Keywords Stroke/Transient ischaemic attack/FAST checklist/Brain/Imaging

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In this article...

- Definitions of the different types of stroke
- The burden of stroke for individuals and healthcare systems
- Magnetic resonance imaging versus computed tomography in suspected stroke

Stroke 1: definition, burden, risk factors and diagnosis

Nursing Times Self-assessment

Key points

Stroke is an acute, focal injury of the central nervous system of a vascular origin contributing to a neurological insult

Many risk factors predispose a person to stroke, some of which are modifiable through public health policies

If stroke is suspected outside the acute setting, reducing the time to diagnosis and treatment is crucial

Patients with suspected stroke should have a brain scan within one hour of arriving at the hospital

Clinical examination and imaging are both key in diagnosing stroke

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Abstract The field of stroke has benefitted from many advances in recent decades, in particular improved imaging techniques. This, coupled with better knowledge of brain function among professionals and greater awareness of stroke signs and symptoms among the general public, leads to earlier identification, diagnosis and treatment – which are key as stroke is a medical emergency. However, more needs to be done to reduce the personal and societal burden of stroke. This article, the first of a five-part series on stroke, discusses definitions, epidemiology, risk factors and diagnosis to help nurses gain in-depth understanding of this complex condition.

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Stroke is the second-leading single cause of disease in the world, closely behind ischaemic heart disease, and the fourth in the UK, with first-time stroke occurring worldwide every two seconds (World Health Organization, 2017). It is also one of the largest causes of disability: half of all stroke survivors have a disability and over one-third are dependent on carers (Stroke Association, 2016; Moorley et al, 2014).

The media have played a crucial role in raising public awareness of the personal and societal consequences of stroke. Our society has become more cognisant of the function and complexity of the human brain, thanks to enhanced multidisciplinary and international communication, expanding research, increasing media coverage, and high-profile cases such as those of Andrew Marr and Sharon Stone.

Definition

The term 'stroke' was coined and introduced to medicine by William Cole in the late 17th century (Cole, 1689), and has remained a generic definition since. Physiologically, stroke is an acute, focal injury of the central nervous system (CNS) of a vascular origin, contributing to a local or systemic neurological insult. Technological advances (Adams et al, 2007) have proved beneficial in terms of identifying the origins of the injury and determining whether it is a cerebral infarct, subarachnoid haemorrhage or intracerebral bleed. However, despite these improvements, the definition of stroke remains inconsistent (Sacco et al, 2013).

The WHO describes stroke as a clinical syndrome typified by "rapidly developing clinical signs of focal or global disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause apart that of vascular origin" (Hatano, 1976, WHO 1965).

This definition is no longer accurate, as it does not take into account the advances that have been and continue to be made in imaging techniques and diagnostics. The detrimental and permanent effects of stroke can occur much earlier, so the 24-hour inclusion criteria is not accurate. Equally, the deterioration of global

cerebral function can be the result of stroke, but also of other direct or indirect cerebral pathologies.

Stroke is different from transient ischaemic attack (TIA) as its symptoms last longer than 24 hours and it carries an increased risk of mortality; diagnosis is supported by evidence of focal infarction or haemorrhage on imaging. Conversely, a TIA is a dysfunction of vascular origin lasting less than 24 hours, with no evidence of infarction on imaging.

A group of experts convened by the American Heart Association and American Stroke Association (Sacco et al, 2013) has produced consensus definitions in an attempt to accurately describe the different types of stroke (Table 1).

Epidemiology and cost

While the incidence of stroke is declining in many developed countries, it is likely that, with a globally ageing population, the absolute numbers of stroke will increase worldwide. Stroke affects 15 million people worldwide every year; it is estimated that five million of these will die and a further five million will be left with a permanent disability (WHO, 2002). This makes stroke the second-leading cause of death worldwide behind ischaemic heart disease.

In the US, 795,000 strokes occur each year (Benjamin et al, 2017) while in the UK there are more than 100,000 (Royal College of Physicians, 2017). Worldwide, someone has a stroke every two seconds – in the UK it is every five minutes; in the US every 40 seconds – and worldwide, a stroke leading to death occurs every four minutes.

In the UK, first-ever stroke affects about 230 people per 100,000 population each year and accounts for 11% of all deaths (Rothwell et al, 2005). In England and Wales alone, over 80,000 people are hospitalised with acute stroke each year (Intercollegiate Stroke Working Party, 2016).

Approximately 85% of strokes are due to cerebral infarction, 10% to primary haemorrhage and 5% to subarachnoid haemorrhage. The risk of recurrence is 26% within five years and 39% within 10 years of a first stroke (Mohan et al, 2011).

Most strokes occur in people over 40 years of age, but children are also affected. Approximately 400 childhood strokes occur in the UK each year (Stroke Association, 2017). Children with sickle cell disease are 333 times more likely to be at risk than a normal, healthy child (Ohene-Frempong et al, 1998). In the UK, more people are surviving stroke than ever

Fig 1. **Areas of the brain and their functions**

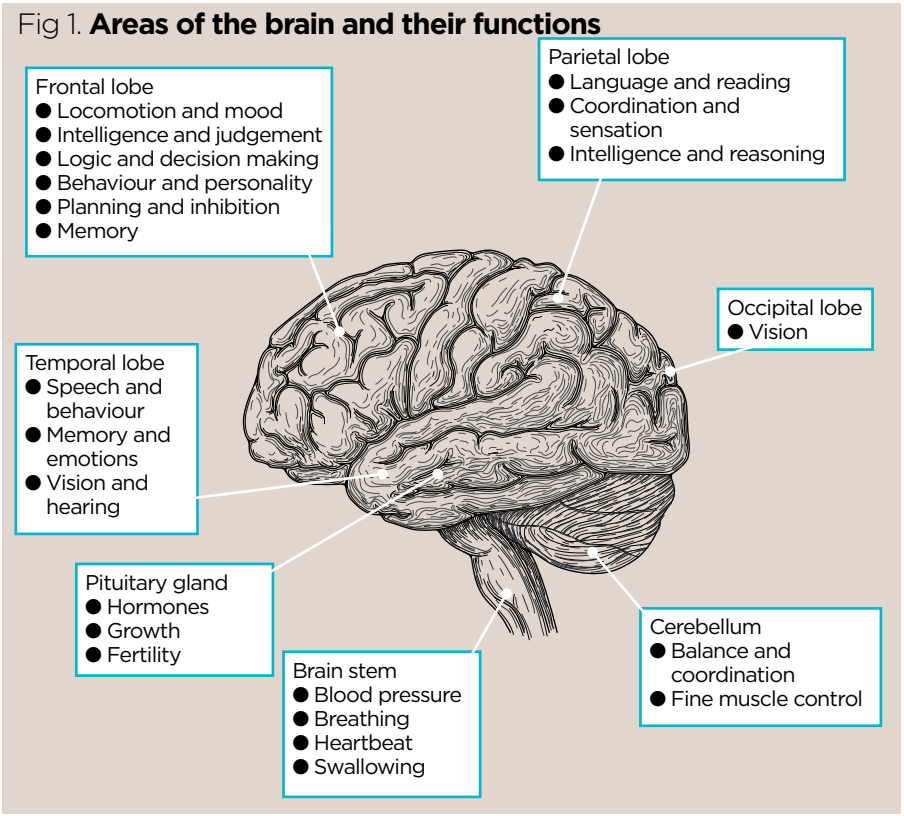

Table 1. **Definitions of stroke**

Type of stroke	Description
Ischaemic stroke	Neurological dysfunction due to infarction at cerebral, spinal or retinal sites
Silent CNS infarction	CNS infarction supported by imaging/neuropathological evidence without prior acute neurodysfunction
Intracerebral haemorrhage	Localised collection of blood in the brain parenchyma/ventricular system that is not induced by trauma
Stroke from intracerebral haemorrhage	Non-trauma-induced, rapid development of neurological symptoms of dysfunction due to localised collection of blood in the brain parenchyma/ventricular system
Silent cerebral haemorrhage	Long-term localised collection of blood in the brain parenchyma/subarachnoid space/ventricular system that is not induced by trauma, with no history of acute neurological dysfunction. Detected on neuroimaging and neuroexamination
Subarachnoid haemorrhage	Bleeding into the space between the arachnoid membrane and the pia mater of the brain or spinal cord
Stroke from subarachnoid haemorrhage	Changes to neurological function and incidence of headaches due to bleeding into subarachnoid space that are not induced by trauma
Stroke from cerebral venous thrombosis	Thrombosis in the cerebral venous structure that causes infarction or haemorrhage
Unspecified stroke	Acute neurological dysfunction due to ischaemia or haemorrhage lasting for more than 24 hours or until death, and lacking evidence allowing categorisation

CNS = central nervous system
Source: Adapted from Sacco et al (2013)

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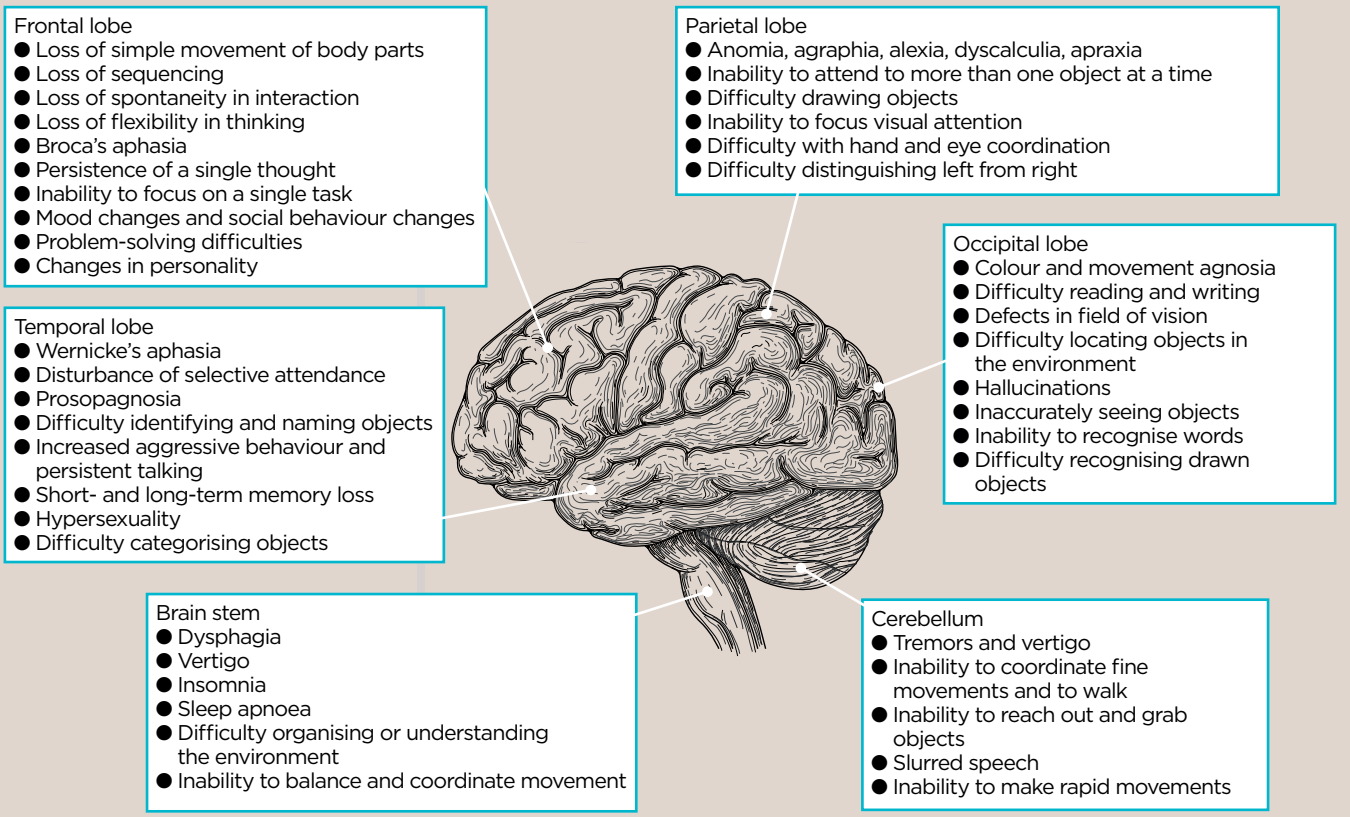
Fig 2. **Potential impairments from stroke according to brain areas**



before; however, it is the largest single cause of major disability. The consequences of a stroke are wide-ranging and often highly debilitating. Fig 1 shows the different areas of the brain and their functions, while Fig 2 shows the potential impairments resulting from stroke according to brain area.

In England, the annual cost to the NHS of caring for stroke patients is estimated to be around £1.7bn, with each patient costing £22,000 per year on average (RCP, 2016a). Previous research found that stroke as a whole costs the UK £9bn a year (Stroke Association, 2014) – this figure includes £2.4bn in informal care costs, £1.3bn in lost income due to disability, death and caring duties, and £800m in benefit payments (Saka et al, 2009).

Risk factors

There are many risk factors that predispose people to stroke, some of which are modifiable. Lack of exercise, poor diet, smoking and excessive alcohol intake are common risk factors that can be countered by cost-effective patient education, and there is an urgent need for government-led strategies aimed at improving public health.

Box 1 and Box 2 feature modifiable and non-modifiable risk factors, respectively (Romero, 2008). Gender, ethnicity and socioeconomic group are further discussed below.

Sex

Men have a higher risk of a stroke than women and often experience stroke at a younger age (RCP, 2017). However, women are more likely to die from stroke, as they tend to live longer and have strokes at an older age (Stroke Association, 2017).

Ethnicity

White people are more likely than non-white people to have atrial fibrillation with a history of smoking or alcohol use, while black people are more likely than white people to have sickle cell disease, hypertension and diabetes – all of which are risk factors for stroke. People of South Asian origins are more likely the rest of the population, to have hypertension, high cholesterol and diabetes (Banerjee et al, 2010).

Socioeconomic group

People from more deprived areas and backgrounds are more likely to have a stroke, and the strokes they experience are likely to be more severe (Marshall et al, 2015). Fifty years ago, stroke was associated with higher socioeconomic groups, but this trend has been reversed as risk factor profiles have changed (WHO, 2011). This reversal is largely due to higher levels of smoking, hypertension and diabetes in lower socioeconomic groups.

Diagnosis

Given the above statistics showing the personal and societal cost of stroke, it is imperative that stroke is efficiently and effectively diagnosed and treated globally. It still carries a high morbidity and mortality and, despite lower incidence, much remains to be done to improve patient outcomes and prevention.

Diagnosis is only possible through a combination of thorough clinical examination, critical review of the patient's history and careful investigations with multi-imaging techniques. Each step adds to the clarity of the eventual diagnosis, consequently improving the chances of patients receiving the right treatment and experiencing better outcomes.

'Time is brain'

Stroke is a medical emergency requiring urgent diagnosis and treatment: the phrase 'time is brain' stressing that human nervous tissue is rapidly lost as stroke progresses (Saver, 2006).

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Box 1. Modifiable risk factors for stroke

High blood pressure – Major risk factor for heart attack and the most important risk factor for stroke
Abnormal blood lipids – High total cholesterol levels, high levels of low-density lipoprotein cholesterol and triglycerides, and low levels of high-density lipoprotein cholesterol increase risk of coronary heart disease and ischaemic stroke
Smoking – Increases risk of cardiovascular disease, especially in people who started young and heavy smokers; passive smoking is also a factor
Physical inactivity – Increases risk of heart disease and stroke by 50%
Obesity – Major risk factor for coronary heart disease and diabetes
Unhealthy diet – Low fruit and vegetable intake is estimated to cause about 31% of coronary heart disease and 11% of stroke worldwide; high intake of saturated fat increases the risk of heart disease and stroke through its effect on blood lipids and thrombosis
Diabetes – Major risk factor for coronary heart disease and stroke

Source: Adapted from Romero et al, 2008

Box 2. Non-modifiable risk factors for stroke

Advancing age – Most powerful independent risk factor for cardiovascular disease; risk of stroke doubles every decade after the age of 55
Heredity or family history – Increased risk if a first-degree blood relative has had coronary heart disease or stroke before the age of 55 (if the relative is a man) or 65 years (if the relative is a woman)
Sex – Higher rates of coronary heart disease in men compared with women of premenopausal age; risk of stroke similar for men and women
Ethnicity – Stroke occurs more often in black, some Hispanic-American, Chinese and Japanese populations; increased number of deaths from cardiovascular disease in South Asian and black American people

Source: Adapted from Romero et al, 2008

Most people experience stroke outside the acute hospital environment, so it is crucial to improve the recognition and immediate management of acute stroke, both among the public and first-responding health professionals.

The publicising of the FAST checklist (Harbison et al, 2003) and widespread media coverage of what to do in case of a TIA or stroke have had an informative and encouraging impact in stimulating public awareness about stroke and its symptoms.

FAST provides a quick checklist of signs and symptoms of stroke and prompts people to urgent action. The acronym stands for:

Face – has the face fallen to one side?
Arms – can both arms be raised and held raised?
Speech – is speech slurred or difficult to understand?
Time – call 999 if any of these signs of stroke are present.

However, while the FAST checklist can help identify the onset of TIA and stroke, it does not take into account certain clinical presentations such as sudden-onset visual disturbance or unilateral and widespread brain dysfunction.

TIAs as a warning sign of stroke

The UK Stroke Association recommends that TIAs – also called mini strokes (Moorley et al, 2014) – are taken as seriously as strokes. A TIA can be viewed as a warning of a forthcoming stroke – approximately 15% of ischaemic strokes (the most common type) are preceded by a TIA, and there is a 5% risk of stroke in the 48 hours following a TIA. It is estimated that 10,000 strokes in the UK could be prevented if TIAs were treated in time (Stroke Association, 2017).

Scan within one hour of hospital arrival

In 2016, the RCP published a revised version of its national clinical guideline for stroke (RCP, 2016b), which highlights how stroke care should be provided in the UK and the importance of reducing the time it takes to diagnose and treat the condition to optimise patients' outcomes.

The guideline includes revised recommendations for patients with suspected acute stroke. One of the main recommendations that differs from the earlier version of the guideline is that all patients with suspected stroke should receive a brain scan within one hour of arriving at hospital.

The 2012 edition recommended scanning only certain patients (such as those who may be eligible for thrombolysis) within one hour and all others within 12 hours. Box 3 contains the key recommendations from the new guideline.

Imaging as a guide to treatment

Computed tomography (CT) and magnetic resonance imaging (MRI) are the two main approaches used for brain imaging studies in the hospital setting. They can be further divided into several types of CT and categories of MRI studies.

With the introduction of better techniques, the goals of brain imaging have shifted to include the detailed evaluation of the intravascular thrombus, identification of hypoperfused tissues and irreversibly infarcted tissues, and evaluation of thrombolytic and thrombectomical treatment approaches (Latchaw et al, 2009).

Therapy is often guided by the use of either CT or MRI. The primary goal of imaging in patients with suspected stroke is to rule out haemorrhage. The current first-line treatment of acute ischaemic stroke, after ruling out haemorrhage, is recombinant tissue plasminogen activator (rt-PA) (Hacke et al, 2008).

The aim of this intravenous, fast-acting therapy is thrombolysis and restarting blood flow around the affected tissues. It should only be used after careful examination of imaging results, as administrating it without a clear diagnosis of the type of stroke can have detrimental effects.

Choosing the imaging technique

One key difference between imaging techniques is that CT can provide static images whereas MRI can deliver static or dynamic cerebral vascular images results rich in diagnostic information. Another important difference is the risk of radiation. Longer exposure to CT scanning carries an increased risk of radiation. With MRI, there is no exposure to harmful ionising radiation, which means its use is favoured over that of CT in clinical settings. Whether detailed CT images are needed for diagnosis is a matter for collaborative clinical judgement.

MRI also has a higher specificity for detecting neurological and vascular malformations, toxic and metabolic disorders, abnormal tissue growth and infection (Hagmann et al, 2007). Thanks to new approaches in medical biophysics used in various MRI techniques, MRI helps differentiate between stroke abnormalities with incredible accuracy and anatomical detail.

Between CT and MRI, the latter prevails as the superior imaging technique due to its high sensitivity, increased definition of results and multimodal functions. However, clinicians are often forced to use CT because of a lack of MRI equipment, patients' fears of the MRI procedure, its high cost, and contraindications linked to

the presence of ferromagnetic and other metallic substances in patients' bodies.

Ultimately, the choice of brain imaging technique depends on the availability of instruments, speed of image acquisition, patient stability, potential risks and clinical expertise available on site.

Stroke assessments

The brain and neurological system constantly produce signs and symptoms that provide clues to diagnosis. There are many technological tools to aid diagnosis, but it can also be achieved by thorough bedside clinical assessment by clinicians with an in-depth understanding of brain anatomy and neurological function.

Stroke requires a patient-centred, culturally appropriate and evidence-based approach to care and treatment (National Institute for Health and Care Excellence, 2017). Stroke assessments should focus on the disabilities and needs of patients and be conducted with relatives and carers, to promote both holistic treatment and collaborative decision-making. It is important to acknowledge spiritual beliefs and cultural specificities to ensure care is delivered sensitively (Moorley et al, 2016).

Conclusion

If left untreated, stroke is a debilitating disease that can lead to death. Current statistics reflect the negative impact of unhealthy lifestyles and genetic and environmental predispositions, and the consequent burden on healthcare systems.

Refining the definitions of the different types of stroke has helped us better understand the disease, improve its diagnosis and tailor its treatment. For all the advances in brain imaging techniques, thorough bedside clinical assessment is key in reaching an accurate diagnosis, which then allows appropriate treatment. The importance of good clinical assessments of patients with suspected stroke cannot be overestimated. **NT**

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Box 3. Diagnosis and treatment guidance

- Patients with suspected acute stroke should receive brain imaging urgently and no later than one hour after arrival at hospital
- Patients with suspected acute stroke should be admitted directly to a hyperacute stroke unit and assessed for emergency treatment by a specialist physician without delay
- Interpreting acute stroke imaging to decide whether to give thrombolytic treatment should only be made by health professionals who have received appropriate training
- Patients with ischaemic stroke who are eligible for endovascular therapy should immediately have a CT angiogram from aortic arch to skull vertex – this should not delay the administration of intravenous thrombolysis
- MRI with stroke-specific sequences (diffusion-weighted imaging, T2) should be performed in patients with suspected acute stroke when there is diagnostic uncertainty

Source: Adapted from Royal College of Physicians (2016b)

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