Clinical diagnosis of stroke subtypes

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INTRODUCTION

The two broad categories of stroke, hemorrhage and ischemia, are diametrically opposite conditions: hemorrhage is characterized by too much blood within the closed cranial cavity, while ischemia is characterized by too little blood to supply an adequate amount of oxygen and nutrients to a part of the brain [1]. Each of these categories can be divided into subtypes that have somewhat different causes, clinical pictures, clinical courses, outcomes, and treatment strategies. As an example, intracranial hemorrhage can be caused by intracerebral hemorrhage (ICH), also called parenchymal hemorrhage, which involves bleeding directly into brain tissue, and subarachnoid hemorrhage (SAH), which involves bleeding into the cerebrospinal fluid that surrounds the brain and spinal cord [1].

This topic will review the categories of stroke and their clinical diagnosis. An overview of the evaluation of stroke and the clinical manifestations of transient cerebral ischemia are discussed separately. (See "Overview of the evaluation of stroke" and "Definition, etiology, and clinical manifestations of transient ischemic attack".)

The classification of stroke is reviewed here briefly and discussed in detail separately. (See "Stroke: Etiology, classification, and epidemiology".)

CLASSIFICATION

Stroke is classified into the following subtypes: intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), and brain ischemia due to thrombosis, embolism, or systemic hypoperfusion.

Brain ischemia — The three main subtypes of brain ischemia are thrombosis, embolism, and hypoperfusion.

- Thrombosis generally refers to local in situ obstruction of an artery. The obstruction may be due to disease of the arterial wall, such as arteriosclerosis, dissection, or fibromuscular dysplasia; there may or may not be superimposed thrombosis. Thrombotic strokes can be divided into either large or small vessel disease (table 1). These two subtypes of thrombosis are worth distinguishing since the causes, outcomes, and treatments are different. Atherosclerosis is by far the most common cause of in situ local disease within the large extracranial and intracranial arteries that supply the brain.

  In patients with thrombosis, the neurologic symptoms often fluctuate, remit, or progress in a stuttering fashion (figure 1). (See 'Clinical course of symptoms and signs' below and "Definition, etiology, and clinical manifestations of transient ischemic attack".)

- Embolism refers to particles of debris originating elsewhere that block arterial access to a particular brain region. Embolic strokes may arise from a source in the heart, aorta, or large vessels (table 1). The embolus suddenly blocks the recipient site so that the onset of symptoms is abrupt and usually maximal at the start (figure 2). Unlike thrombosis, multiple sites within different vascular territories may be affected when the source is the heart (eg, left atrial appendage or left ventricular thrombus) or aorta.

- Systemic hypoperfusion is a more general circulatory problem, manifesting itself in the brain and perhaps other organs. Reduced cerebral blood flow is more global in patients with systemic hypoperfusion and does not affect isolated regions. Symptoms of brain dysfunction typically are diffuse and **nonfocal** in contrast to the other two categories of ischemia. The neurologic signs are typically bilateral, although they may be asymmetric when there is preexisting asymmetrical craniocerebral vascular occlusive disease.

Intracerebral hemorrhage — Bleeding in ICH is usually derived from arterioles or small arteries. The bleeding is directly into the brain, forming a localized hematoma that spreads along white matter pathways. Accumulation of blood occurs over minutes or hours and the neurologic symptoms usually increase gradually over minutes or a few hours. In contrast to brain embolism and SAH, the neurologic symptoms do not begin abruptly and are not maximal at onset (figure 3).

Subarachnoid hemorrhage — Rupture of an aneurysm releases blood directly into the cerebrospinal fluid (CSF) under arterial pressure. The blood spreads quickly within the CSF, rapidly increasing intracranial pressure. Death or deep coma ensues if the bleeding continues. The bleeding usually lasts only a few seconds but rebleeding is very common. With causes of SAH other than aneurysm rupture, the bleeding is less abrupt and may continue over a longer period of time.

Symptoms of SAH begin abruptly in contrast to the more gradual onset of ICH. The sudden increase in pressure causes a cessation of activity (eg, loss of memory or focus or knees buckling). Headache is an invariable symptom and is typically instantly severe and widespread. There are usually no important focal neurologic signs unless bleeding occurs into the brain and CSF at the same time (meningocerebral hemorrhage).

Onset headache is more common in SAH than in ICH, whereas the combination of onset headache and vomiting is infrequent in ischemic stroke (figure 4).

DISTINGUISHING STROKE SUBTYPES

Many findings of the history and physical examination suggest certain stroke subtypes (table 2). This presumptive clinical diagnosis requires confirmation by brain and vascular imaging. (See "Overview of the evaluation of stroke".)

Clinical course of symptoms and signs — The most important historical item for differentiating stroke subtypes is the pace and course of the symptoms and signs and their clearing [1]. Each subtype has a characteristic course [2].

- Embolic strokes most often occur suddenly (figure 2). The deficits indicate focal loss of brain function that is usually maximal at onset. Rapid recovery also favors embolism.
- Thrombosis-related symptoms often fluctuate, varying between normal and abnormal or progressing in a stepwise or stuttering fashion with some periods of improvement (figure 1).
- Penetrating artery occlusions usually cause symptoms that develop during a short period of time, hours or at most a few days (figure 5), compared with large artery-related brain ischemia, which can evolve over a longer period.
- Intracerebral hemorrhage (ICH) does not improve during the early period; it progresses gradually during minutes or a few hours (figure 3).

- Aneurysmal subarachnoid hemorrhage (SAH) develops in an instant. Focal brain dysfunction is less common.

Patients often do not give a specific history regarding the course of neurologic symptoms. It is useful to ask if the patient could walk, talk, use the phone, use the hand, etc, as the events developed after the first symptoms occurred [1].

Neurologic worsening after acute ischemic stroke is not uncommon. In a large prospective study, neurologic deterioration during the acute phase (48 to 72 hours from onset) of cerebral ischemia occurred in 256 (13 percent) of 1964 patients [3]. Deterioration was related mainly to progressive infarction, increased intracranial pressure, recurrent cerebral ischemia, and secondary parenchymal hemorrhage. Independent predictors of neurologic deterioration included the following:

- Internal carotid artery occlusion
- Brainstem infarction
- Middle cerebral artery M1 segment occlusion
- Territorial infarction
- Diabetes mellitus

Silent brain infarcts — Silent brain infarcts (ie, silent strokes) are infarcts identified only by neuroimaging. There is no accompanying clinical history of stroke or TIA. However, this relationship is somewhat clouded because a more detailed history may elicit symptoms to suggest that a lesion is not truly silent [4]. In addition, these lesions seem to be associated with cognitive deficits [5,6]. Therefore, it is more appropriate to refer to these clinically unrecognized lesions as **covert** brain infarcts.

Patients with TIA and minor stroke appear to have a high risk of covert infarcts as well as clinically symptomatic infarcts. This point is illustrated by a study of 143 hospital patients with TIA or minor stroke [7]. On follow-up at 30 days, the risk of new ischemic lesions on magnetic resonance imaging (MRI) diffusion-weighted imaging or fluid-attenuated inversion recovery (FLAIR) sequences was approximately 10 percent, and nearly half of these new lesions were asymptomatic [7].

Covert brain infarction may be more common than symptomatic stroke [8]. In a population-based cross-sectional survey of 267 older adult community residents in Germany, the prevalence of silent stroke was 12.7 percent [9]; the presence of silent stroke was associated with diminished cognitive performance in the domain of procedural speed. Patients with severe atherosclerotic disease may have silent infarcts at younger ages than those without such disease burden [10].

In the Cardiovascular Health Study, 1433 participants with no brain infarcts on a baseline head MRI scan had a repeat head MRI at five years [5]. One or more infarcts were detected in 18 percent of subjects, and these MRI defined infarcts were typically:

- Single infarcts (76 percent)
- Small (3 to 20 mm in 87 percent)
- Subcortical (80 percent)
- Without acute symptoms recognized as a TIA or stroke (89 percent)

Furthermore, these covert infarcts were associated with subtle cognitive change. Subjects with MRI defined infarcts had a significantly greater decline on the Modified Mini-Mental State Examination and Digit Symbol Substitution test than those without infarcts at follow-up. The severity of white matter changes on initial MRI was the strongest predictor of new infarcts.

Covert infarcts may have important prognostic implications for stroke risk and cognitive decline. In the Rotterdam Scan Study, patients with silent brain infarcts were at significantly increased risk for subsequent stroke (adjusted hazard ratio 3.9) [11]. Patients with more than one silent infarct were at higher risk than those with one silent infarct, and patients with more white matter lesions were also at increased risk for subsequent stroke. In another report from the Rotterdam Scan Study, the presence of silent brain infarcts significantly increased the risk of dementia (hazard ratio 2.26) [6]. The presence of silent brain infarcts on the baseline MRI was associated with decreased performance on neuropsychological tests and a steeper decline in global cognitive function.

Ecology and risk factors — Ecology refers to known demographic and historical features that provide probabilities of the patient having one or more of the stroke subtypes. The presence of these risk factors increase the odds that a stroke is due to a particular mechanism, but the clinician cannot make a firm diagnosis simply on the basis of probability.

As examples: some conditions such as hypertension predispose to more than one subtype (thrombosis, ICH); the presence of a prior myocardial infarction increases the likelihood of cardiac origin embolism, but also increases the likelihood of carotid and vertebral artery neck occlusive disease (thrombosis); and an older patient with severe atherosclerosis may also harbor an unexpected cerebral aneurysm.

Age, sex, and race — Age, sex, and race are important demographic variables known to the clinician before taking the history [2].

- Most thrombotic and embolic strokes related to atherosclerosis occur in older patients. Individuals under age 40 rarely have severe atherosclerosis unless they also have

important risk factors such as diabetes, hypertension, hyperlipidemia, smoking, or a strong family history. By contrast, hemorrhages (both ICH and SAH) are common in adolescents and young adults [12]. Cardiac-origin embolism is also common in young people who are known to have heart disease.

- Hypertensive ICH is more common among Black and Asian individuals than among White individuals.

- Premenopausal women have a lower frequency of atherosclerosis than men of similar age unless they have major stroke risk factors. While data are limited, stroke prevalence may be increasing in women aged 45 to 54 years [13].

- Black and Asian populations, and adult females have a lower incidence of occlusive disease of the extracranial carotid and vertebral arteries than adult White males [14-16].

- Small vessel strokes, strokes of undetermined origin and large vessel strokes are more common among Black people compared with White people. (See "Stroke: Etiology, classification, and epidemiology", section on 'Epidemiology'.)

Heart disease — Heart disease, including atrial fibrillation, valvular disease, recent myocardial infarction, and endocarditis, increases the probability of a stroke due to embolism (table 3) [17]. Of these, atrial fibrillation is the most prominent, causing nearly half of all cardioembolic strokes. The risk of stroke appears to be greatly increased after myocardial infarction (MI), particularly in the first 30 days [18,19].

A number of minor cardiac sources of emboli are known but have an uncertain association with stroke. (See "Stroke: Etiology, classification, and epidemiology", section on 'Embolism'.)

Hypertension — Hypertension is the most common and most important stroke risk factor [20,21], including isolated systolic hypertension [22,23]. Epidemiologic studies show that there is a gradually increasing incidence of both coronary disease and stroke as the blood pressure rises above 110/75 mmHg (figure 6) [20,24]. Both prior blood pressure and current blood pressure are important risk factors [25]. However, these observations do not prove a causal relationship, since increasing blood pressure could be a marker for other risk factors such as increasing body weight, which is associated with dyslipidemia, glucose intolerance, and the metabolic syndrome. (See "Metabolic syndrome (insulin resistance syndrome or syndrome X)".)

The best evidence for a causal role of increasing blood pressure in cardiovascular complications is an improvement in outcome with antihypertensive therapy. An overview of 14 hypertension

treatment trials concluded that a long-term (mean five years) 5 to 6 mmHg decrease in the usual diastolic blood pressure was associated with a 35 to 40 percent reduction in stroke [21].

Severe uncontrolled hypertension is a strong risk factor for ICH. A young person who enters the hospital with the acute onset of a focal neurologic deficit and a blood pressure greater than 220/120 mmHg has a high likelihood of having an ICH. In a Korean cohort study, for each 20 mmHg increase in systolic blood pressure, the increased relative risk for hemorrhagic stroke was greater than that for ischemic stroke (3.18 versus 2.23) [26]. For blood pressures greater than 180/110 mmHg, the difference in relative risk was even more pronounced between hemorrhagic and ischemic stroke subtypes (28.83 versus 9.56).

Chronic hypertension is a risk factor for both thrombotic extracranial and intracranial large artery disease and penetrating artery disease. Conversely, the absence of a history of hypertension or of present hypertension reduces the likelihood of ICH and penetrating artery disease.

Smoking — Smoking increases the likelihood of extracranial occlusive vascular disease, nearly doubling the risk of stroke [27,28]. The risk of ischemic stroke decreases over time after smoking cessation. In one series of middle-aged women, for example, the excess risk among former smokers largely disappeared two to four years after cessation [29].

Other risk factors — Other risk factors for stroke include the following:

- Diabetes increases the likelihood of large and small artery occlusive disease and ischemic stroke but has not been shown to predispose to hemorrhagic stroke [30]. However, data from the Nurses' Health Study suggest that type 1 diabetes might also be a risk factor for hemorrhagic stroke [31].

- Elevated total cholesterol and decreased high-density lipoprotein cholesterol have been associated with increased risk of ischemic stroke and large artery stroke in some, but not all, studies. This topic is discussed separately. (See "Overview of secondary prevention of ischemic stroke", section on 'Dyslipidemia'.)

- Elevated serum lipoprotein(a) has been associated with intracranial [32], extracranial [33], and aortic [34] large artery occlusive disease.

- The use of amphetamines increases the likelihood of both ICH and SAH but not brain ischemia. Many younger individuals who suffer an ICH following amphetamine use have an underlying vascular lesion such as an aneurysm or arteriovenous malformation [35].

- Cocaine-related strokes are often hemorrhagic (ICH and SAH), due to hypertensive surges and aneurysms [36]. Cocaine is also associated with brain ischemia, especially involving the posterior circulation intracranial arteries; this is probably due to vasoconstriction [37]. (See "Clinical manifestations, diagnosis, and management of the cardiovascular complications of cocaine abuse", section on 'Stroke'.)

- Stroke during the puerperium has an increased likelihood of being related to venous or arterial thrombosis.

- The presence of a known bleeding disorder or prescription of oral anticoagulants predisposes to hemorrhage, into either the brain or the cerebrospinal fluid.

- Phenylpropanolamine in appetite suppressants appears to be an independent risk factor for hemorrhagic stroke (including ICH and SAH) in women, especially in those who take a higher than recommended amount [38].

The link between stroke and oral contraceptive use has been a controversial issue. Initial studies suggesting this association were performed with oral contraceptives containing higher doses of estrogen [39]; the risk may not be as great with current low dose oral contraceptives. (See "Combined estrogen-progestin contraception: Side effects and health concerns".)

Other historical features

Previous transient ischemic attack — A history of transient ischemic attack (TIA), especially more than one, in the same territory as the stroke strongly favors the presence of a local vascular lesion (thrombosis). Attacks in more than one vascular territory suggest brain embolism from the heart or aorta. TIAs are not a feature of brain hemorrhage.

Patients often will not volunteer a prior history of symptoms consistent with a TIA. Many patients, for example, do not relate prior hand or eye problems to subsequent leg problems. Thus, the physician must ask directly about specific symptoms. "Did your arm, hand, or leg ever transiently go numb?" "Did you ever having difficulty speaking?" "Did you ever lose vision? If so, in what part of your vision? Was it in one eye and, if so, which one?"

Activity at the onset or just before the stroke — Hemorrhages (ICH and SAH) can be precipitated by sex or other physical activity, while thrombotic strokes are unusual under these circumstances. Trauma before the stroke suggests traumatic dissection or occlusion of arteries or traumatic brain hemorrhage. Sudden coughing and sneezing sometimes precipitates brain embolism. Similarly, getting up during the night to urinate seems to promote brain embolism (a matutinal embolus). There is a trend toward clustering of ischemic stroke in the morning hours,

but insufficient specificity to predict with any reasonable likelihood the stroke subtype according to the circadian pattern of symptom onset [40].

Associated symptoms — The presence of fever, headache, vomiting, seizures, and hypotension are suggestive of specific stroke subtypes.

- Fever raises the suspicion of endocarditis and resulting embolic stroke.
- Infections activate acute phase blood reactants, thereby predisposing to thrombosis.
- Severe headache at the onset of neurologic symptoms favors SAH, while headache that develops after symptom onset that is accompanied by gradually increasing neurologic signs, decreased consciousness, and vomiting is most often indicative of ICH (figure 4). Some patients have headaches in the prodromal period before thrombotic strokes. A prior history of intermittent severe headaches that are instantaneous in onset, persist for days, and prevent daily activities often reflects the presence of an aneurysm.
- Vomiting is common in patients with ICH, SAH, and posterior circulation large artery ischemia (figure 4).
- Seizures in the acute phase of stroke are most often seen in patients with lobar ICH or brain embolism; they are less common in patients with acute thrombosis [41]. In a population-based study, the incidence of seizures within the first 24 hours of stroke onset for SAH, ICH, and ischemic stroke was 10, 8, and 3 percent, respectively [42].
- Reduced alertness favors the presence of hemorrhage. Accompanying neurologic signs are suggestive of ICH, while the absence of focal signs suggests SAH. Reduced consciousness may also occur with thrombotic and embolic strokes that are large or involve the posterior circulation large arteries. In particular, ischemia involving the tegmentum of the pons can cause loss of consciousness. Large hemispheric infarcts are typically followed by edema that can progress to coma.

CLINICAL EVALUATION

General physical examination — Important clues in the general physical examination include the following:

- Absent pulses (inferior extremity, radial, or carotid) favors a diagnosis of atherosclerosis with thrombosis, although the sudden onset of a cold, blue limb favors embolism.

- The internal carotid arteries in the neck cannot be reliably palpated but, in some patients, occlusion of the common carotid artery in the neck can be diagnosed by the absence of a carotid pulse.

- The presence of a neck bruit suggests the presence of occlusive extracranial disease, especially if the bruit is long, focal, and high pitched.

- Palpating the facial pulses is helpful in diagnosing common carotid and internal carotid artery occlusions and temporal arteritis. The facial pulses on the side of the occlusion are often lost with common carotid artery occlusions. By contrast, some patients with internal carotid artery occlusion will have increased facial pulses on the side of the occlusion because collateral channels develop between the external carotid artery facial branches and the carotid arteries intracranially.

- Cardiac findings, especially atrial fibrillation, murmurs and cardiac enlargement, favor cardiac-origin embolism. (See "Auscultation of cardiac murmurs in adults".)

- Careful examination of the optic fundus may reveal a cholesterol crystal, white platelet-fibrin, or red clot emboli. Subhyaloid hemorrhages in the eye suggest a suddenly developing brain or SAH. When the carotid artery is occluded, the iris may appear speckled and the ipsilateral pupil can become dilated and poorly reactive. The retina in that circumstance may also show evidence of chronic ischemia (venous stasis retinopathy).

Neurologic examination — The patient's account of his or her neurologic symptoms and the neurologic signs found on examination tell more about the location of the process in the brain than the particular stroke subtype. Nevertheless, the presence of some constellations of symptoms and signs occasionally suggests a specific process. As examples:

- Weakness of the face, arm, and leg on one side of the body unaccompanied by sensory, visual, or cognitive abnormalities (pure motor stroke) favors the presence of a thrombotic stroke involving penetrating arteries or a small ICH.

- Large focal neurologic deficits that begin abruptly or progress quickly are characteristic of embolism or ICH.

- Abnormalities of language suggest anterior circulation disease, as does the presence of motor and sensory signs on the same side of the body (figure 7).

- Vertigo, staggering, diplopia, deafness, crossed symptoms (one side of the face and other side of the body), bilateral motor and/or sensory signs, and hemianopsia suggest

involvement of the posterior circulation. (See "Posterior circulation cerebrovascular syndromes".)

- The sudden onset of impaired consciousness in the absence of focal neurologic signs is characteristic of SAH. (See 'Clinical course of symptoms and signs' above.)

Neuroimaging — In the evaluation of acute stroke, imaging studies are necessary to identify hemorrhage as a cause of the deficit, and they are useful to assess the degree of brain injury and to identify the vascular lesion responsible for the ischemic deficit. Advanced CT and MRI technologies are able to distinguish between brain tissue that is irreversibly infarcted and that which is potentially salvageable, thereby allowing better selection of patients who are likely to benefit from therapy. (See "Neuroimaging of acute stroke".)

Biomarkers — Numerous biomarkers and panels of biomarkers have been studied to improve the early diagnosis of stroke. Two blood biomarkers, NT-proBNP and D-dimer, may have the strongest data to support clinical use in differentiating stroke mechanism, but none have sufficient sensitivity or specificity for routine clinical use. They must be interpreted in the context of the clinical and other laboratory findings. These issues are discussed in greater detail elsewhere. (See "Blood biomarkers for stroke".)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Stroke in adults".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a

variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Stroke (The Basics)")
- Beyond the Basics topics (see "Patient education: Stroke symptoms and diagnosis (Beyond the Basics)")

SUMMARY

- **Classification** – Stroke is classified into three main subtypes: intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), and ischemic stroke. The classification of stroke is discussed in detail separately. (See "Stroke: Etiology, classification, and epidemiology".)
- **Distinguishing stroke subtypes** – Patient demographic variables, the presence of stroke risk factors, and findings from the history and physical examination may suggest certain stroke subtypes (table 2). This presumptive clinical diagnosis requires confirmation by brain and vascular imaging. (See 'Distinguishing stroke subtypes' above.)
- **Clinical course** – The most important historical item for differentiating stroke subtypes is the pace and course of the symptoms and signs and their clearing. Embolic strokes most often occur suddenly (figure 2). Thrombosis-related symptoms often fluctuate (figure 1). Penetrating artery occlusions usually cause symptoms that develop during a short period of time, hours or at most a few days (figure 5), whereas large artery-related brain ischemia can evolve over a longer period. Intracerebral hemorrhage (ICH) does not improve during the early period; it progresses gradually during minutes or a few hours (figure 3). Aneurysmal subarachnoid hemorrhage (SAH) develops in an instant. Focal brain dysfunction is less common. (See 'Clinical course of symptoms and signs' above.)
- **Ecology and risk factors** – Ecology refers to known demographic and historical features that provide probabilities of the patient having one or more of the stroke subtypes. The presence of these risk factors increases the odds that a stroke is due to a particular mechanism, but the clinician cannot make a firm diagnosis simply on the basis of probability.
  - Age, sex, and race (see 'Age, sex, and race' above)
  - Heart disease and atrial fibrillation (see 'Heart disease' above)
  - Hypertension (see 'Hypertension' above)
  - Smoking (see 'Smoking' above)

- Hyperlipidemia and diabetes (see 'Other risk factors' above)

- **Other historical features** – A history of transient ischemic attack (TIA), activity just before or at the time of stroke onset, and associated symptoms (eg, fever, severe headache, vomiting, seizure, reduced alertness) are additional features that may favor particular stroke subtypes. (See 'Other historical features' above.)

- **Clinical evaluation** – The general physical examination may provide clues suggesting a particular stroke subtype. As an example, the presence of atrial fibrillation favors embolism from the heart. The symptoms and signs found on neurologic examination tell more about the stroke localization than the particular stroke subtype. However, some constellations of symptoms and signs occasionally suggest a specific process; as an example, unilateral weakness unaccompanied by sensory, visual, or cognitive abnormalities (pure motor stroke) favors the presence of a thrombotic stroke involving penetrating arteries or a small ICH. (See 'Clinical evaluation' above.)

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GRAPHICS

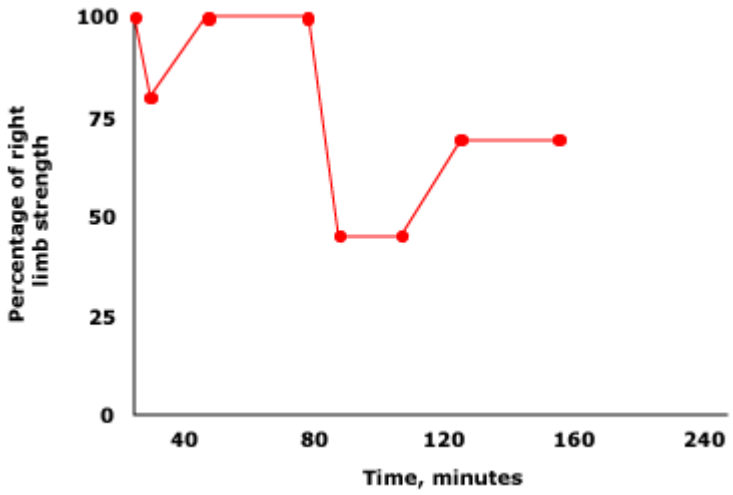
Pathophysiologic ischemic stroke classification

Large vessel atherothrombotic stroke
More common
Bifurcation of the common carotid artery
Siphon portion of the common carotid artery
Middle cerebral artery stem
Intracranial vertebral arteries proximal to middle basilar artery
Origin of the vertebral arteries
Less common
Origin of the common carotid artery
Posterior cerebral artery stem
Origin of the major branches of the basilar-vertebral arteries
Origin of the branches of the anterior, middle, and posterior cerebral arteries
Small vessel (lacunar) stroke
Mechanism
Lipohyalinotic occlusion
Less frequently proximal atherothrombotic occlusion
Least likely embolic occlusion
Most common locations
Penetrating branches of the anterior, middle, and posterior cerebral and basilar arteries
Cardioaortic embolic stroke
Cardiac sources definite - antithrombotic therapy generally used
Left atrial thrombus
Left ventricular thrombus
Atrial fibrillation and paroxysmal atrial fibrillation
Sustained atrial flutter
Recent myocardial infarction (within one month)
Rheumatic mitral or aortic valve disease

Bioprosthetic and mechanical heart valve
Chronic myocardial infarction with ejection fraction <28 percent
Symptomatic heart failure with ejection fraction <30 percent
Dilated cardiomyopathy
Cardiac sources definite - anticoagulation hazardous
Bacterial endocarditis (exception nonbacterial)
Atrial myxoma
Cardiac sources possible
Mitral annular calcification
Patent foramen ovale
Atrial septal aneurysm
Atrial septal aneurysm with patent foramen ovale
Left ventricular aneurysm without thrombus
Isolated left atrial spontaneous echo contrast ("smoke") without mitral stenosis or atrial fibrillation
Mitral valve strands
Ascending aortic atheromatous disease (>4 mm)
True unknown source embolic stroke
Other
Dissection
Moyamoya
Binswanger's disease
Primary thrombosis
Cerebral mass

Graphic 55099 Version 4.0

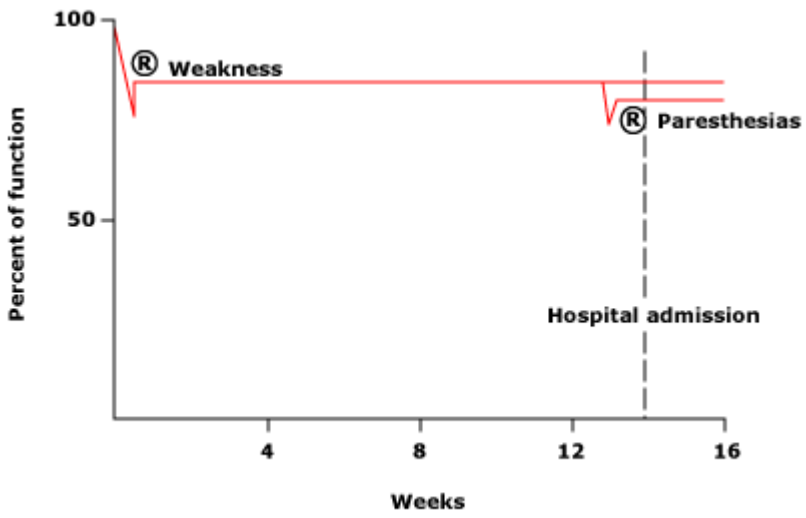
Stuttering time course of thrombotic stroke



The course of weakness of the right limb in a patient with a thrombotic stroke reveals fluctuating symptoms, varying between normal and abnormal, progressing in a stepwise or stuttering fashion with some periods of improvement.

Graphic 64107 Version 2.0

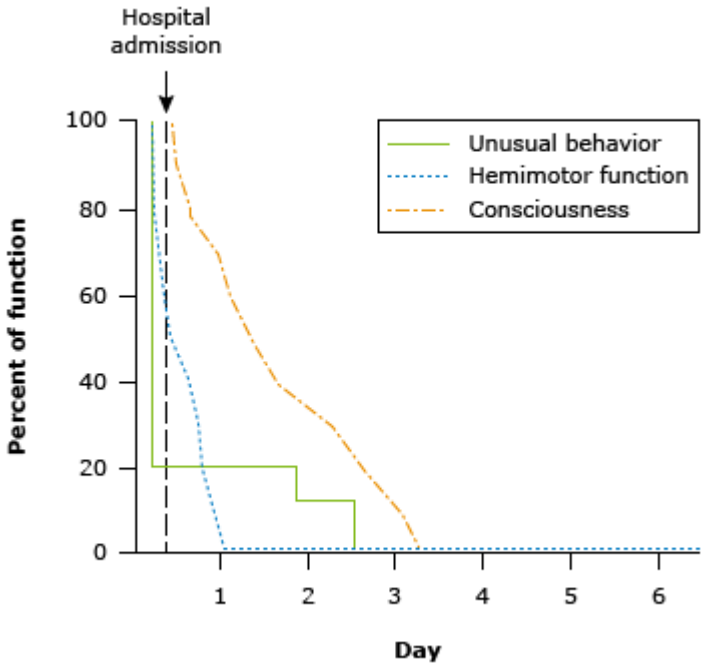
Time course of embolic stroke



Embolic stroke occurs suddenly, with symptoms maximal at onset. This patient had multiple embolic events with different clinical symptoms (initially weakness, followed by paresthesias).

Graphic 73261 Version 1.0

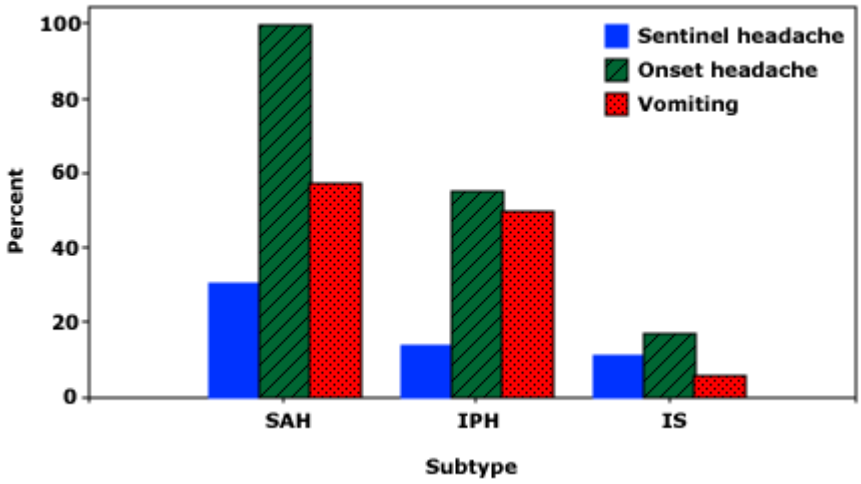
Time course of neurologic changes in intracerebral hemorrhage



Schematic representation of rapid downhill course in terms of unusual behavior (solid line), hemimotor function (dotted line), and consciousness (dash-dotted line) in a patient with intracerebral (intraparenchymal) hemorrhage.

Graphic 61491 Version 3.0

Headache and vomiting in stroke subtypes



The frequency of sentinel headache, onset headache, and vomiting in three subtypes of stroke: subarachnoid hemorrhage, intraparenchymal (intracerebral) hemorrhage, and ischemic stroke. Onset headache was present in virtually all patients with SAH and about one-half of those with IPH; all of these symptoms were infrequent in patients with IS.

SAH: subarachnoid hemorrhage; IPH: intraparenchymal (intracerebral) hemorrhage; IS: ischemic stroke.

Data from: Gorelick PB, Hier DB, Caplan LR, Langenberg P. Headache in acute cerebrovascular disease. Neurology 1986; 36:1445.

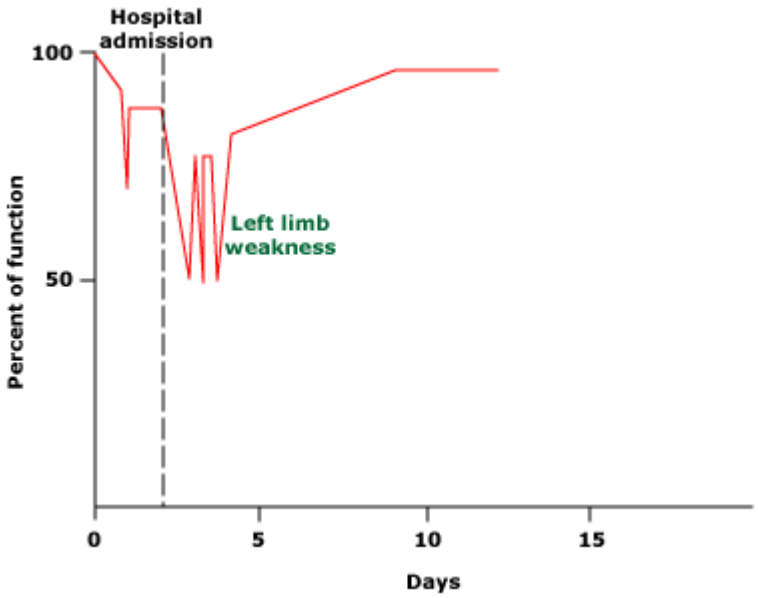
Graphic 60831 Version 4.0

Characteristics of stroke subtypes

Stroke type	Clinical course	Risk factors	Other clues
Intracerebral hemorrhage	Gradual onset and progression during minutes or hours in most patients, but may present abruptly with maximal deficit at onset.	Hypertension, trauma, bleeding diatheses, illicit drugs (eg, amphetamines, cocaine), vascular malformations. More common in Black people and Asian people than in White people.	May be precipitated by sex or other physical activity. Patient may have reduced alertness
Subarachnoid hemorrhage	Abrupt onset of sudden, severe headache. Focal brain dysfunction less common than with other types.	Smoking, hypertension, moderate to heavy alcohol use, genetic susceptibility (eg, polycystic kidney disease, family history of subarachnoid hemorrhage) and sympathomimetic drugs (eg, cocaine)	May be precipitated by sex or other physical activity. Patient may have reduced alertness
Ischemic (thrombotic)	Stuttering progression with periods of improvement. Lacunes develop over hours or at most a few days; large artery ischemia may evolve over longer periods.	Atherosclerotic risk factors (age, smoking, diabetes mellitus, etc). Males affected more commonly than females. May have history of TIA.	May have neck bruit.
Ischemic (embolic)	Sudden onset with deficit maximal at onset. Clinical findings may improve quickly.	Atherosclerotic risk factors as listed above. Males affected more commonly than females. History of heart disease (valvular, atrial fibrillation, endocarditis).	Can be precipitated by getting up at night to urinate o sudden coughing or sneezing.

Graphic 69907 Version 5.0

Time course of lacunar infarction



Penetrating artery occlusions usually cause symptoms that develop over a short period of time, hours or at most a few days, compared to large artery-related brain ischemia which can evolve over a longer period. A stuttering course may ensue, as with large artery thrombosis. This patient had a pure motor hemiparesis.

Graphic 52246 Version 1.0

Cardioaortic sources of cerebral embolism

Sources with high primary risk for ischemic stroke	Sources with low or uncertain primary risk for ischemic stroke
Atrial fibrillation	**Cardiac sources of embolism:**
Paroxysmal atrial fibrillation	Mitral annular calcification
Left atrial thrombus	Patent foramen ovale
Left ventricular thrombus	Atrial septal aneurysm
Sick sinus syndrome	Atrial septal aneurysm and patent foramen ovale
Atrial flutter	Left ventricular aneurysm without thrombus
Recent myocardial infarction (within one month prior to stroke)	Left atrial spontaneous echo contrast ("smoke")
Mitral stenosis or rheumatic valve disease	Congestive heart failure with ejection fraction <30%
Mechanical heart valves	Bioprosthetic heart valves
Chronic myocardial infarction together with low ejection fraction (<28%)	Apical akinesia
Dilated cardiomyopathy (prior established diagnosis or left ventricular dilatation with an ejection fraction of <40% or fractional shortening of <25%)	Wall motion abnormalities (hypokinesia, akinesia, dyskinesia) other than apical akinesia
Nonbacterial thrombotic endocarditis	Hypertrophic cardiomyopathy
Infective endocarditis	Left ventricular hypertrophy
Papillary fibroelastoma	Left ventricular hypertrabeculation/non-compaction
Left atrial myxoma	Recent aortic valve replacement or coronary artery bypass graft surgery
Presence of left ventricular assist device	Paroxysmal supraventricular tachycardia
	Aortic sources of embolism:
	Complex atheroma in the ascending aorta or proximal arch (protruding with >4 mm thickness or mobile debris, or plaque ulceration)

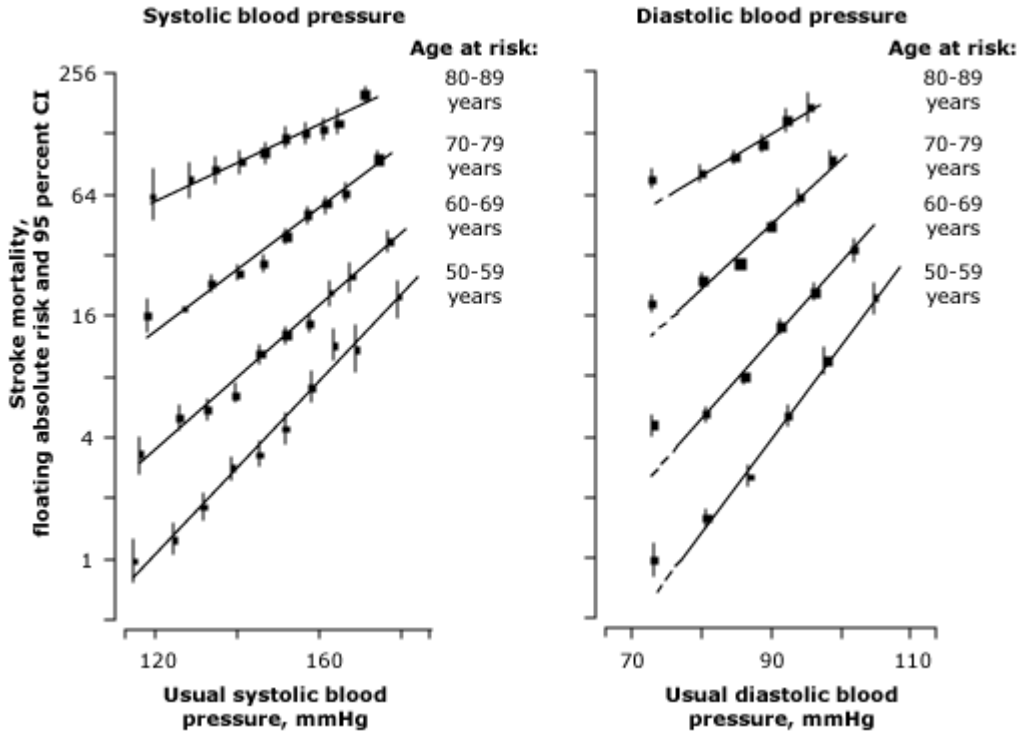
The high- and low-risk cardioaortic sources in this table are separated using an arbitrary 2% annual or one-time primary stroke risk threshold.

Data from:

1. *Ay H, Benner T, Arsava EM, et al. A computerized algorithm for etiologic classification of ischemic stroke: the Causative Classification of Stroke System. Stroke 2007; 38:2979.*
2. *Ay H, Furie KL, Singhal A, et al. An evidence-based causative classification system for acute ischemic stroke. Ann Neurol 2005; 58:688.*
3. *Arsava EM, Ballabio E, Benner T, et al. The Causative Classification of Stroke system: an international reliability and optimization study. Neurology 2010; 75:1277.*
4. *Kamel H, Elkind MS, Bhave PD, et al. Paroxysmal supraventricular tachycardia and the risk of ischemic stroke. Stroke 2013; 44:1550.*
5. *Kirklin JK, Pagani FD, Kormos RL, et al. Eighth annual INTERMACS report: Special focus on framing the impact of adverse events. J Heart Lung Transplant 2017; 36:1080.*

Graphic 60843 Version 11.0

Stroke mortality related to blood pressure and age



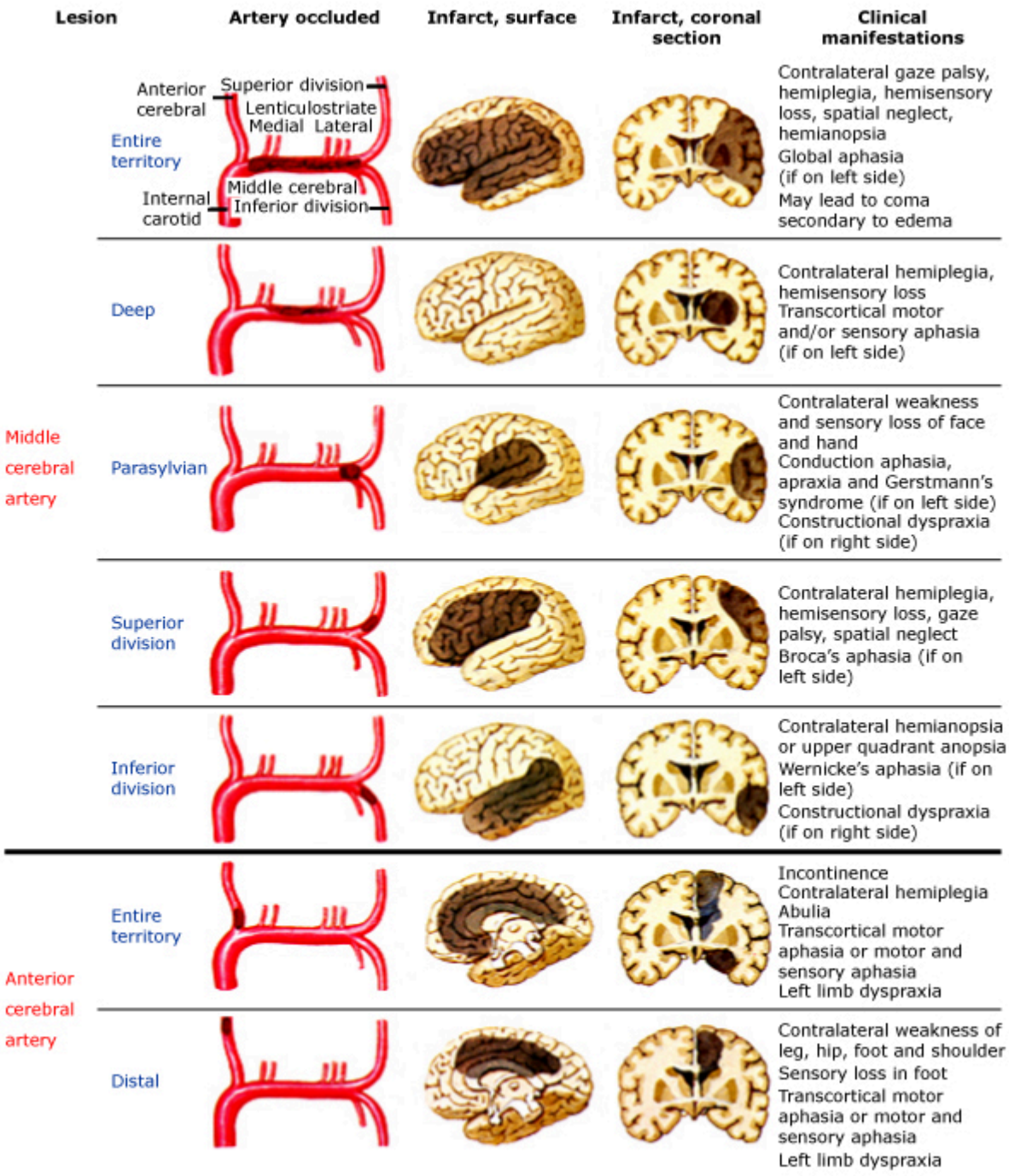
Stroke mortality rate, pictured on a log scale with 95% CI, in each decade of age in relation to the estimated usual systolic and diastolic blood pressure at the start of that decade. Stroke mortality increases with both higher pressures and older ages. For diastolic pressure, each age-specific regression line ignores the left-hand point (ie, at slightly less than 75 mmHg) for which the risk lies significantly above the fitted regression line (as indicated by the broken line below 75 mmHg).

CI: confidence interval.

Data from Prospective Studies Collaboration, Lancet 2002; 360:1903.

Graphic 66793 Version 5.0

Occlusion of middle and anterior cerebral arteries



Graphic 69630 Version 1.0