Section I Cerebrovascular disease

Chapter 1

Cerebral venous sinus thrombosis

Jonathan C. Roberts and Christopher M. Fischer

Cerebral venous sinus thrombosis (CVST) is an uncommon cause of stroke. Arterial strokes are much more common. CVST more commonly affects younger adults and children and can be associated with significant rates of morbidity and mortality.

Diagnosing CVST requires a high index of suspicion, as the presenting symptoms can be highly variable and their onset can be subacute. Few large clinical investigations of CVST have been performed; therefore, much controversy and misunderstanding persist surrounding its clinical presentation, diagnosis, and management.

Anatomy

The cerebral venous sinus network, a series of vascular channels suspended within the dura mater, drains cerebrospinal fluid (CSF) and venous blood from the brain into the systemic venous circulation. CSF bathes the central nervous system (CNS) and provides the brain and spinal column with a protective cushion. CSF is produced by the choroid plexus and modified ependymal cells found within the lateral third and fourth ventricles. It flows through a ventricular system into the subarachnoid space, where it eventually passes through arachnoid villi into cerebral venous sinuses. Venous blood also drains from deeper cortical veins into this same sinus system.

The major cerebral venous sinuses are the superior and inferior sagittal sinuses, the straight sinus, the transverse sinuses, the sigmoid sinuses, the cavernous sinuses, and the superior and inferior petrosal sinuses. Disruption of this vascular sinus network can impair venous and CSF outflow, causing hydrocephalus and catastrophic changes in cerebral perfusion pressure, along with possible infarction and hemorrhage.

Pathophysiology

CVST is a rare form of stroke, caused by a blockage of this drainage system. Thrombosis may be confined to the large cerebral venous sinuses or may involve the deeper cortical veins. Isolated thrombosis of a large cerebral venous sinus impairs venous drainage and CSF absorption, which results in an elevation of intracranial pressures. This can cause abrupt alterations in consciousness and impaired vital functions by affecting perfusion of the brainstem. Thrombosis of draining cortical veins results in cytotoxic and vasogenic edema with possible subsequent capillary rupture, hemorrhage, and infarction from impaired perfusion.

If collateral circulation remains intact, patients may present with extremely subtle symptoms and physical examination findings. Thrombus progression to multiple venous sinuses and cortical veins with impaired collateral circulation may cause more focal neurologic signs, seizures, and altered mental status.[1,2]

Epidemiology and risk factors

CVST has an annual incidence of two to four per million[3] and an overall mortality rate approximating 8%.[4] Although the exact incidence is unknown, CVST is thought to account for 1 to 2% of all strokes. While arterial stroke tends to affect older patients, with a slight male predominance,[5] CVST affects predominantly younger patients, with peaks in childhood and in the fourth and fifth decades of life, and with a 3 : 1 female predominance.[4]

There are numerous risk factors for the development of CVST (Table 1.1). Genetic or acquired prothrombotic states are found in more than 85%

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Table 1.1 Causes of and risk factors for development of cerebral venous sinus thrombosis

Medications
Oral contraceptives
Genetic prothrombotic tendencies
Factor V Leiden mutation
Protein C and protein S deficiency
Antithrombin deficiency
Prothrombin mutation
Acquired prothrombotic states
Pregnancy and peripartum period
Nephrotic syndrome
Dehydration
Hematologic conditions
Polycythemia
Thrombocytosis
Leukemia
Mechanical causes
Head trauma
Neurosurgical procedures
Lumbar puncture
Infection
Mastoiditis, otitis, sinusitis
Meningitis
Inflammatory disease
Inflammatory bowel disease
Systemic lupus erythematosus
Sarcoidosis
Adapted from Stam.[1]

of patients with CVST.[1,6] Oral contraceptive use is the most commonly identified risk factor for CVST; several case-control studies demonstrated a greater than 10-fold increase in risk among women using those medications.[7,8] Infections, including otitis media and mastoiditis, may also predispose individuals to CVST. Trauma can disrupt the normal vascular channel anatomy and lead to thrombosis. The risk of CVST increases during pregnancy and the immediate postpartum period.[1] Other risk factors include disease processes that induce a prothrombotic state. These include factor V Leiden mutation, protein S and C deficiency, antithrombin III deficiencies, inflammatory bowel disease, and malignancy. Despite extensive evaluation, no clear cause is identified in approximately 20% of cases. Case reports have described rare associations between CVST and paroxysmal nocturnal hemoglobinuria,[9] heparin-induced thrombocytopenia,[10] and even lumbar puncture.[11]

Clinical presentation

CVST is a very rare form of stroke with variable presentations. The variable nature of the symptoms and the subtle presentation can often delay diagnosis. In one study, investigators found the median delay between symptom onset and diagnosis of CVST was seven days.

History

Headache is the most common presenting symptom of CVST, present in more than 75% of patients. The nature of the headache can be highly variable and is not helpful in distinguishing CVST from other causes of headache. Up to 15% of patients may report sudden onset of a thunderclap headache more typical of subarachnoid hemorrhage.[12] Other neurologic symptoms may be associated with increased intracranial pressure and include dizziness, nausea, and visual disturbances. Focal or generalized seizures may be part of the initial presentation and occur in as many as half of patients.[13] Seizures may be even more common in peripartum women with CVST.[14] Other possible focal neurologic symptoms include focal weakness, sensory deficits, aphasia, and visual field deficits. Coma and stupor may result from dramatic increases in intracranial pressure and are a poor prognostic sign.

CVST can mimic other conditions. The combination of headache, visual disturbances, and papilledema can also be found in idiopathic intracranial hypertension (pseudotumor cerebri). In one study, 10% of 106 patients diagnosed with presumed idiopathic intracranial hypertension were ultimately found to have CVST.[15]

Physical examination

Careful neurologic examination is important to elicit the sometimes subtle findings that can be associated with CVST. Cranial nerve examinations may demonstrate papilledema, nerve palsies, or visual field deficits. Focused neurologic examination may elicit focal weakness or signs that accompany increased

intracranial pressure, including gait instability and abnormal reflexes.

Diagnosis

Diagnosing CVST depends on a high index of suspicion and appropriate imaging studies. Imaging may also provide prognostic information for patients with CVST. The extent of venous sinus involvement and the presence of intraparenchymal hemorrhage may correlate with functional outcome.[2]

Non-invasive imaging

Unenhanced brain computed tomography (CT) is useful in identifying secondary signs of CVST, including hemorrhagic infarction, brain edema, mass effect, hydrocephalus, subdural effusion, and subarachnoid hemorrhage. It may also infrequently identify primary signs of CVST, including the dense triangle sign and the cord sign. The dense triangle sign or delta sign represents a hyperintense thrombus within the superior sagittal sinus and may be visible on axial images through the superior sagittal sinus. The cord sign represents a hyperintense thrombus within a deeper cortical vein.[16] However, only 25% of patients with CVST demonstrate these signs on unenhanced brain CT.[17] The most common finding on an unenhanced CT scan is a non-arterial distribution of areas of hemorrhage – this finding represents the venous congestion resulting from venous thrombosis.

Enhanced brain CT has emerged as a possible alternative to magnetic resonance imaging/magnetic resonance venography (MRI/MRV) for non-invasive diagnosis of CVST. Computed tomography venography (CTV) imaging protocols use intravenous contrast to highlight draining cortical and dural venous sinuses and can thus readily identify filling defects. The empty delta sign represents an occlusive thrombus within the venous sinus, which prevents contrast-mediated enhancement, and is found in 30% of patients with known CVST.[17] Disadvantages of CTV include exposure to ionizing radiation, exposure to iodinated contrast, and hyperdense bony artifact requiring digital subtraction techniques for optimal image quality. Many authors suggest that CTV's sensitivity and specificity for identifying CVST are equivalent to those for the more time-consuming magnetic resonance (MR) techniques.

Unenhanced brain MRI is more sensitive than unenhanced brain CT in identifying CVST. Using intravenous contrast and time-of-flight techniques, enhanced brain MRV is able to reliably detect alterations in cerebral venous flow, identifying CVST with an overall sensitivity and specificity similar to those for CTV. In addition, MR techniques may be able to identify deeper cortical vein thrombus more readily than CT.[18]

A proposed CVST management algorithm published by the American Heart Association and the American Stroke Association in 2011 recommends T2-MRI + MRV as the initial diagnostic modality of choice. CT + CTV is the preferred alternative if MR is not readily available or is contraindicated.[18]

Invasive imaging

Cerebral angiography provides detailed images of the deep cortical veins and cerebral venous sinus network. It can serve as an alternative imaging modality when CT and MR prove inconclusive or are unavailable.

Additional diagnostics

Many patients with the symptoms of CVST undergo lumbar puncture during their initial evaluation. The most common finding on lumbar puncture is an elevated opening pressure (>20 cm H_2O), which is found in more than 80% of cases. In addition, the diagnosis of CVST should be entertained if an elevated opening pressure is encountered during the workup of the headache patient. This may very well be the one clue that leads to the diagnosis.

Treatment

Treatment of CVST can involve multiple approaches, including systemic anticoagulation, chemical or mechanical endovascular thrombectomy, and surgical decompression or open clot retrieval.[19]

Few studies have investigated the safety and efficacy of systemic anticoagulation for CVST. Concern that this procedure can precipitate hemorrhage or exacerbate pre-existing hemorrhage in CVST creates barriers to aggressive and effective treatment. This unproven risk of progressive hemorrhage must be weighed against the real risk of withholding anticoagulation and thus promoting venous infarction with hemorrhagic conversion.[20]

Two randomized trials have evaluated systemic anticoagulation in CVST. They were combined in a Cochrane Review meta-analysis,[3] which found a

non-significant trend toward reduced death and disability (relative risk [RR] 0.33 and 0.46, respectively) in patients treated with systemic anticoagulation. No cases of spontaneous or progressive hemorrhage were documented.

The best available evidence supporting the safety and efficacy of systemic anticoagulation for CVST is based on observational cohorts of undifferentiated CVST patients (including those with intracerebral hemorrhage).[3] The International Study on Cerebral Vein and Dural Sinus Thrombosis (ISCVT) CVST cohort (624 patients known to have CVST and treated with systemic anticoagulation) demonstrated a non-significant reduction in death and disability (12.7% and 18.3%, respectively). The rates of spontaneous and progressive hemorrhage did not increase.

Additional studies support systemic anticoagulation as a safe and effective therapeutic approach for patients with CVST in the emergency department (ED). However, given the rarity of this condition, all clinical trials conducted thus far are underpowered to establish statistical significance.[19]

Not all patients respond to systemic anticoagulation, so alternative methods to re-establish normal outflow have been explored. Systemic or localized fibrinolysis has been evaluated in small trials and has yielded mixed results. At best, thrombolytics provide a safe and effective alternative for CVST that is resistant to systemic anticoagulation. At worst, they might increase the risk of spontaneous or progressive hemorrhage. A handful of small studies have investigated mechanical thrombectomy as an alternative to systemic or localized chemical thrombolysis. Balloon angioplasty, stenting, clot maceration, and rheolytic thrombectomy are promising alternatives for CVST resistant to systemic anticoagulation and might be associated with reduced rates of hemorrhage compared with chemical thrombolysis. Surgical intervention via intracerebral pressure monitor placement or hemicraniectomy for hematoma evacuation may be indicated for management of elevated intracranial pressure.[19]

Multiple studies have evaluated risk factors for and prognostic implications of early seizures in CVST. A prospective observational study of 194 patients found a threefold increase in the mortality rate among patients with CVST who experienced early seizure.[21] A second prospective observational study found that supratentorial hemorrhage, seizures at the time of presentation, and motor deficits were predictive of subsequent seizure activity and clinical deterioration.[22] The use of antiepileptic drugs may be indicated in this subgroup of CVST patients; however, no studies have demonstrated that their use reduces the morbidity or mortality rate.

Clinical approach when resources are limited

In most cases, CVST can be diagnosed definitively only with the use of advanced imaging modalities, including unenhanced CT, contrast CT, MRI, and magnetic resonance angiography (MRA). When these advanced modalities are not available, the diagnosis might be suspected but cannot be confirmed easily. The diagnosis should be considered in patients with focal neurologic deficits and risk factors for CVST, especially those who are using oral contraceptives or have a genetic predisposition for thrombosis. Close coordination with consulting neurologists, when available, should be part of the management of these patients.

Pearls and pitfalls

- Consider CVST in patients with headache, neurologic findings, and risk factors.
- Consider CVST in patients with a history suggestive of pseudotumor cerebri (idiopathic intracranial hypertension).
- Anticoagulation should be considered in patients with CVST even if there is concurrent hemorrhagic infarction.

Critical actions

- CVST can be associated with subtle symptoms and a subacute onset. Knowledge of the epidemiology and risk factors for CVST can help raise suspicion for this often-overlooked diagnosis.
- Prompt attention to airway, breathing, circulation (ABCs) in patients who present with stupor or coma is essential.
- A thorough neurologic examination is important to elicit findings that indicate CVST (focal weakness, sensory deficits, aphasia, papilledema, visual field deficits).
- Recognition of a non-arterial distribution of hemorrhage, caused by venous congestion, on a brain CT scan suggests the diagnosis and should prompt further investigation and consultation.

- Anticoagulation should be initiated promptly in appropriate patients.
- If a patient does not respond to systemic anticoagulation, more invasive options should be considered.

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Section I **Cerebrovascular disease**

Chapter 2

Acute ischemic stroke

Cemal B. Sozener and Phillip A. Scott

Stroke is the third leading cause of death and the leading cause of disability in the United States. In addition, it is an extremely common condition around the world and has become a global health threat, along with diabetes and heart disease. Ischemic stroke afflicts more than 795,000 Americans each year, 610,000 of whom have a first attack. Stroke accounts for 1 in every 18 deaths in the United States, or just over 130,000 deaths, per year.[1] An additional 200,000 to 500,000 Americans experience transient ischemic attack (TIA). *Stroke* refers to any disease process that alters blood flow to a focal region of the brain. This chapter focuses on ischemic causes, which account for 87% of strokes. Timely diagnosis and appropriate management of acute ischemic stroke (AIS) and TIA can reduce morbidity and mortality rates.

Pathophysiology

Ischemic strokes are generally divided into three major categories: thrombotic, embolic, and hypoperfusion associated (watershed strokes). A substantial portion of strokes (30–40%) defy etiologic categorization and are considered cryptogenic. Vasculitic causes of stroke include Takayasu's arteritis, systemic lupus erythematosus, and polyarteritis nodosa. Hypercoagulable states and arterial dissection may also result in cerebral infarction.

Thrombotic strokes, the most common subtype, are characterized by a narrowing of the vascular lumen, typically as a result of atherosclerotic disease, with subsequent platelet adhesion and local clot formation. Thrombosis occurs most commonly in the internal carotid and the middle cerebral and basilar arteries. Clinically, thrombotic stroke symptoms may wax and wane in severity depending on direct flow as well as collateral circulation to the affected tissue.

Embolic strokes, the second most common subtype, account for approximately 20% of ischemic strokes. They result from the release of material into the vascular lumen, which travels distally to occlude a cerebral vessel. The majority of these emboli are cardiac in origin, either from mural thrombi (arising from untreated cardiac dysrhythmias or myocardial infarction) or valvular abnormalities. Other causes include paradoxic emboli (related to right-to-left shunting in patients with a patent foramen ovale or other septal defect), artery-to-artery embolization (resulting from the migration of proximal clots from atherosclerotic disease in larger vessels), or emboli from fat (fractures) or air (injection, diving). Embolic strokes are typically abrupt in onset and manifest maximal deficits early.

Hypoperfusion-related strokes, the least common type of ischemic stroke, are typically the result of systemic disease from cardiac failure, causing diminished blood flow to watershed regions of the cerebral vasculature. The neurologic symptoms of this type of infarct are more diffuse than those associated with strokes of other cause and correlate with the magnitude of reduction in blood pressure.

Epidemiology

In 2006, more than 6.4 million American adults had a stroke.[1] At younger ages, the incidence of stroke is higher among men than women; this trend is reversed in older age groups. Blacks have a higher incidence than whites, particularly in younger populations. The stroke-related mortality rates in the two racial groups are similar. Mexican Americans have a higher incidence of stroke than non-Hispanic whites.[2] Among patients $\geq$65 years of age, stroke has a 30-day mortality of 8.1%.[3]

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Risk factors for stroke parallel those for cardiovascular disease. The degree and duration of hypertension strongly correlate with stroke risk.[1] Atrial fibrillation leads to a fivefold increase in lifetime stroke risk throughout all age groups.[4,5] Cigarette smoking doubles the lifetime risk. Diabetes increases incidence at all age groups; however, the risk is magnified in blacks younger than 55 and whites younger than 65.[6] Female sex, advancing age, prior TIA, obesity, high cholesterol, pregnancy (particularly the peripartum to six weeks postpartum period), physical inactivity, and sickle cell disease are also independent risk factors.

Recovery following stroke is variable. Approximately 50 to 70% of stroke survivors regain functional independence, but 15 to 30% are permanently disabled. Approximately 20% of survivors require institutional care 90 days after a stroke.[1] In the Framingham Study, residual disabilities included hemiparesis in 50% of patients, aphasia in 18%, difficulty with activities of daily living in 26%, and inability to ambulate without assistance in 30%.[7] Disability is associated with substantial economic costs. In 2010, total direct and indirect costs attributed to ischemic stroke in the United States were estimated at $73.3 billion.[1] The majority of direct medical costs are attributed to rehabilitation and nursing home expenditures.[8]

Worldwide, 15 million people experience stroke annually, and 5.5 million of them die, making stroke the second leading cause of death among people over the age of 60. Although the incidence of stroke is declining in some developed countries secondary to better blood pressure control and decreased rates of smoking, the absolute number of strokes continues to increase because of the aging of the population.[9]

Diagnosis

History

Patients with stroke symptoms require immediate evaluation because diagnosis and treatment are time sensitive. The paramount initial historical element to obtain from either the patient or bystander is the time of the onset of symptoms. This is defined as the time the patient was last at his or her neurologic baseline. Care should be taken in determining this time in patients who wake up with symptoms ("wake-up strokes").

Establishing stroke risk factors may aid in identifying the subtype of ischemic stroke. The presence of comorbid conditions such as hypertension, diabetes mellitus, atherosclerotic disease, sickle cell disease, pregnancy, drug abuse, migraine headache, seizure disorder, trauma, and infection should be determined. Inclusion and exclusion criteria for thrombolytic eligibility are reviewed below.

Stroke syndromes

Common stroke presentations are described here based on the vascular structures that are involved.[10]

Anterior cerebral artery (ACA) syndrome. Patients with this syndrome present with contralateral weakness in the leg greater than the arm, with mild deficits in sensation. They may exhibit slowness of speech or motor actions. Proximal lesions are less symptomatic, owing to collateral flow from the paired anterior communicating artery. Distal lesions tend to produce more severe presentations.

Middle cerebral artery (MCA) syndrome. The MCA is the most common site of ischemic stroke. Occlusion leads to contralateral hemiplegia and hemianesthesia. Symptoms generally affect the face and arm more than the leg. If the dominant hemisphere is involved, aphasia may be encountered. The left hemisphere is dominant in right-handed patients and in approximately 80% of those who are left handed. Proximal lesions create substantial clinical deficits and can result in significant cerebral edema.

Posterior cerebral artery (PCA) syndrome. The PCA supplies blood to the occipital lobe, parts of the temporal lobe, thalamus, upper brainstem, and midbrain. Proximal occlusions lead to minor deficits, as the posterior communicating artery often provides collateral circulation. Distal occlusions lead to complications such as homonymous hemianopsia. Occipital cortex lesions resulting in visual deficits can be difficult to determine unless visual fields are formally tested. Light touch and pinprick sensation may also be reduced.

Vertebrobasilar syndrome. The vertebrobasilar circulation provides blood to the brainstem and cerebellum. Crossed neurologic deficits (e.g., ipsilateral facial weakness with contralateral weakness of the body) are the hallmark of posterior

fossa involvement. Physical findings may be subtle and easily attributed to other conditions. Commonly encountered symptoms include vertigo, ataxia, diplopia, dysarthria, and dysphagia.

Cerebellar stroke syndrome. This is a subset of posterior circulation stroke and presents as sudden onset of vertigo and inability to stand. Patients may also complain of associated headache, nausea, vomiting, and cervical pain. Early identification and neurosurgical consultation is critical in order to monitor for potential herniation or brainstem compression due to posterior fossa edema.

Lacunar stroke syndrome. This syndrome results from occlusion of small penetrating arteries, typically due to chronic hypertension. There are five classic lacunar syndromes: hemiparesis (pure motor, most common), ataxic hemiparesis (combines motor and cerebellar symptoms), clumsy hand dysarthria (manifests as hand weakness and clumsiness with dysarthria), pure sensory (persistent or transient unilateral numbness, tingling, pain, or burning), and mixed sensorimotor (hemiparesis or hemiplegia with ipsilateral sensory impairment).

Physical examination

The clinical examination begins with assessment of the airway, breathing, and circulation. The general inspection should evaluate for signs of trauma, particularly of the head and neck. Examination of the oropharyngeal space should include inspection of the tongue for lacerations, which would suggest an alternate cause (seizure). The neck should be examined for the presence of carotid bruit or jugular venous distension. The cardiac examination should screen for tachycardia, irregular rhythm, and murmur. The skin should be examined to identify petechiae suggestive of coagulopathies or platelet dysfunction.

Neurologic examination

The goal of the neurologic examination is to localize the lesion and exclude other disease processes. Review of the entire examination is beyond the scope of this text, but we advocate the use of a formal stroke scale, such as the National Institutes of Health (NIH) Stroke Scale (NIHSS) (Table 2.1), as a component of it. Determining a patient's score can enhance the emergency practitioner's assessment, enhance

Table 2.1 National Institutes of Health Stroke Scale

Tested item	Title	Responses and scores
1A	Level of consciousness	0 – Alert 1 – Drowsy 2 – Obtunded 3 – Coma/unresponsive
1B	Orientation questions (2)	0 – Answers both correctly 1 – Answers one correctly 2 – Answers neither correctly
1C	Response to commands (2)	0 – Performs both tasks correctly 1 – Performs one task correctly 2 – Performs neither
2	Gaze	0 – Normal horizontal movements 1 – Partial gaze palsy 2 – Complete gaze palsy
3	Visual fields	0 – No visual field deficit 1 – Partial hemianopia 2 – Complete hemianopia 3 – Bilateral hemianopia
4	Facial movement	0 – Normal 1 – Minor facial weakness 2 – Partial facial weakness 3 – Complete unilateral palsy
5	Motor function (arm) a. Left b. Right	0 – No drift 1 – Drift before 5 seconds 2 – Falls before 10 seconds 3 – No effort against gravity 4 – No movement
6	Motor function (leg) a. Left b. Right	0 – No drift 1 – Drift before 5 seconds 2 – Falls before 5 seconds 3 – No effort against gravity 4 – No movement
7	Limb ataxia	0 – No ataxia 1 – Ataxia in one limb 2 – Ataxia in two limbs
8	Sensory	0 – No sensory loss 1 – Mild sensory loss 2 – Severe sensory loss
9	Language	0 – Normal 1 – Mild aphasia 2 – Severe aphasia 3 – Mute or global aphasia
10	Articulation	0 – Normal 1 – Mild dysarthria 2 – Severe dysarthria
11	Extinction or inattention	0 – Absent 1 – Mild (loss of one sensory modality) 2 – Severe (loss of two modalities)

communication with consultants, and allow quantifications of changes in the patient's condition. In addition to its good reproducibility over serial examinations, the NIHSS has been shown to correlate with subsequent infarct volume. Caution is warranted because the NIHSS favors evaluation of the anterior circulation and can miss subtle posterior circulation stroke syndromes.

The station and gait portion of the neurologic examination is frequently not obtained or documented in the emergency department, but it can greatly assist in the difficult stroke diagnosis. Because station and gait are a culmination of motor, sensory, and central integration, subtle asymmetries and signs of stroke can be magnified with this part of the physical examination.

Laboratory tests to obtain in the emergency department

The following blood tests should be obtained rapidly upon the patient's arrival: blood glucose level (preferably a rapid, point-of-care test), complete blood count with platelets (CBCP), electrolytes, renal function, prothrombin time (PT), activated partial thromboplastin time (aPTT), international normalized ratio (INR), and type and screen.[11] Measuring cardiac ischemia markers can be useful, because cardiac disease is prevalent in these patients. Depending on the context, consider hepatic function tests (if coagulopathy related to liver disease is suspected), toxicology screening (for possible sympathomimetic abuse), measurement of the blood alcohol level, a pregnancy test, and arterial blood gas measurement (if altered mental status is suspected as a result of hypoxia or hypercarbia). Having a predetermined panel of tests speeds the process.

Imaging in the emergency department

A non-contrast computed tomography (CT) scan of the brain should be performed early during the evaluation. The CT scan assists in differentiating hemorrhagic and ischemic stroke. Typically, in patients with ischemic stroke less than six hours old, no acute changes are identified on CT imaging. For stroke patients who might be eligible for reperfusion therapies, the goals are to obtain CT imaging within 25 minutes after arrival in the emergency department (ED) and to interpret the study within 45 minutes.[12] Some hospitals have the capability to perform advanced neuroimaging using magnetic resonance imaging (MRI) sequences, CT perfusion, and CT angiography (CTA). These studies, however, should not be obtained at the expense of early initiation of thrombolytic therapy in eligible patients unless they are required because of diagnostic uncertainty or other clinical indications. MRI is superior to CT in the assessment of stroke patients; if it can be performed and interpreted as rapidly as CT, it is preferred.

Pearls and pitfalls related to specific presentations

Young adults (age $<$ 50) with stroke

In young adults, consider the possibility of arterial dissection, sympathomimetic or injection drug use, a cardioembolic event (or paradoxic embolism via a patent foramen ovale), and air emboli as potential causes of the stroke.

Uncooperative patients

In uncooperative patients, particularly in the elderly, consider the possibility of a non-dominant hemisphere stroke or other stroke syndrome as the cause of the behavior, especially if the change is abrupt. A thorough history and physical examination will aid in the diagnosis of a stroke.

Patients with vertigo and vomiting

Consider posterior circulation infarcts in patients presenting with vertigo and nausea or vomiting. Early identification of a cerebellar stroke and neurosurgical consultation for possible decompressive surgery may be life-saving.

Emergency department management

Prehospital care/triage

Between 29% and 65% of patients with signs or symptoms of acute stroke access the medical system via emergency medical services (EMS) systems.[11] When prehospital care personnel notify the receiving facility that a potential stroke patient is en route, the time from symptom onset to physician evaluation can be

reduced, as is the time to diagnostic imaging; therefore, evaluation of the patient for eligibility for thrombolytic treatment is facilitated.[13–21] Successful hospital systems use a multidisciplinary approach for the identification and treatment of patients with AIS.

First 15 minutes

Patients with acute stroke symptoms should be evaluated similarly to those with other time-sensitive conditions, such as myocardial infarction or trauma. Critical pathways for stroke patients should be in place and utilized for urgent evaluation of these patients.

Initial assessment

The emergency physician should obtain a quick, but thorough, history and physical examination. Critical pathway order sets should be initiated for intravenous (IV) line placement, with blood being sent for testing as previously described, a 12-lead electrocardiogram (ECG), and an emergent non-contrast head CT scan. If CT imaging is unavailable, arrangements should be made to transfer the patient immediately to a facility with that capability. If a stroke team is available, it should be contacted at the earliest possible opportunity.

The last time the patient was known to be normal must be established rapidly in order to identify patients who are eligible for reperfusion therapy. This information might be available from family members, caregivers, or EMS personnel. Context clues such as what television show was playing at the time of symptom onset can be particularly helpful in establishing onset time. Thrombolytic therapy is not indicated if a reliable time of symptom onset cannot be determined.

Critical actions

- Rapid evaluation of the suspected stroke patient.
- Initiation of an acute stroke care pathway.
- Quick, but thorough, history and physical examination, with special attention to time of onset of stroke symptoms (last time the patient was known to be normal).
  - Application of a formal stroke scale such as the NIHSS.
  - Stroke team activation, if available.
- Placement of IV line, with blood drawn and sent to the lab.
  - Glucose determination.
  - CBCP, basic metabolic panel.
  - Coagulation profile (PT, INR, aPTT).
  - Type and screen.
- Twelve-lead ECG.
- Initiation of an emergent head CT scan, with notification to radiologist that images will need to be rapidly interpreted.

Table 2.2 Differential diagnosis of stroke

Condition	Specific causes
Metabolic	Hyperglycemia/hypoglycemia Hyponatremia Hepatic encephalopathy
Toxicologic	Lithium, phenytoin, alcohol intoxication, Wernicke's encephalopathy
Vascular	Polyarteritis nodosa, systemic lupus erythematosus, Takayasu's arteritis, hypertensive encephalopathy, arterial dissection, cerebral venous sinus thrombosis
Idiopathic	Meniere's disease
Central nervous system	Trauma (subdural/epidural hematoma) Seizure with post-ictal (Todd's) paralysis Migraine Mass lesion Multiple sclerosis Bell's palsy
Psychiatric	Factitious disorders Conversion disorder Functional hemiparesis
Miscellaneous	Positional vertigo, syncope

Differential diagnosis

Specific causes of stroke are presented in Table 2.2.

Treatment

General management

Patients with low oxygen saturation levels should receive oxygen by nasal cannula unless airway protection becomes an issue necessitating emergent treatment. If appropriate, the head of the patient's bed should be elevated to 30°. Intravenous fluids should be used judiciously. Fever leads to a worse neurologic outcome, so it should be treated and the source identified.[22–27] The patient should be maintained on a cardiorespiratory monitor.