

Implementing the
National

STROKE

Strategy – an
imaging guide

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Foreword

by Professor Roger Boyle

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To achieve the vision outlined in the National Stroke Strategy will not be an easy task. This imaging guide suggests both practical changes that can be made now, as well as providing aspirations for the future.

Since the launch of the strategy, work has begun to improve stroke services and the quality of care received by all who need it. One of the biggest challenges set out in the strategy is the need for rapid imaging, both for Transient Ischaemic Attack (TIA) and stroke. We promised to develop an imaging guide to assist local decision-making and to describe options for imaging services to be developed.

Imaging services present a very real challenge to the goal of improving stroke services, but by working together, sharing our experience, and putting into practice what we know to be effective, we can take the steps necessary to conquer the challenge of stroke.

Following the guidance described here will optimise a key component of stroke care and contribute to improvements in mortality and morbidity. It can be used to guide discussions on how to improve imaging services to meet the needs of people with TIA and stroke.

The imaging guide has been developed by experts in imaging, and we would like to thank those who have been involved for sharing ideas, contributing their experience, time, and expertise, and, through the development of this guide, supporting implementation of the stroke strategy.



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Executive Summary

1. High quality imaging of the brain and blood vessels is a key part of a successful stroke service. It is inevitable that advances will be made and therefore imaging for both TIA and stroke needs to be kept under review. This guide is intended to describe the gold standard in imaging for TIA and stroke, while providing some pragmatic advice on how to start implementing what may be dramatic service change in some areas.
2. The guide first considers the markers of a quality service set out in the National Stroke Strategy related to imaging of TIA and stroke. Using these as the gold standard of TIA and stroke imaging services, the rest of the guide suggests how local areas might implement these markers in their own services.
3. Imaging for TIA is needed to ensure appropriate treatment that will prevent subsequent stroke and to ensure carotid intervention is used where appropriate. For stroke, urgent brain imaging is required to determine the cause and to enable appropriate treatment to be started. All stroke patients will benefit from rapid admission to a stroke unit, while a smaller number may benefit from thrombolysis, and/or neurosurgery. Diagrams of TIA and stroke imaging pathways are included.
4. There are a variety of techniques used to image the brain and carotid arteries in TIA and stroke. Each method offers different costs and benefits, which need to be taken into account when developing imaging services.
5. Imaging services managing TIA and stroke will need to be able to provide the following services:

5.1 TIA

- MRI/MRA brain for those patients requiring it available seven days a week with Contrast Enhanced MRA (CEMRA) for first-line carotid imaging. This requires MR software for diffusion weighted and gradient echo imaging and CEMRA, and a pump injector for CEMRA; and
- Carotid imaging seven days a week, which will ideally include CEMRA and duplex ultrasound, and CT angiography.

5.2 Stroke

- 24 hour access to CT;
- Rapidly accessible MRI, with the features described above, for those patients who require it; and
- Ability to undertake more complex imaging examinations for stroke subtypes as required.

6. This guide uses expert opinion to estimate service impact in terms of the number of people requiring imaging and when they might require it. This may require service reorganisation and have implications for workforce and training. Developing imaging services for TIA and stroke may have an impact on organisation of the service and on the workforce providing it.
7. Finally, the guide reviews those actions from the National Stroke Strategy that may be needed to support development of imaging services.

Introduction

What is the aim of this guide?

1. This guide aims to set out useful information for those professionals dealing with stroke services, including those who are:
 - involved in the care of patients who require imaging following known or suspected TIA or stroke;
 - managing imaging services for known or suspected TIA or stroke;
 - involved in the education and training of staff who will be working with patients who require imaging following known or suspected TIA or stroke; and
 - responsible for commissioning imaging services for patients following known or suspected TIA or stroke.
2. The role of imaging in TIA and stroke is considered in detail throughout this guide. The clinical guidelines for stroke proposed by the Royal College of Physicians (2004),¹ state that access to brain and vascular imaging services should be part of efficient and effective stroke service management.

Definitions

- Transient Ischaemic Attack (TIA) – sometimes known as a minor stroke, in which blood supply to the brain is temporarily disturbed leading to stroke-like symptoms, but where these symptoms resolve within 24 hours. The cause of a TIA is the same as the cause of an ischaemic stroke (see below).
 - Stroke – caused by a disturbance of the blood supply to the brain. There are two main types of stroke:
 - Ischaemic: stroke caused by a clot narrowing or blocking a blood vessel so that blood cannot reach the brain, causing brain cells in the area to die due to lack of oxygen; and
 - Haemorrhagic (or Primary Intracerebral Haemorrhage, PICH): stroke caused by the bursting of a blood vessel leading to bleeding in the brain, which causes damage.
3. There are other, unusual and relatively rare types of stroke and other conditions that mimic the symptoms of stroke. The role of imaging in excluding or identifying these is considered later. These include cerebellar haematoma (bleeding in the lower part of the brain), basilar thrombosis (a clot in the artery at the base of the brain), venous thrombosis (a clot in the veins connected to the brain), subarachnoid haemorrhage (bleeding between the brain and skull), and large vessel dissection (a tear in a blood vessel wall).

¹ Royal College of Physicians, 2004, *National Clinical Guidelines for Stroke*, Second edition, prepared by the Intercollegiate Stroke Working Party, London, RCP

Implementing the quality markers from the National Stroke Strategy

4. Rapid access to imaging services is a key element in the gold standard service envisioned in the National Stroke Strategy.² The chapter describing acute care of TIA and stroke, *Time is Brain*, contains two quality markers relevant to imaging.
 - QM5. Assessment – referral to specialist (TIA and minor stroke)
 - Immediate referral for appropriately urgent specialist assessment and investigation is considered in all patients presenting with a recent TIA or minor stroke;
 - A system which identifies as urgent those with early risk of potentially preventable full stroke – to be assessed within 24 hours in high risk cases; all other cases to be assessed within 7 days; and
 - Provision to enable brain imaging within 24 hours and carotid intervention, echocardiography and ECG within 48 hours where clinically indicated.
 - QM7. Urgent response (stroke)
 - All patients with suspected acute stroke are immediately transferred by ambulance to a receiving hospital providing hyper-acute stroke services (where a stroke triage system, expert clinical assessment, timely imaging and the ability to deliver intravenous thrombolysis treatment are available throughout the 24 hour period).
5. These are ambitious goals but will enable prevention of subsequent stroke in cases of TIA, and timely treatment in cases of stroke, reducing subsequent death and disability.
6. The need for prompt imaging of TIA has been realised in the light of recent developments in clinical research. This may represent a more significant challenge than the urgent response to stroke, in terms of changes to service provision, particularly out of hours.
7. The development of TIA and stroke imaging services is supported by the inclusion of a marker in the Vital Signs indicators, which form part of the NHS Operating Framework for 2008/09.³ All Primary Care Trusts will be expected to collect data regarding treatment of higher-risk individuals with TIA, defined by a score of 4 or more on the ABCD2⁴ system. They will need to provide the proportion of these patients who are scanned and treated within 24 hours of symptom onset. This will enable a clearer picture of current service provision to be established and encourage service improvement.

² Department of Health, 2007, *National Stroke Strategy*, London, DH

³ Department of Health, 2008, *Operational Plans 2008/09-2010/11*, London, DH

⁴ ABCD2 score is calculated using the patient's age (A); blood pressure (B); clinical features (C); duration of TIA symptoms (D); and presence of diabetes (2). Scores are between 0 and 7 points. Low risk = 0–3 points; moderate risk = 4–5 points; high-risk = 6–7 points.

8. The imaging guide is thought not likely to impact differently on people on grounds of their race, disability, gender, transgender, age, religion or belief, and sexual orientation, and no combinations of these groups. The reason for this is that people of different groups will not be imaged differently when they have signs of TIA or stroke. For more information on equality issues related to the stroke strategy as a whole, please see the equality impact assessment for the National Stroke Strategy.⁵
9. There are forthcoming National Institute for Health and Clinical Excellence (NICE) guidelines for acute stroke and TIA. The NICE algorithms for treating TIA and stroke contained in this document are based on those published in the consultation draft of the NICE clinical guideline. Local areas will need to reflect the final recommendations in the NICE guideline that relate to imaging in their plans for imaging services development.

⁵ www.dh.gov.uk/stroke

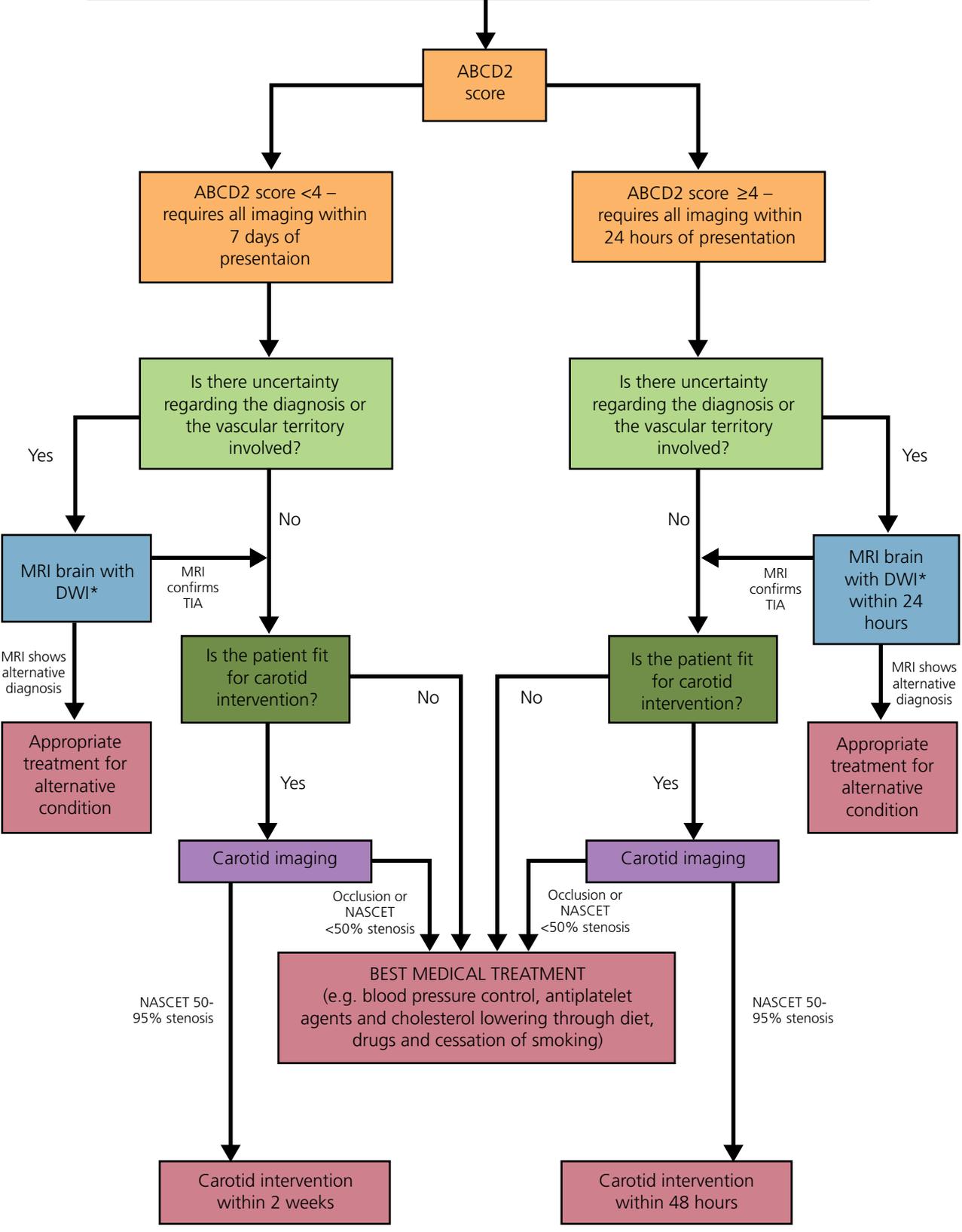
Imaging for TIA

1. The role of imaging in TIA is to confirm the diagnosis, confirm the vascular territory affected (where the lesion is), and to identify those people who would benefit from carotid intervention.
2. TIAs carry a significant mortality and morbidity risk. They may be the only warning that a major stroke is imminent. Approximately 20 per cent of TIAs will be followed by a stroke within four weeks. Investigating and treating high-risk patients with TIA within 24 hours could reduce by 80 per cent the number of people who go on to have a full stroke.⁶
3. The risk of stroke is greatest immediately after a new TIA. The ABCD2 scoring system determines the likely risk of subsequent stroke. A higher risk individual, with a score of 4 or more, requires specialist assessment and investigation within 24 hours. Those with a score less than 4 require specialist assessment and investigation within seven days at the most.
4. Specialist assessment and investigation will include expert clinical assessment, and most people will require imaging of some kind. Approximately 50 per cent will require Magnetic Resonance Imaging (MRI) of the brain and approximately 80 per cent of people will require carotid imaging (of the vessels in the neck).
5. About 50 per cent of suspected TIAs require MRI of the brain. The diagnosis of TIA is difficult and doubt often remains, even after expert clinical assessment, as to whether or not the event was a TIA. Of patients presenting with symptoms suggesting a TIA, about half prove to have some other cause. For those who have had a TIA, the location of the lesion (damaged tissue) may not be known.

⁶ Rothwell, PM, et al., 2007, 'Effect of urgent treatment of transient ischaemic attack and minor stroke on early recurrent stroke (EXPRESS study): a prospective population-based sequential comparison', *Lancet*, 270 1432-42.

6. Computed Tomography (CT) is not sufficiently sensitive to demonstrate the small lesions found in TIA. MRI of the brain with diffusion weighted imaging (DWI) is needed where the diagnosis or location of the lesion remains in doubt. The MRI may answer the question of whether the lesion is in vertebral (brain/brainstem) or carotid neck territory, prompting further carotid investigation where appropriate. If multiple lesions are found, this may suggest a cardiac source of the clot(s), and prompt investigation of the heart.
7. About 80 per cent of TIAs require imaging of the carotid arteries, which provide the blood supply to the brain. The remaining 20 per cent of people have a vertebrobasilar TIA (brain stem and cerebellum) and will not benefit from carotid imaging. The aim of carotid imaging is to identify whether there is carotid stenosis (narrowing of the vessels) so that the patient can benefit from rapid carotid intervention.
8. Carotid imaging should ideally be performed at initial assessment and should not be delayed for more than 24 hours after first clinical assessment of TIA for those at higher risk of stroke (i.e. ABCD2 score ≥ 4) or in those with non-cardioembolic carotid-territory minor stroke. Those people who are found to have carotid stenosis will require carotid intervention within 48 hours of presentation.
9. For those people at lower risk of subsequent stroke (i.e. ABCD2 score < 4), carotid imaging should be performed within seven days. If they are found to have carotid stenosis, they should have carotid intervention within two weeks of presentation.
10. Expert clinical assessment coupled with appropriate imaging provide the best diagnostic pathway for patients with TIA.

Suspected Transient Ischaemic Attack and Minor

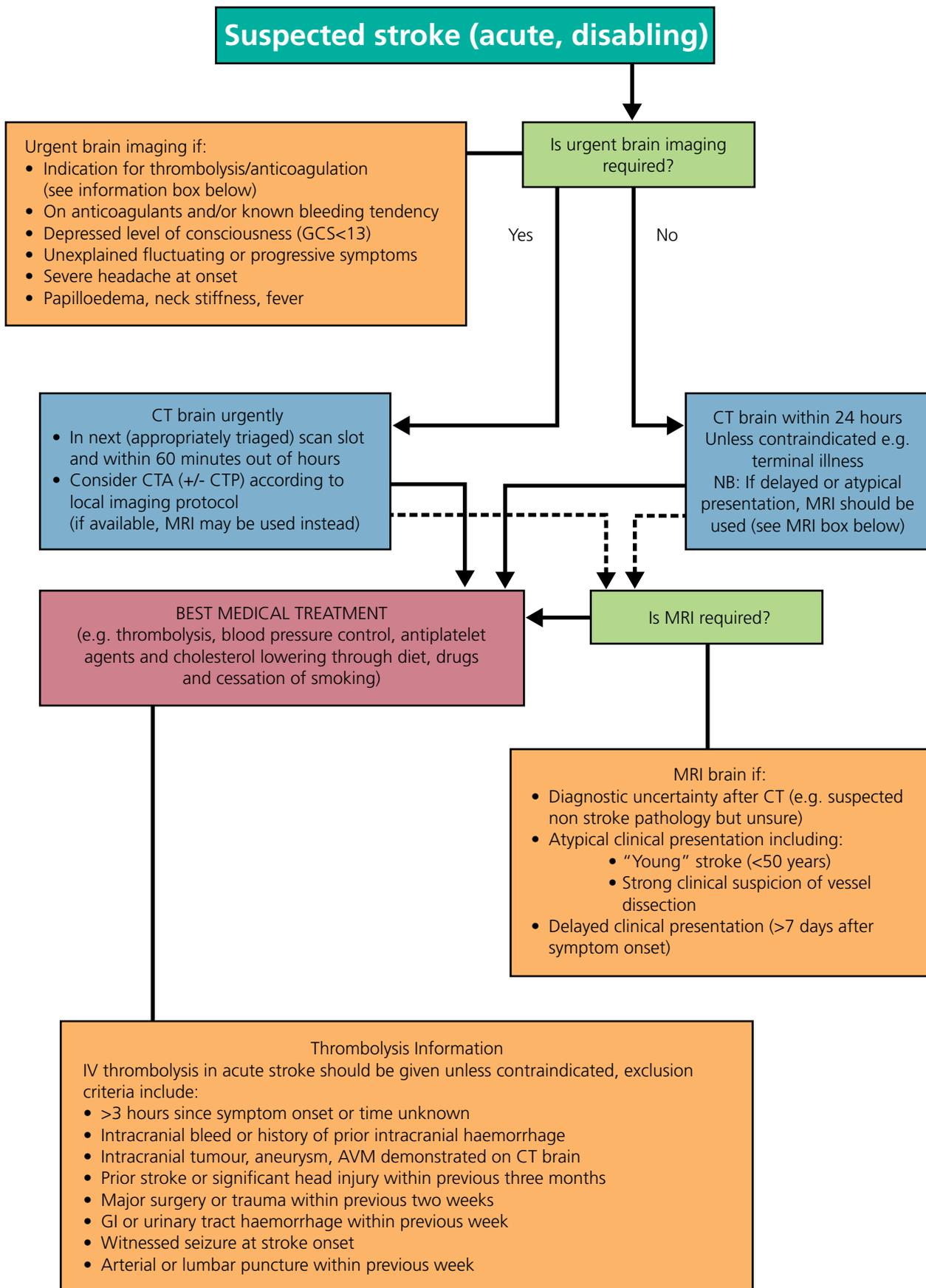


*Unless MRI contraindicated, in which case CT should be used

Imaging for stroke

1. The role of imaging in stroke is to determine the type of stroke, exclude conditions that can mimic a stroke and to evaluate appropriate treatment options.
2. Conditions with symptoms that mimic stroke need to be excluded first. An initial structured assessment, for example, the Recognition Of Stroke In the Emergency Room (ROSIER) scale,⁷ in a high-dependency area such as the emergency department or medical assessment unit, is needed to determine the diagnosis and whether urgent brain imaging is required.
3. People with a suspected stroke should undergo a CT scan as a matter of urgency. An urgent CT is needed to differentiate between those who have had an ischaemic stroke and those who have had a stroke due to primary intracerebral haemorrhage. It is not possible to do this by clinical examination alone. For those who have had an ischaemic stroke, thrombolysis (treatment with clot-busting drugs) is a possible treatment option, but could be fatal in those with a haemorrhagic stroke. Currently, CT scanning is adequate to determine the type of stroke and will allow decisions about thrombolysis to be made for most patients.
4. Treatment of ischaemic stroke should be delayed as little as possible. In the case of IV thrombolysis for ischaemic stroke, current licensing guidelines indicate a limit of three hours from symptom onset for the use of rTPA (recumbent tissue plasminogen activator – “Actilyse”) as an agent for thrombolysis.
5. For practical purposes, during the normal working day an urgent CT scan would be in the next ‘scan slot’, bearing in mind the need to investigate patients with other conditions also requiring urgent and emergency investigation. Outside normal working hours patients would undergo a CT scan within 60 minutes of a request.
6. At least 10-20 per cent of people will require further brain imaging with MRI, for instance, when the diagnosis remains in doubt or if there is an atypical or delayed presentation of stroke.
7. Expert clinical assessment coupled with appropriate imaging provide the best diagnostic pathway for patients with stroke.

⁷ Nor AM, Davis J, Sen B, et al., 2005, The Recognition of Stroke in the Emergency Room (ROSIER scale: development and validation of a stroke recognition instrument), *Lancet Neurology* 4(11), 727-34



Imaging techniques

Brain Imaging

TIA

Objective: To confirm the diagnosis and/or vascular territory affected in those patients where either is unclear.

1. MRI is recommended for TIA as CT has low spatial resolution and may be unable to detect small lesions. It may, however, remain an appropriate alternative in those for whom MRI is contraindicated.
2. Moreover, as services will need to develop adequate capacity and access times for MRI, clinicians may need to continue to request alternative brain imaging in the form of CT. This will only be appropriate for those patients seen rapidly and the use of CT for TIA should continue only as long as necessary for services to develop.
3. MRI in TIA needs to include diffusion weighted imaging (DWI) and gradient echo sequences (GRE). DWI shows lesions in up to half of TIAs but it is not absolutely specific and care is required in its interpretation with particular reference to the other MR sequences obtained. GRE is very sensitive to bleeding, reliably detecting both acute and chronic haemorrhages.
4. In many instances, MR Angiography (MRA – imaging of blood vessels) of the brain will also be appropriate to clarify the arteries affected. This can be done at the same time as the MRI. Contrast Enhanced MRA (CEMRA) using a pump injector is required and this needs appropriate software to be installed on the MR machine.
5. In line with the forthcoming NICE guidelines and National Stroke Strategy, it is advised that brain MRI, where required, is performed within 24 hours of presentation in those classed as higher risk patients [ABCD2 score ≥ 4) and within seven days in lower risk patients.

Stroke

Objective: To determine whether the stroke is ischaemic or haemorrhagic; to exclude conditions that can mimic a stroke; and to identify people eligible and suitable for thrombolysis as quickly as possible.

6. CT brain imaging is widely used in acute stroke because it is accurate, quick and widely available. MRI may also be used but is less widely available and is less well tolerated in patients with acute disabling stroke: 30-40 per cent either have a contraindication or fail to tolerate MRI studies.⁸
7. When someone presents more than seven days after symptom onset then CT is less reliable for differentiating between ischaemic and haemorrhagic stroke and MRI should be used instead. Sometimes, even after a CT has been undertaken, the diagnosis may remain unclear, and MRI is indicated.
8. When selecting appropriate imaging for suspected stroke, consideration of possible subtypes plays a role. For a stroke due to suspected arterial dissection (a tear in a blood vessel wall), although CT/CTA can detect it, MRI is more accurate and the usual first choice imaging technique. MRI for this indication needs to include MRA, and preferably CEMRA. For suspected cerebral venous occlusion (clot in the veins of the brain) causing a stroke, CT venography (imaging of the veins) is at least as accurate as standard MRI techniques and quicker and easier to obtain. Image interpretation is also more straightforward.
9. Imaging technologies are advancing all the time, imaging for TIA and stroke will need to develop in line with improvements.
10. Currently, we know that additional useful information regarding the ischaemic penumbra (area of brain that could potentially be salvaged with rapid treatment) may be gained by performing CT perfusion (CTP) with or without CTA at the same time.
11. Furthermore, a number of trials using thrombolysis are demonstrating the possibility of extending the limited time-window for treatment beyond three hours. Identification of the ischaemic penumbra is required to safely select such patients, using, for instance, DWI and perfusion weighted (PWI) MR or perfusion CT.

Summary

12. Brain imaging services managing TIA and stroke will need to be able to provide the following services:

⁸ Hand PJ et al (2005) Magnetic Resonance brain imaging in patients with acute stroke: feasibility and patient related difficulties. *Journal of Neurology, Neurosurgery and Psychiatry*, 76 1525–7.

Singer OC et al (2004) Practical Limitations of acute stroke MRI due to patient related problems. *Neurology*, 62 1848–9.

Sarji SA et al (1998) Failed MRI examinations due to claustrophobia. *Australasian Radiology*, 42 293–5.

13. TIA

- MRI/MRA brain for those patients requiring it available seven days a week during the daytime; and

14. Stroke

- 24 hour access to CT. For those in whom urgent brain imaging is indicated CT to be performed in next scan slot and at most within 60 minutes of request (whether in or out of normal working hours);
- MRI rapidly available for the those patients who require it; and
- Ability to undertake more complex imaging examinations for stroke subtypes such as suspected venous stroke or arterial dissection as required.

Carotid Imaging

(see appendix A for overview of carotid techniques)

Objective: To identify those people with significant carotid stenosis (narrowing of the arteries in the neck due to plaque) who would benefit from carotid intervention in order to prevent stroke.

15. Significant disease is usually defined using criteria from NASCET (North American Symptomatic Endarterectomy Trial).^{9,10}
16. There is another system for measuring carotid stenosis: the European Carotid Surgery Trialists' (ECST) collaborative group. It is apparent that some departments are unclear what system they use,¹¹ and this may cause confusion. A NASCET stenosis value of 50 per cent is broadly equivalent to a 70 per cent value in ECST, while a 70 per cent NASCET value corresponds to 85 per cent ECST.¹² (See note on page 18)
17. All carotid imaging needs to be undertaken in laboratories and/or departments that subject themselves to regular audit.

⁹ North American Symptomatic Carotid Endarterectomy Trial. Methods, patient characteristics, and progress, 1991, *Stroke* 22(6), 711-20

¹⁰ Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. North American Symptomatic Carotid Endarterectomy Trial Collaborators. 1991, *New England Journal of Medicine*, 325, 445-53

¹¹ Walker J, Naylor AR, 2006, Ultrasound based measurement of 'carotid stenosis >70%': an audit of UK practice. *European Journal of Vascular and Endovascular Surgery*, 31 487-90

¹² Rothwell PM, Gutnikov SA, Warlow CP, 1994, Equivalence of measurements of carotid stenosis. A comparison of three methods on 1001 angiograms, European Carotid Surgery Trialists' Collaborative Group

- 18.** Carotid imaging requires:
- Assessment of severity of stenosis at the carotid bifurcation (where the carotid arteries split); and
 - Exclusion of an embolic source in the carotid arteries or elsewhere.

Assessment of severity of carotid stenosis

- 19.** In general, duplex ultrasound is the most widely available and frequently used initial investigation for the assessment of carotid stenosis.
- 20.** Duplex ultrasound is operator dependent requiring significant skill in image and data acquisition as well as interpretation. Currently, these skills are not often available at night and weekends.
- 21.** Evidence suggests that more recently introduced non-invasive imaging modalities, especially CEMRA, may be more accurate. For example, the sensitivity of CEMRA is reported as 0.94 compared with 0.89 for ultrasound.¹³ The technologies underpinning CT and MR are advancing rapidly and are likely to deliver further improvements in sensitivity and specificity.
- 22.** Imaging pathways that allow more people to reach carotid intervention quickly have the potential to prevent most strokes following TIA and to produce greatest net benefit. A recent review by Health Technology Assessment (HTA) indicated that offering carotid intervention to those with less stenosis (50-69 per cent) in addition to those at the highest risk of stroke (70-99 per cent stenosis) would prevent the most strokes. On the other hand, those presenting late after TIA and/or with lesser degrees of stenosis need higher test accuracy – the intervention has fewer benefits but equivalent risks. The HTA review recommended that ultrasound results in these people (ie, those with less stenosis) be confirmed by CEMRA before carotid intervention is undertaken.

Exclusion of alternative embolic sources

- 23.** Carotid duplex ultrasound can only directly evaluate the portion of the extracranial carotid circulation within the neck. Significant disease at other locations, such as the aortic arch or distal internal carotid artery, may be the cause of the embolism.
- 24.** Exclusion of other sources of emboli will require overview imaging techniques that can image from the origin of the carotid artery to the circle of Willis within the brain. Overview imaging techniques include CEMRA and CTA. In rare cases, clots can be formed within the heart, for which echocardiography may be required.
- 25.** All units that examine these patients should have facilities to undertake these examinations.

¹³ Health Technology Assessment 2006; Vol 10: number 30, *Accurate, practical and cost-effective assessment of carotid stenosis in the UK*, London

Summary

- Institutions undertaking carotid imaging will need access to CEMRA, requiring pump driven contrast injection and appropriate MRI software; and
- All carotid imaging needs to be undertaken in laboratories and/or departments that subject themselves to regular audit.

Pathway for higher risk TIA

- Where a brain MRI with DWI is performed within 24 hours it should include CEMRA to detect carotid stenosis.
- Stenosis found in those fit for carotid intervention by either CEMRA or first-line ultrasound duplex ideally should be confirmed with additional imaging (e.g. ultrasound duplex with a different operator, if appropriate, or CTA).
- Lesions identified other than at the carotid bifurcation should also be confirmed by an alternative imaging technique (e.g. CTA or catheter angiography).
- Carotid intervention within 48 hours.

Pathway for lower risk TIA

- Ultrasound duplex as first line investigation.
- Stenosis found in those fit for carotid intervention ideally should be confirmed with additional imaging (e.g. ultrasound duplex with a different operator, or CTA).
- Carotid intervention within two weeks.
- If no stenosis is identified, the need for further investigation of alternative sources of emboli determined by experienced clinical assessment.

NB: Currently, there are a wide range of different criteria used to grade the severity of disease, which can lead to uncertainty and repeat testing. To address this and the confusion around NASCET/ESCT criteria, The Society for Vascular Technology of GB & Ireland (SVT) and Vascular Society (VS) set up a joint working group. This group is therefore representative of the diagnostic needs of vascular surgeons and the specialist vascular scientists and sonographers performing carotid duplex prior to a patient going to surgery.

The aim of the group was to gain consensus on the issues and to produce best practice recommendations. It is envisaged that adoption of these recommendations would lead to a general improvement in performance and uniformity of results of carotid duplex investigations across the country.

The best practice recommendations are now complete and have been through both SVT and VS councils. Final discussions are ongoing about seeking endorsement from other relevant professional groups and the most appropriate place to publish. Both will be influenced by the recognition that these recommendations need to be in the workplace as soon as possible.

Impact on imaging services

The expected workloads calculated below are based on estimates of the number of cases of TIA and stroke in England each year, and on the experience of experts in the field of imaging. They should not be used as targets or as definitive estimates. Local areas will need to use information about local incidence of TIA and stroke to estimate future workload. These figures are a guide and may help those who will struggle to collect information initially.

Expected Workload

1. TIA per 500,000 population
 - 30 patients per week if everyone is referred/attends hospital
 - Most will present between 6am and 11pm
 - Depending on local clinical expertise and practice, approximately 50% will require brain imaging – 2/3 as a matter of urgency (within 24h)
 - Approximately 80 per cent of confirmed TIA patients will require carotid imaging* – 2/3 as a matter of urgency (within 24h)
 - Anticipated imaging during the week = 12 MRI/MRA, 10 for carotid imaging (may also require brain imaging e.g. CT)
 - Anticipated imaging during the weekend = 3 MRI/MRA, 2 of whom will also require urgent carotid imaging
2. Many of these patients are not currently being imaged. Of those that are, few are imaged with any urgency. Both the number of imaging examinations (mainly MRI) and the urgent component will rise very substantially. The same applies to carotid imaging.

* Carotid imaging includes duplex ultrasound and CEMRA

3. Each year in a population of 500,000 about 500 patients will have a TIA, about 400 will have a minor stroke suitable for outpatient assessment, and about 500 will have a TIA-like episode for which an alternative diagnosis is eventually reached. A General Practitioner with a list size of 2,000 patients will see approximately four suspected TIA and two minor strokes each year.
4. Stroke per 500,000 population
 - 25 patients per week if everyone is referred/attends hospital
 - Most will present between 6am and 11pm
 - Virtually all will require brain imaging – more than half as a matter of urgency (in the next scan slot or within one hour)
 - Approximately 10-20 per cent of urgent cases will require further brain imaging, such as MRI (within 24h)
 - Anticipated imaging during the week = 15-17 brain CT and 3-4 brain MRI
 - Anticipated imaging during the weekend = 7-9 per week (1-2 per month requiring further brain imaging).
5. Most of these patients are already being imaged but the proportion examined as a matter of urgency and the proportion undergoing MRI as well or instead of CT will increase.
6. Each year in a population of 500,000 about 1000 patients will have a stroke, and about 300 will have a stroke-like episode for which an alternative diagnosis is eventually reached.

Service organisation

Networks

7. It is becoming increasingly impractical for single organisations to offer first class care for patients with TIA or stroke without being part of a well-defined and managed network. Stroke networks need to include all healthcare organisations involved in the provision of services, for example acute trusts, ambulance trusts and primary care trusts. Networks make the most effective use of resources and expertise. Stroke Improvement, part of NHS Improvement, provide guidance and support for stroke networks.*
8. Although, within a network, some patients will need to be transferred to tertiary units or “hyper-acute stroke centres” for certain aspects of acute care, this does not imply that all imaging must be provided by the centre. Imaging should be performed in the most appropriate setting given the need for timely investigation and treatment. This may mean imaging is performed at a hospital with a stroke unit that accesses support from a tertiary centre or hyper-acute centre to direct clinical management. The National

* www.improvement.nhs.uk/stroke

Diagnostic Imaging Board and the Royal College of Radiologists (RCR) publish information on the use of Teleradiology in such circumstances.¹⁴ The I.T infrastructure to support regional stroke imaging is being developed.

9. Current RCR guidance on the use of Teleradiology is available on the college website, *Teleradiology – A guidance document for Radiologists (2004)*.¹⁵ This document is undergoing revision and is likely to be updated in the latter half of 2008. Guidelines for sharing patients' images between organisations are available on the Connecting for Health (CFH) website and comprise *NHS CFH PACS imaging sharing policy* and *NHS CFH PACS Data Sharing Protocol Templates for Web Server and Host Workstations*.¹⁶ The governance issues apply to CFH and non CFH image sharing solutions.
10. Networks, in consultation with local providers, need to determine the availability of imaging at all sites within the network so that there is clarity of patient pathways for imaging as well as clinical assessment both within and outside normal working hours. This may require the appointment of an imaging lead within the network. Responsibility for rapid image interpretation, whether at the site providing the imaging or remotely by teleradiology, needs to be defined by clear protocols.

Multi-disciplinary Teams

11. Hyper-acute stroke services provide, as a minimum, 24-hour access to brain imaging, expert interpretation and the opinion of a consultant stroke specialist, and thrombolysis for those who can benefit. The importance of regular multi-disciplinary team (MDT) meetings for stroke including input from the imaging department, particularly neuroradiology support, cannot be overemphasised. Funding and staffing to support this contribution, including the appointment within the imaging team of an MDT co-ordinator, may be needed.

Neuroscience expertise

12. Facilities are required to investigate and treat unusual causes of stroke. There are relatively few indications for neurosurgery in patients with stroke, but appropriate intervention in specific cases such as cerebellar haematoma, hydrocephalus and massive peri-infarct oedema may be life-saving. The care of these patients is increasingly managed by a multidisciplinary team in a neurosciences centre consisting of a stroke specialist, neurosurgeon and interventional neuroradiologist. There may also be a role for interventional neuroradiology (intra-arterial thrombolysis or angioplasty) in the management of basilar thrombosis.

Physical facilities

13. Those responsible for siting relevant items of imaging equipment, particularly CT and MR scanners, should take this opportunity to review the location of such equipment

¹⁴ <http://www.18weeks.nhs.uk/Content.aspx?path=/achieve-and-sustain/Diagnostics/Imaging>

¹⁵ <http://www.rcr.ac.uk/index.asp?PageID=310&PublicationID=195>

¹⁶ <http://www.connectingforhealth.nhs.uk/pacs/refdocuments>

within their organisations. Timely access to appropriate imaging requires the equipment to be sited as close as possible to the point of entry of the patient to the hospital. In particular, provision of CT services close to the A&E department is also essential for the modern management of patients with a range of other acute conditions including trauma.

14. Services might wish to consider the potential of high quality, portable ultrasound scanners for 'one stop' carotid imaging in TIA clinics.

Summary

- Stroke networks will need to develop an agreed protocol for resourced support from tertiary or hyper-acute stroke centres;
- Input from imaging to MDT meetings is very important – an MDT coordinator may be required;
- Networks will need to support reaching agreement on access to specialist neuro-intensivist care including interventional neuroradiology and neurosurgery expertise; and
- Physical location of imaging modalities needs to be considered to facilitate urgent imaging.

Workforce

Capacity

15. Existing imaging staffing numbers and skill mix profiles in many areas are insufficient to deliver the required input in TIA and stroke care pathways. Workforce review is therefore needed, along with a workforce plan that defines the care pathway, lists the functions at each stage and the competencies required to perform the functions, and then ensures training is available to support staff to acquire those competencies.
16. The workforce to deliver effective imaging in TIA and stroke includes staff with skill in image acquisition and competent image interpretation and more specialised neuroradiological expertise where required. The requirement for x-ray nursing staff, clerical nursing staff and portering will also need to be taken into account.
17. The Society and College of Radiographers (SCOR) is committed to training all newly trained radiographers to undertake emergency CT brain imaging. However it is important to stress that only senior CT radiographers should be trained to report on images and that additional skills will be required of CT radiographers to undertake CTA.
18. As part of the overall strategy, the Department of Health has published a workforce resource pack online¹⁷ which contains statements from professionals' groups including the role of the radiographer in stroke management and examples of job redesign.

¹⁷ www.dh.gov.uk/stroke

19. The Workforce Review Team is reviewing staffing requirements for stroke imaging as part of its annual review of stroke services and will be publishing their risk assessment in the autumn of 2008.

Training

20. There are specific training requirements both for the performance and interpretation of relevant imaging techniques.
21. The SCOR has developed detailed advice for training in image acquisition. The complexity and demands of this training are likely to increase with the advent of advanced imaging procedures such as CTA and CTP as well as DWMRI and CEMRA.
22. The SCOR has also developed focused image interpretation courses in MRI or CT for experienced senior radiographers. This may contribute to delivery of service in some departments but is unlikely to deliver accurate image interpretation 24 hours a day, seven days a week.
23. The Royal College of Radiologists (RCR) has developed a structured training programme of which neuroradiology is a key component. The first three years of training are supported by an extensive e-learning programme. Neuroradiology is a recognised subspecialty training programme within the College.
24. If other clinical specialists are to contribute to image interpretation to inform the management of stroke, their training and assessment should be equivalent to that provided by the RCR. Training of other clinical groups will require additional support if this is to be provided by existing radiologist trainers.
25. The workforce carrying out carotid ultrasound investigations come from a wide variety of backgrounds (e.g. vascular scientists, sonographers, technologists, nurses). As Duplex ultrasound is operator dependent, requiring significant skill in image and data acquisition and interpretation, ensuring the right competencies are held by this group is essential.
26. Local, regional and national training needs assessments are required for all staff groups involved in stroke patient care and a workforce action plan is highly recommended.
27. Stroke care is being considered as part of the Department of Health's review of curricula in undergraduate and post-graduate training with professional and regulatory bodies. The other national initiative to support strategy implementation is the establishment of a National Training Forum which is taking forward work to establish nationally recognised, quality assured transferable learning programmes in stroke at pre-registration and post-graduate level.

Summary

- A workforce review is needed to develop a workforce plan; outlining the care pathway and functions and competencies required at each stage;
- Local and regional training needs assessments are needed to ensure all staff groups involved in TIA and stroke care receive appropriate training; and
- Training should be put in place to support acquisition of appropriate competencies.

Actions for Implementation from the National Stroke Strategy

28. Investing in imaging services to diagnose TIA and stroke and manage subsequent risk of stroke will result in savings to acute care costs, as more strokes will be prevented.
29. The National Stroke Strategy outlines actions that will need to be taken to achieve the quality markers. Those relevant to imaging of TIA and minor stroke are:
 - Local referral protocols should be agreed between primary and secondary care to facilitate the timely assessment of people who have had a TIA or minor stroke;
 - Review access to brain imaging;
 - Estimate the likely impact on demand for brain imaging;
 - Establish a clear pathway for managing TIA and minor stroke cases – high-risk and others; and
 - Establish a pathway for carotid intervention.
30. Those relevant to imaging of stroke are:
 - Review of access to brain imaging and plan to enable slots at the appropriate time.
31. Further information about how to develop stroke services in line with the quality markers can be found in chapter five of the National Stroke Strategy.

Glossary

This section provides brief descriptions of the technical terms used throughout this document. It is not an exhaustive list, or a set of exhaustive definitions, but should enable those individuals involved in the non-technical aspects of imaging services provision to understand the imaging guide.

Imaging Techniques

Magnetic Resonance (MR) – a non-invasive technique where a strong magnetic field provides an image of tissues in the body or brain. Also:

- **MR Imaging (MRI)** of the brain
- **MR Angiography (MRA)** combines MRI with a contrast agent injected into the bloodstream, giving a more detailed picture of the blood vessels. Ideally, this should be Contrast-Enhanced MRA (CEMRA)
- **Diffusion weighted imaging (DWI)** produces a more detailed image than MRI alone by looking at the local characteristics of water in different areas of the brain
- **Gradient echo sequences (GRE)** are more sensitive to irregularities in the brain, making clots, for example, much more obvious on an image than most other MRI sequences.

Computed Tomography (CT) – an X-ray procedure that uses a computer to produce a detailed picture of a cross section of the body or brain. Also:

- **CT Angiography (CTA)** combines CT with a contrast agent injected into the bloodstream, giving a more detailed picture of the blood vessels
- **CT Perfusion (CTP)** measuring the movement of fluid through the blood vessels to the brain.

Duplex ultrasound – (also known as Duplex ultrasonography) uses a pulsed-doppler (pulses of ultrasound) to look at blood flow and a colour-doppler display to look at the structure of the vessels. Both of these images are displayed simultaneously on screen leading to a 'duplex' view.

General Terminology

Arterial dissection – a tear in the innermost wall of the artery causing blood to pool in the lining of the artery, which can partially or completely block blood flow, leading to ischaemic stroke

Carotid imaging – scanning of the arteries in the neck as blockages in these can lead to stroke

Carotid intervention – treatment, usually surgical, of blockages in the arteries to prevent subsequent stroke. Includes e.g. carotid endarterectomy where the plaque that has blocked up an artery is removed through surgery

Carotid stenosis – plaque that has gathered in the arteries of the neck limiting or blocking blood flow to the brain

Cerebral venous occlusion – a clot in the veins of the brain

Contrast injection/agent – a dye that is injected for imaging, which improves the contrast and therefore the visibility of structures

CT venography – CT imaging of the veins

Embolism – blood vessel blocked by a blood clot, or “embolus”

Lesion – abnormal tissue damaged by disease or trauma. In TIA and stroke, this is caused by disturbed blood supply to the brain

Thrombolysis – treatment for ischaemic stroke that breaks down clots restoring blood flow to the brain

Vertrobasilar TIA – where the source of the TIA is in the artery supplying the brain stem and/or cerebellum, both of which are found at the base of the brain

Appendix

Overview of carotid imaging techniques

Modality	Features
Ultrasound (US)	<p data-bbox="847 904 1023 938">Advantages:</p> <ul data-bbox="847 954 1449 1391" style="list-style-type: none"><li data-bbox="847 954 1449 1032">• Non-invasive screening technique for the carotid bifurcation lesion.<li data-bbox="847 1048 1190 1081">• Relatively inexpensive.<li data-bbox="847 1097 1417 1216">• Cost-effective when performed as first or repeat test in comparison with intra-arterial angiography.<li data-bbox="847 1232 1426 1391">• Generally the most accessible test (but must be performed by expert operators and quality controlled through regular audit practices). <p data-bbox="847 1429 1062 1462">Disadvantages:</p> <ul data-bbox="847 1478 1426 1930" style="list-style-type: none"><li data-bbox="847 1478 1171 1512">• Operator dependent.<li data-bbox="847 1527 1390 1606">• Variable parameters used to signify a significant carotid stenosis.<li data-bbox="847 1621 1399 1740">• Unable to visualise the arch origins or distal ICA and may therefore miss the index lesion.<li data-bbox="847 1756 1426 1834">• Limited by a number of anatomical and physiological parameters.<li data-bbox="847 1850 1094 1883">• sensitivity 0.89.<li data-bbox="847 1899 1094 1933">• specificity 0.84.

Modality	Features
Intra-arterial Angiography (IAA)	<p>Advantages:</p> <ul style="list-style-type: none"> • Historically considered the 'gold standard' for carotid imaging. • The only modality to provide accurate dynamic information and can therefore differentiate trickle flow from collapse distal to a tight stenosis. • The Imaging modality used in the major endarterectomy trials.
	<p>Disadvantages:</p> <ul style="list-style-type: none"> • There is recognized intraobserver variability regarding the degree of stenosis. • It is expensive, not easily accessible and selective carotid angiography has a stroke risk of 1-5%, even in expert hands. • Radiation and iodinated contrast burden.

Modality	Features
CT Angiography (CTA)	<p>Advantages:</p> <ul style="list-style-type: none"> • It is less invasive and presents lower risk than IAA. • Lower radiation burden than IAA. • Generally accessible. • Specificity 0.94 (highest of all non-invasive imaging modalities). <p>Disadvantages:</p> <ul style="list-style-type: none"> • It has lower spatial resolution than IAA. • Iodinated contrast and radiation burden. • Calcification at the bulb can render accurate measurement of the degree of stenosis difficult. • No dynamic information is provided and the technique therefore cannot differentiate between trickle flow and distal collapse. • Sensitivity 0.84 (studies predate MDCT but lowest of all non-invasive imaging modalities).
Magnetic Resonance Angiography (MRA) (Time Of Flight)	<p>Advantages:</p> <ul style="list-style-type: none"> • No (ionising) radiation burden. • No iodinated contrast burden. <p>Disadvantages:</p> <ul style="list-style-type: none"> • Less accessible than other modalities. • Non-contrast techniques are prone to artefacts. • Will not provide dynamic information. • Sensitivity 0.88. • Specificity 0.84.

Modality	Features
Contrast Enhanced MRA (CEMRA)	<p data-bbox="770 394 948 427">Advantages:</p> <ul data-bbox="770 443 1334 667" style="list-style-type: none"><li data-bbox="770 443 1334 521">• The most accurate of the non-invasive imaging modalities.<li data-bbox="770 533 1023 566">• Sensitivity 0.94.<li data-bbox="770 577 1023 611">• Specificity 0.93.<li data-bbox="770 622 1334 667">• CEMRA visualizes the vascular lumen. <p data-bbox="770 701 987 734">Disadvantages:</p> <ul data-bbox="770 750 1334 974" style="list-style-type: none"><li data-bbox="770 750 1334 828">• Availability is <i>currently</i> limited in the NHS.<li data-bbox="770 840 1334 873">• Will not provide dynamic information.<li data-bbox="770 884 1334 974">• Small risks associated with gadolinium (Nephrogenic Systemic Fibrosis).



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