Cerebral Infarction

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Profile

Definition

- *Cerebrovascular disease* refers to a group of disorders that result from a pathological process that compromises blood supply to the brain.
- Such disorders may be either ischemic or hemorrhagic.
- Infarction is a local tissue injury or necrosis from reduced or absent blood flow to a specific part of the body, including the brain.
- Cerebral infarction (cerebral infarct, cerebrovascular accident [CVA], or stroke) is usually a *focal ischemic* event with an acute onset of asymmetric clinical signs that are progressive for a short time.
- *Global brain ischemia* can also occur (eg, anesthetic accidents, cardiopulmonary arrest).
- By definition, clinical signs must be present for at least 24 hours to be considered a stroke.\(^1,2\)
- Transient ischemic attack (TIA) is the term used to describe a cerebrovascular disorder in which clinical signs resolve within 24 hours following transient ischemia.

Pathophysiology

- There is little energy reserve in the brain, so it is dependent on continuous delivery of oxygen and glucose for energy; it is capable of only aerobic metabolism.\(^1\)
- The brain receives 20% of cardiac output and accounts for 15% of oxygen consumption, despite comprising only 2% of body weight.\(^1\)
- Infarcts can be described based on their underlying pathophysiology or location and size.

Underlying Pathophysiology\(^2,3\)

- *Ischemic infarct* is secondary to lack of oxygen delivery caused by blood vessel obstruction; this is the most common form of cerebral infarct in dogs and cats.
- *Hemorrhagic infarct* is secondary to ruptured blood vessels leading to hemorrhage within the brain parenchyma.

Location & Size\(^1,3\)

- *Territorial infarct* is a large area of tissue damage secondary to obstruction of one of the major arteries to the brain (eg, middle cerebral artery, rostral cerebellar artery).
- *Lacunar infarct* is a smaller area of tissue damage from obstruction of small superficial or deep penetrating arteries.
Predisposing Conditions for Cerebral Infarction
- Aberrant parasite migration (e.g., *Cuterebra* spp, *Dirofilaria immitis*)
- *Angiostrongylus vasorum* infection
- Atherosclerosis
- Cardiac disease
- Coagulopathy
- Chronic kidney disease
- Extension of CNS infection
- Hyperadrenocorticism
- Hyperlipidemia
- Hypertension
- Hypothyroidism
- Increased blood viscosity (e.g., polycythemia, multiple myeloma)
- Intravascular neoplasia (e.g., lymphoma, hemangiosarcoma)
- Liver disease
- Protein-losing nephropathy
- Sepsis and bacterial thromboembolism
- Vasculitis

Signalment
- Infarction can occur at any age but is typically diagnosed in middle-aged to geriatric dogs and cats.4-6
- No apparent gender predisposition.
- They can occur in all breeds of dogs and cats, but the following breeds may be at increased risk6-10:
  - Greyhounds: Especially cerebellar infarcts; these are often idiopathic but may be hypertension-related.
  - Cavalier King Charles spaniels: Possibly related to local alterations in intracranial pressure secondary to Chiari-like malformation.
  - Miniature schnauzers: Possibly related to hyperlipidemia.
  - Brachycephalic breeds: Increased risk for global ischemia, especially with ketamine anesthetic protocols.

Risk Factors
- The three most common risk factors for cerebral infarction are hypertension, hypercoagulability, and hyperviscosity.

Predisposing Conditions2,4,6,11
- The most common predisposing causes are idiopathic hypertension, chronic kidney disease, and hyperadrenocorticism.

### Table 1. Ancillary Diagnostics

<table>
<thead>
<tr>
<th>Ischemic Infarction</th>
<th>Hemorrhagic Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine protein:creatinine ratio if proteinuria</td>
<td>Rickettsial disease testing</td>
</tr>
<tr>
<td>Clotting studies: buccal mucosal bleeding time, prothrombin time (PT), activated partial thromboplastin time (APTT)</td>
<td></td>
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<tr>
<td>Serum antithrombin III activity</td>
<td>von Willebrand factor analysis</td>
</tr>
<tr>
<td>D-dimer tests</td>
<td>Testing for <em>Angiostrongylus vasorum</em> in endemic regions</td>
</tr>
<tr>
<td>Echocardiography and electrocardiography if underlying cardiac condition</td>
<td></td>
</tr>
</tbody>
</table>

History
- Patients are usually presented for evaluation following peracute to acute onset of neurologic signs that are non-progressive after 24 hours.
- Rarely, progression may occur at 48-72 hours because of secondary cerebral edema.1,2
- Common clinical signs noted by owners include vestibular dysfunction, seizures, altered mental status, paresis, or ataxia.

Physical Examination
- General examination may be normal or demonstrate changes consistent with a predisposing condition (e.g., cranial abdominal organomegaly, thin hair coat).
- Retinal fundic examination is recommended.
- Hypertension may cause enlarged or tortuous retinal vessels.
- Papilledema may be present if increased intracranial pressure.
- Concurrent chorioretinitis or infil-

DWI = diffusion weighted images
trative disease (eg, lymphoma) further suggests presence of a concurrent, predisposing condition.

Neurologic Examination
- As with all neurologic disorders, neurologic signs reflect lesion location and extent rather than cause.
- Common signs based on lesion location include:
  - Cerebrum: Seizures, mental obtunding, circling, pacing, inappropriate elimination
  - Thalamus: Signs of cerebral disease as above or vestibular dysfunction (possibly from damaged thalamic relay centers associated with cerebellar and vestibular nuclei; damage to the medial longitudinal fasciculus; input of vestibular information to the thalamus; or diaschisis, a sudden change in function in one area of the brain from damage in a distant location).
  - Brainstem: Altered mental status, cranial nerve deficits, vestibular dysfunction, paresis, ataxia.
  - Cerebellum: Paradoxical central vestibular dysfunction, hypermetria, cerebellar (intention) tremors, truncal sway/ataxia.

Diagnosis

Definitive Diagnosis
- Definitive diagnosis requires histopathology at necropsy.
- CT- or MRI-guided stereotactic biopsy may not provide a definitive diagnosis of infarction but may help rule out other possible causes (eg, neoplasia, encephalitis).
- A presumptive diagnosis can be made via advanced imaging and exclusion of other potential causes.

Differential Diagnoses
- Intracranial neoplasia
- Immune-mediated, non-infectious encephalitis (eg, granulomatous meningoencephalomyelitis, necrotizing encephalitis)
- Infectious encephalitis
- Traumatic brain injury

Laboratory Findings
- Minimum database includes CBC, serum chemistry panel, thyroid hormone analysis, and urinalysis.
- Serial systolic blood pressure measurements should be obtained to rule out systemic hypertension.
- Thoracic radiographs and abdominal ultrasound are recommended to screen for neoplasia and predisposing conditions.
- Ancillary diagnostics should be performed based on the type of infarction present (Table 1, previous page).

Imaging
- MRI is the advanced imaging modality of choice given its superior soft tissue resolution.
  - The classic MRI characteristic of an ischemic stroke (Figure 1, next page) is an intra-axial lesion (often wedge-shaped) that is hypointense (bright) on T2-weighted and fluid attenuation inversion recovery (FLAIR) images, iso- to hypointense (dark) on pre-contrast T1-weighted images, and minimal to no contrast enhancement.
  - Diffusion weighted imaging (DWI, Figure 2, next page) is the sequence of choice for acute ischemic infarction.
    - DWI detects lack of normal Brownian motion of molecules, particularly lack of intercellular water movement from cell swelling associated with cytotoxic edema.
    - An acute infarction appears as a hyperintense region.
  - The MRI appearance of hemorrhagic infarction (Figure 3, next page) varies greatly as blood cells and hemoglobin degrade (Table 2).

### Table 2. MRI Characteristics of Hemorrhage

<table>
<thead>
<tr>
<th>Stage</th>
<th>Time frame</th>
<th>Hemoglobin state</th>
<th>T2-weighted</th>
<th>T1-weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peracute</td>
<td>&lt;24 hrs</td>
<td>Oxyhemoglobin</td>
<td>Hyperintense</td>
<td>Isointense</td>
</tr>
<tr>
<td>Acute</td>
<td>1-3 days</td>
<td>Deoxyhemoglobin</td>
<td>Hypointense</td>
<td>Isointense</td>
</tr>
<tr>
<td>Early subacute</td>
<td>3-7 days</td>
<td>Intracellular methemoglobin</td>
<td>Hypointense</td>
<td>Hyperintense</td>
</tr>
<tr>
<td>Late subacute</td>
<td>&gt;7 days</td>
<td>Extracellular methemoglobin</td>
<td>Hyperintense</td>
<td>Hyperintense</td>
</tr>
<tr>
<td>Chronic</td>
<td>&gt;14 days</td>
<td>Hemosiderin</td>
<td>Hypointense</td>
<td>Iso- to hypointense</td>
</tr>
</tbody>
</table>

continues
Hemorrhagic infarcts can be difficult to distinguish from hemorrhagic brain tumors (e.g., glioma, hemangiosarcoma).

The T2*-gradient echo (T2*GRE) sequence is best for identifying hemorrhage as it is hypointense on this sequence.

T2*GRE is also hypointense for mineralization, air, iron, melanin, and foreign bodies.

MRI images from a dog with a presumed hemorrhagic infarct (arrows) based on improved clinical signs and reduction in size on follow-up MRI imaging without definitive treatment. There is a large, intra-axial lesion in the right parietal & occipital lobes. Images (A) and (G) are parasagittal T2-weighted and T1-weighted images, respectively. Images (B) through (F) are transverse images at the left of the midbrain. Image (H) is a dorsal view. The lesion is heterogeneous and primarily hypointense on T2-weighted (A, B) and FLAIR (C) images; hypointense on T2*GRE (D) images consistent with hemorrhage; hypointense with a rim of hyperintensity on T1-weighted images (E); and has moderate-to-marked peripheral rim contrast enhancement (F-H).

MRI images of a dog with a right cerebellar infarct (A). Note the wedge-shaped intra-axial lesion in the right dorsal cerebellar gray matter (arrow) that is hyperintense on T2-weighted images (B), isoointense on T1-weighted images (G), and does not contrast enhance (D).

DWI obtained from a dog showing a wedge-shaped, markedly hyperintense signal in the left dorsal cerebellar gray matter consistent with a left cerebellar infarct (arrow). DWI is the MRI sequence of choice for peracute to acute infarction.

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Inpatient or Outpatient
- Patients with mild signs may be treated on an outpatient basis.
- Non-ambulatory patients with moderate to severe clinical signs, especially larger-breed dogs, may need to be hospitalized until they are able to walk with minimal to no assistance.

Acute Medical Treatment
- In general, there is no specific treatment for cerebral infarction.
- So-called clot busters or thrombolytic agents (e.g., tissue plasminogen activator [tPA], streptokinase) are frequently used in human medicine. These medications are infrequently used in veterinary medicine because blood clots are rarely a cause of infarction in dogs and cats, thrombolytic agents need to be given within 6 hours of infarction, and expense or limited availability preclude their use.
- Mannitol (0.5-1.0 g/kg IV over 10-15 minutes) or hypertonic saline 7.5% (3-5 mL/kg IV over 10-15 minutes) may be needed to reduce brain swelling.
- There is a theoretical risk for exacerbating hemorrhage or cerebral edema if mannitol is given to patients with intracranial hemorrhage, but benefits likely outweigh risks.
- Hypertension should be treated to prevent ongoing damage.
- Initial treatment recommendations include enalapril (dogs, 0.5 mg/kg PO q12h) or amlodipine (cats, 0.625-1.25 mg per cat PO daily).
- Oxygen support is recommended in moderate to severe cases, especially if hypoventilation is present.
- Nursing care for recumbent patients is critical and includes frequent turning and thick bedding to prevent pressure...
Nutritional Aspects

- There are no specific nutritional recommendations for infarction, but diets higher in essential fatty acids and omega-3 may be beneficial.
- Diet recommendations should also be based on predisposing conditions, such as a low-protein diet in patients with kidney disease.

Activity

- There are no activity restrictions for this condition.
- Physical rehabilitation is highly recommended to improve recovery and shorten duration of signs.

Client Education

- Clients should be taught how to provide nursing care for recumbent animals, as well as how to treat underlying predisposing conditions.

Follow-up

Patient Monitoring

- Patients should be monitored for signs of progression that might be consistent with a diagnosis other than stroke.
- If signs are progressive, further examination is required as that would suggest the patient did not have a stroke.
- Clients should be instructed to observe for signs of recumbency-associated aspiration pneumonia (eg, coughing, tachypnea, dyspnea).

Complications

- The most common complication is recumbency-associated aspiration pneumonia.
- Other complications may be observed depending on concurrent predisposing conditions.

In General

Relative Cost

- Diagnostic workup and acute treatment: $$$$-$$$$$
- Chronic treatment and follow-up: $$-$$$

Cost Key

- $ = up to $100
- $$ = $101-$250
- $$$ = $251-$500
- $$$$ = $501-$1000
- $$$$$ = more than $1000

Prognosis

- In general, the prognosis for recovery is good to excellent for patients with focal infarctions that have limited initial clinical abnormalities, if given enough time and supportive care.
- Some patients have residual clinical signs, but quality of life is acceptable for most patients.
- The prognosis for global brain ischemia is guarded to fair.

References


Suggested Reading

