☐	☐	☐	☐	☐	☐	☐
f) subarachnoid haemorrhage	☐	☐	☐				
g) extradural haemorrhage	☐	☐	☐	☐	☐	☐	☐

i) In your opinion, is the haemorrhage a major component of the infarct which is likely to have worsened mass effect or involved more brain in the damage present and so worsened symptoms, or if remote from the infarct, likely to have contributed significantly to the burden of brain damage? Y ☐ N ☐



Haematoma with no or only slight mass effect

Haematoma with definite mass effect compressing

11. Reduction in brain tissue volume

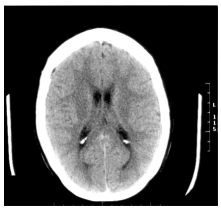
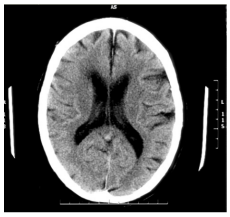
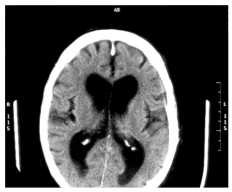
Is there any reduction in brain tissue volume? **Y** ☐ **N** ☐ ***If No go to Q.13***

12. Classify atrophy (see examples and pick nearest likeness):

Central **None** ☐ **Mod** ☐ **Severe** ☐

1 CENTRAL reduction in brain tissue volume

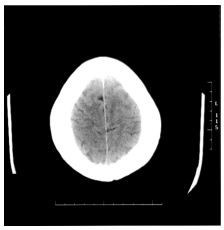
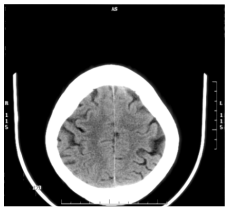
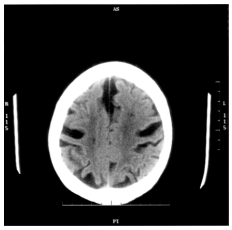
None **Modest** **Severe**

Cortical **None** ☐ **Mild** ☐ **Severe** ☐

CORTICAL reduction in brain tissue

None **Modest** **Severe**

PERIVENTRICULAR LUCENCIES

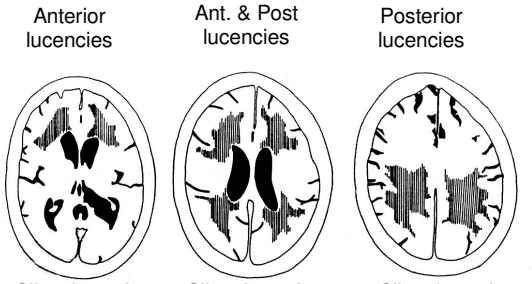
13. Are there any periventricular lucencies? **Y** ☐ **N** ☐ ***If No go to Q.15***

14. Classify extent of white matter lucency

a. Anterior white matter
0= no lucency
1= lucency restricted to region adjoining ventricles
2= lucency covering entire region from lateral ventricle to cortex

b. Posterior white matter
0= no lucency
1= lucency restricted to region adjoining ventricles
2= lucency covering entire region from lateral ventricle to cortex

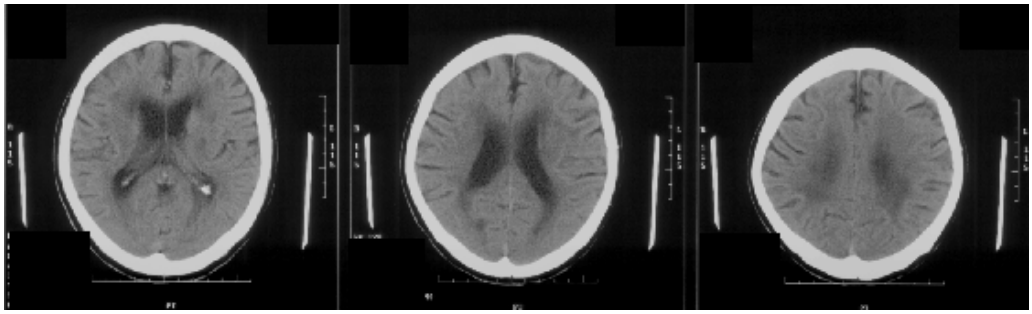
0,1,2 ☐



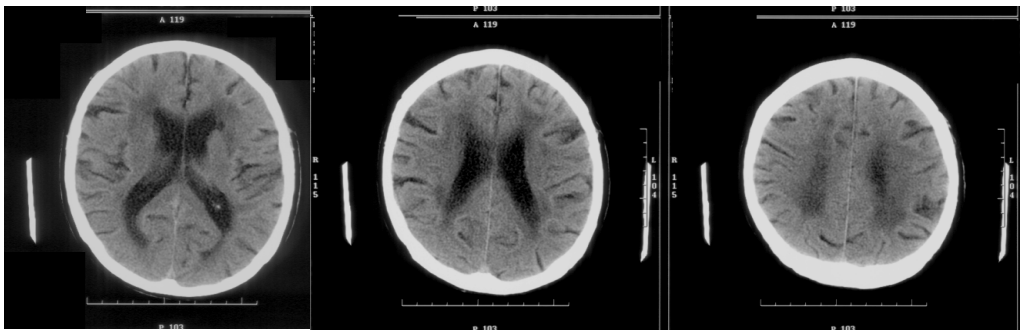
(van Swieten et al. JNNP 1990;53:1080-1083)

0,1,2 ☐

AWM = 1 PWM = 0



AWM = 2 PWM = 1



OLD VASCULAR LESIONS

		Y	N	
15.	Are there any old vascular lesions?	☐	☐	***If No go to Q.17***

		Y	N
16.	Classify old vascular lesion(s):		
	a) old cortical infarct(s)	☐	☐
	b) old striatocapsular infarct(s)	☐	☐
	c) old borderzone infarct(s)	☐	☐
	d) old lacunar infarct(s)	☐	☐
	e) old brainstem/cerebellar infarct(s)	☐	☐
	f) probable old haemorrhage	☐	☐

NON-STROKE LESIONS

		Y	N	
17.	Is there a non-stroke lesion, which could have accounted for the patient's stroke syndrome?	☐	☐	***If No go to Q.19***

		Y	N	
18.	Classify non-stroke lesion:			
	a) cerebral tumour	☐	☐	
	b) encephalitis	☐	☐	
	c) cerebral abscess	☐	☐	
	d) other (e.g. contusion)	☐	☐	**Specify Other:** ☐

19. COMMENT:

IST-3 Perfusion and Angiography Studies

MR image interpretation form

PATIENT ID:

DATE OF READING: **DATE OF SCAN:**

SCAN QUALITY: Good ☐ Moderate ☐ Poor ☐ **Comment:**

READER ID:

TYPE OF SCAN: (tick all the apply)

Diffusion: ☐ **Perfusion:** ☐ **MRA:** ☐

GRE/T2*: ☐ **T2/FLAIR:** ☐

TYPE OF PERFUSION AVAILABLE:

MTT: ☐ **CBV:** ☐ **TMAX:** ☐

CBF: ☐ **TTP:** ☐ **Other:** ☐

Please tick Yes or No. Please do not leave blanks. Thank you.

1. Are all the scan sequences completely normal? **Y** ☐ **N** ☐ ***If YES stop here***

2. **Ischaemic Changes**

Is there any sign of acute ischaemic change on any sequence? If in doubt as to whether acute or old, code as acute. **Y** ☐ **N** ☐ ***If No go to Q.7***

3. Which side of the brain shows ischaemic change? **R** ☐ **L** ☐ ***Tick R and L if both***

4. Classify ischaemic change on DWI, T2/FLAIR.

		Y	**N**
e)	Faint hyperintensity on DWI but no lesion visible on T2/FLAIR.	☐	☐
f)	Bright hyperintensity on DWI but no/pale lesion visible on T2/FLAIR.	☐	☐
g)	Lesion clearly visible on T2/FLAIR as well as on DWI.	☐	☐

h) PWI lesion visible.
(tick one box for each row that applies). The 20% refers to volume.

	N	<20%<DWI	Same as DWI	>20%>DWI
CBF	☐	☐	☐	☐
CBV	☐	☐	☐	☐
MTT	☐	☐	☐	☐
Raw data	☐	☐	☐	☐
TTP	☐	☐	☐	☐
Tmax	☐	☐	☐	☐
ATF	☐	☐	☐	☐
Other (blank to fill in parameters) _____	☐	☐	☐	☐
_____	☐	☐	☐	☐
_____	☐	☐	☐	☐
_____	☐	☐	☐	☐

5. Classify site and size of ischaemic lesion on DWI
(see examples)

a) site (enter most appropriate code in box)

1° ☐

2° ☐

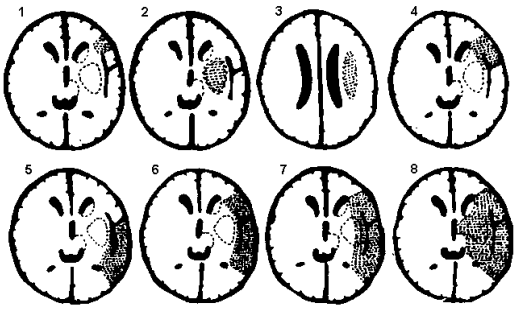
M =MCA* = any lesion in the MCA territory
AS =Infarct of up to half of ACA territory
AL =Infarct of more than half of ACA territory
PS =Infarct of up to half of PCA territory
PL =Infarct of more than half of PCA territory
MAS=M+AS*
MAL=M+AL*
MPS=M+PS*
MPL=M+PL*
MAP=Infarct of whole MCA, ACA and PCA territories
L =Lacune*
B =Borderzone*
C =Cerebellum*
S =Brainstem*
CS =Cerebellum and brainstem

* code sub-territory sites in b

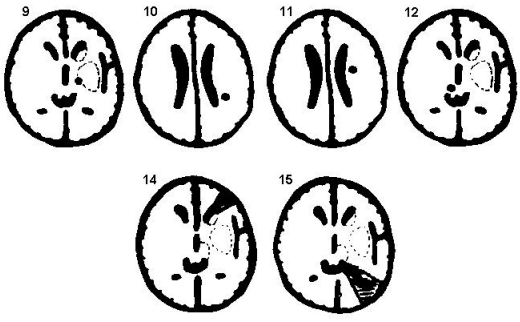
b) sub-territory sites

1° ☐

2° ☐



MCA sub-territory codes
1=small cortical infarct
2=basal ganglia infarct (>2x2x2cm) - striatocapsular
3=striatocapsular infarct lateral to the lateral ventricle (>2x2x2cm)
4=infarct of anterior half of peripheral MCA territory – a=not involving and b=involving part of basal ganglia
5=infarct of the posterior half of peripheral MCA territory – a= not involving and b=involving part of basal ganglia
6=infarct of the most or whole of peripheral MCA territory not including basal ganglia
7=6+infarct of lateral part of basal ganglia
8=infarct of whole of MCA territory



Lacunar/Borderzone sub-territory codes
9=lacune in internal capsule/lentiform
10=lacune in internal border zone
11=lacune in centrum semiovale
12=lacune in thalamus
13=lacune in brainstem, inc. pons (not shown)
14=anterior (mainly) border zone
15=posterior (mainly) border zone

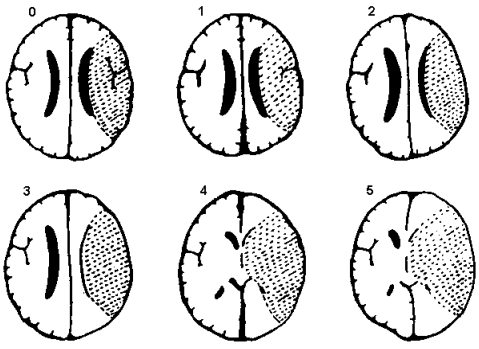
cerebellum sub-territory codes
16=small cortical (not shown)
17=<1/2 hemisphere (medium) (not shown)
18=>1/2 hemisphere (not shown)

Brainstem sub-territory codes
11=small, i.e.<1/2 medulla (not shown)
12=extensive, i.e. pons + medulla (not shown)

c) degree of mass effect on DWI/T2/FLAIR

1° ☐

2° ☐



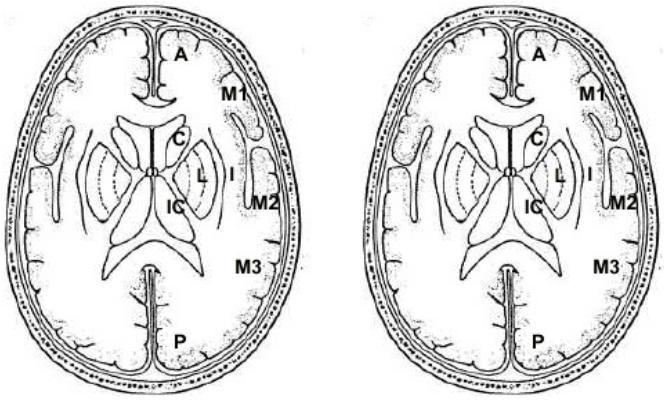
Mass effect grading
0=no swelling
1=effacement of the sulci overlying the infarct
2=1+minor effacement of adjacent lateral ventricle
3=1+complete effacement of lateral ventricle
4=1+effacement of the lateral and third ventricle
5=4+shift of the midline away from the side of the ventricle
6=5+effacement of the basal cisterns

6. ASPECT Score lesion:

Please enter '1' for all abnormal areas, '0' for normal areas, 'U' for unscoreable areas*

	DWI		PWI Raw	MTT	CBF	CBV
	Signal	**Swelling**				
N/A	☐	☐	☐	☐	☐	☐
Caudate (C)	☐	☐	☐	☐	☐	☐
Lentiform (L)	☐	☐	☐	☐	☐	☐
Insula (I)	☐	☐	☐	☐	☐	☐
Internal Capsule (IC)	☐	☐	☐	☐	☐	☐
MCA1 (M1)	☐	☐	☐	☐	☐	☐
MCA2 (M2)	☐	☐	☐	☐	☐	☐
MCA3 (M3)	☐	☐	☐	☐	☐	☐
MCA4 (M4)	☐	☐	☐	☐	☐	☐
MCA5 (M5)	☐	☐	☐	☐	☐	☐
MCA6 (M6)	☐	☐	☐	☐	☐	☐
A	☐	☐	☐	☐	☐	☐
P	☐	☐	☐	☐	☐	☐

***'unscoreable' = areas not included**



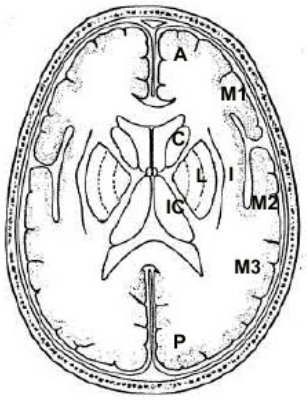
6 continued

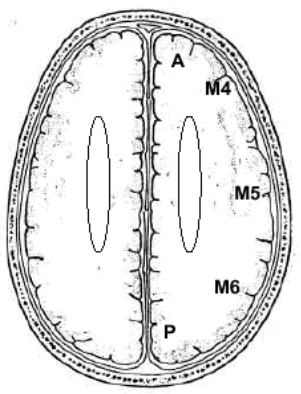
6. ASPECT Score lesion:

Please enter '1' for all abnormal areas, '0' for normal areas, 'U' for unscoreable areas*

	TTP	Tmax	ATF	Other:	Other:
N/A	☐	☐	☐	☐	☐
Caudate (C)	☐	☐	☐	☐	☐
Lentiform (L)	☐	☐	☐	☐	☐
Insula (I)	☐	☐	☐	☐	☐
Internal Capsule (IC)	☐	☐	☐	☐	☐
MCA1 (M1)	☐	☐	☐	☐	☐
MCA2 (M2)	☐	☐	☐	☐	☐
MCA3 (M3)	☐	☐	☐	☐	☐
MCA4 (M4)	☐	☐	☐	☐	☐
MCA5 (M5)	☐	☐	☐	☐	☐
MCA6 (M6)	☐	☐	☐	☐	☐
A	☐	☐	☐	☐	☐
P	☐	☐	☐	☐	☐

***'unscoreable' = areas not included**





7. Hyperintense/Abnormal Vessel Sign

	Y	N
a) Is there a hyperintense artery (i.e. acutely occluded) on FLAIR/T2/T2* (absent flow void/ hyperintense)	☐	☐
b) Is there an occluded artery on MRA?	☐	☐

.

c) Name abnormal artery. If 'Y' to either a) or b), indicate which artery(ies). List most important (largest) abnormal artery first (1) and least important (smallest) last (3) if more than one.

1. ☐

2. ☐

3. ☐

1) ICA	2) MCA main stem
3) MCA Sylvian branch	4) PCA
5) ACA	6) 1+2+3
7) 1+2	8) 2+3

8. If abnormal artery on MRA, indicate the degree of obstruction:

a) TIMI score for abnormal artery: ☐

NEJM 1985;312:932-6

Grade	Criteria on arteriography
0	No flow/patency
1	Minimal flow/patency
2	Partial flow/patency
3	Complete flow/patency

b) MORI score for abnormal artery ☐

Stroke 1988;19:802-812

Grade	Criteria on arteriography
0	No flow/patency
1	Minimal flow/patency
2	Flow/patency of less than 50% of the territory of the occluded artery
3	Flow/patency of more than 50% of the territory of the occluded artery
4	Complete flow/patency

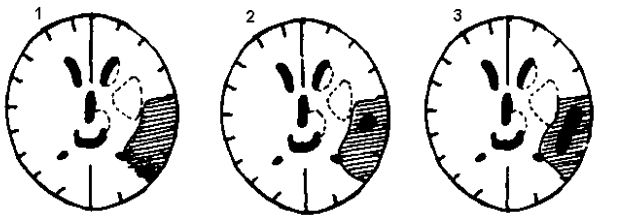
9. Haemorrhagic Changes On GRE/T2*

	Y	N	
Is there any haemorrhage anywhere?	☐	☐	***If No go to Q.11***

10. Classify haemorrhage (if more than one haemorrhage, tick all present – indicate order of significance) :

	Y	N	**Order** (insert 1 (most important), 2, 3 (least important) to indicate your estimate of the order of clinical importance)	**Size of Haematoma** (tick box for max diam.): <3cm	3-5cm	5-8cm	>8cm
a) petechial haemorrhage (example 1 or 2 below)	☐	☐	☐	☐	☐	☐	☐
b) significant haemorrhagic transformation of infarct (i.e. underlying infarct still visible) (example 3 below)	☐	☐	☐	☐	☐	☐	☐
c) parenchymal haematoma (i.e. no infarct visible)	☐	☐	☐	☐	☐	☐	☐
d) parenchymal haematoma clearly remote from infarct	☐	☐	☐	☐	☐	☐	☐
e) subdural haematoma	☐	☐	☐	☐	☐	☐	☐
f) subarachnoid haemorrhage	☐	☐	☐				
g) extradural haemorrhage	☐	☐	☐	☐	☐	☐	☐

i) In your opinion, is the haemorrhage a major component of the infarct which is likely to have worsened mass effect or involved more brain in the damage present and so worsened symptoms, or if remote from the infarct, likely to have contributed significantly to the burden of brain damage? ☐ ☐



Haematoma with no or only slight mass effect

Haematoma with definite mass effect compressing

j) Are there any microhaemorrhages? ☐ ☐

If yes, number of microhaemorrhages: ☐

11. Reduction in brain tissue volume on T2/FLAIR

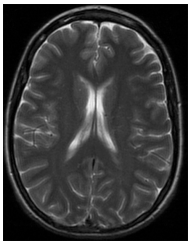
Is there any reduction in brain tissue volume? **Y** ☐ **N** ☐ ***If No go to Q.13***

12. Classify atrophy (see examples and pick nearest likeness):

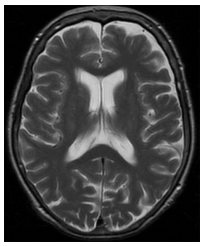
Central **None** ☐ **Mod** ☐ **Severe** ☐

2 CENTRAL reduction in brain tissue volume

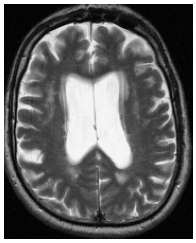
None



Moderate



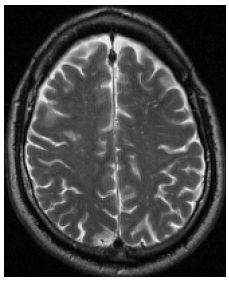
Severe



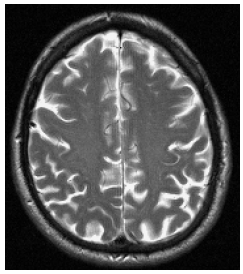
Cortical **None** ☐ **Moderate** ☐ **Severe** ☐

CORTICAL reduction in brain tissue

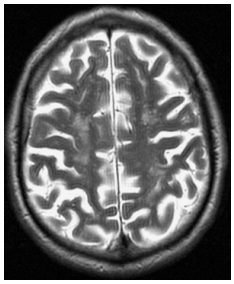
None



Moderate



Severe



13. Periventricular Hyperintensities

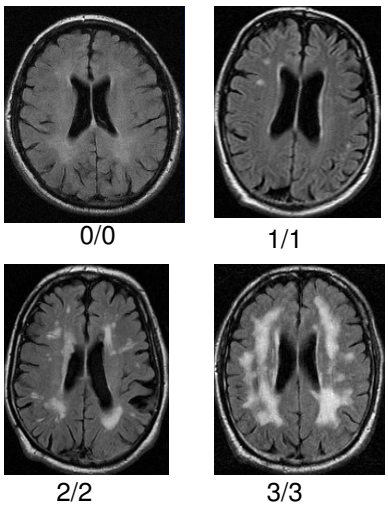
	Y	N
Are there any periventricular hyperintensities?	☐	☐

14. Classify extent of white matter hyperintensity

Fazekas et al (1987) MR signal abnormalities at 1.5T in Alzheimer's disease and normal aging. AJNR, 8:421-426.

a) Periventricular white matter **0,1,2,3** ☐

b) Deep white matter **0,1,2,3** ☐



0/0 1/1 2/2 3/3

PVH/DWMH ratings

15. Old Vascular Lesions

	Y	N
Are there any old vascular lesions?	☐	☐

16. Classify old vascular lesion(s):

	Y	N
f) old cortical infarct(s)	☐	☐
g) old striatocapsular infarct(s)	☐	☐
h) old borderzone infarct(s)	☐	☐
i) old lacunar infarct(s)	☐	☐
j) old brainstem/cerebellar infarct(s)	☐	☐
k) probable old haemorrhage	☐	☐

17. Is there a non-stroke lesion which could have accounted for the patient's stroke syndrome?

	Y	N
	☐	☐

18. Classify non-stroke lesion:

	Y	N
a) cerebral tumour	☐	☐
b) encephalitis	☐	☐
c) cerebral abscess	☐	☐
l) other (e.g.	☐	☐

Specify Other:

19. COMMENT: