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Disease Project: Cerebrovascular Event

ABSTRACT

Cerebrovascular event, commonly known as stroke, is a leading cause of death and disability in the world. Strokes occur from problems with blood vessels that cause damage to the brain by restricting blood flow to the brain. An understanding of the signs, symptoms, and causes of strokes paves the way to developing treatment plans. Due to the accelerated nature of damage and the extreme time sensitivity with strokes, medical professionals are encouraged to utilize all available resources for quick and accurate diagnoses of strokes to allow for the best possible outcome for the patient. Over the years, diagnostic tools have improved the treatment and outcomes of strokes, but modern lifestyle choices related to diet and exercise continue to allow strokes to remain all too common in human life.

Cerebrovascular event, or stroke, is characterized by restricting blood flow from reaching a portion of the brain with subsequent tissue damage, typically manifesting as a sudden and seemingly random event. It is caused by a variety of disease mechanisms that all lead to a similar outcome (Chinnery, 2006). Stroke is a cardiovascular condition that impacts the nervous system; it occurs when a blood vessel that brings oxygen to the brain bursts or is obstructed by a mass, depriving the brain of oxygen, killing the nervous tissue and disabling the part of the body controlled by those nerve cells. (Daneski, 2010). The effects are long-lasting or permanent because brain cells do not perform mitosis and are not replaced when killed or damaged (Chinnery, 2006). Plasticity of the brain allows the possibility to rewire the neurological network and reestablish the connections between mind and body, however, progress is typically limited and takes a significant amount of time (Aderinto et al., 2023).

There are two primary forms of cerebrovascular event that are observed at the tissue level. They are ischemia stroke and hemorrhage stroke. Ischemia stroke involves a blockage of the blood vessel by a body, typically a clot or embolism, that prevents blood from reaching the brain (Caplan, 2013). Hemorrhagic stroke involves the rupture of intracerebral blood vessels around the brain in which blood pools and increases intracranial pressure (ICP), compressing the brain and damaging or destroying neural tissue. Hemorrhage stroke can be further subdivided into intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH), where ICH affects vessels within the brain, and SAH is bleeding into the subarachnoid space of the meninges (Unnithan, M Das, & Mehta, 2023).

Strokes are consistently ranked among the top three leading causes of death and are a leading cause of long-term disability (Caplan, 2013). It is important to understand the different parts of the various blood vessels that supply the brain with blood to better understand the impact of a stroke.

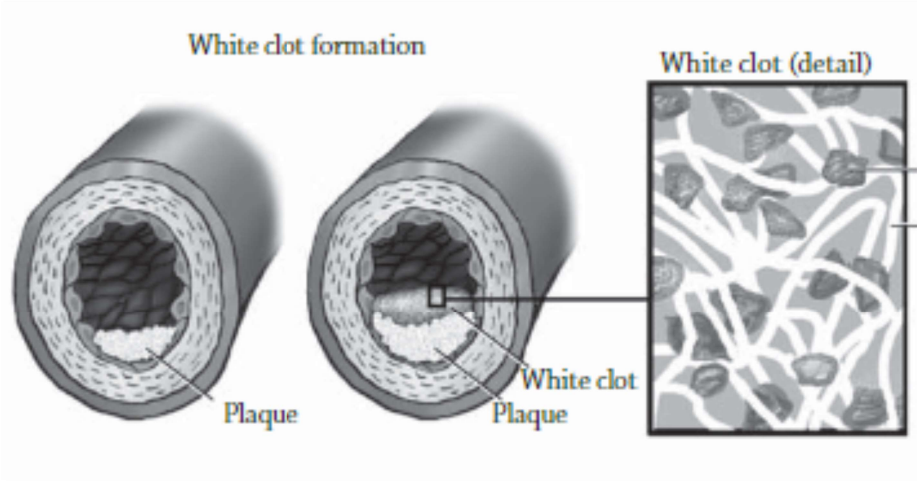
The brain receives blood from the internal carotid arteries and the vertebral arteries. The internal carotid arteries supply to anterior portion of the cerebrum and the bilateral vertebral arteries supply the posterior portion of the cerebrum. The anterior and posterior portions meet at the circle of

Willis, which supplies all major cerebral arteries (Blumenfeld, 2018). Like other organs, the brain's vitality and functionality depends on consistent blood supply. The blood brings oxygen and vital nutrients to the brain. The brain requires significant amounts of energy to function properly; while the brain comprises only 2% of the body's weight, it consumes approximately 20% of the body's energy (Balasubramanian, 2021). The high energy demands of the brain highlight the intense time sensitivity of treating a stroke as quickly as possible. Identification of stroke as early as possible improves one's ability to limit damage from the stroke and can lead to a more complete recovery (Caplan, 2013). Identification of the symptoms of a stroke is one the first steps in treating a stroke.

The area of complete cell death with irreversible damage is called the ischemic core. The area near the ischemic core that has potential to recover, if rapidly provided blood, is the called the penumbra (Sodaei & Shahmaei, 2020). At the cellular level, reactive astrocyte activity near the penumbra is the primary event occurring after the stroke. As time progresses, astrocytes form glial scar tissue around the site of the ischemic core as a response to the brain tissue trauma in a process called astrogliosis (Li, et al., 2014). In addition, microglial cells activate. At rest, they have a small cell body with many branches. Once activated, the shape changes and microglial cells display an enlarged cell body with shorter and fewer processes (Li, et al., 2014).

Strokes do not occur spontaneously but rather stem from other underlying health problems. Lifestyle choices such as diet, exercise, smoking/use of nicotine products, excesively drinking alcoholic beverages, and illicit drug use all contribute to the high rate of stroke worldwide (Caplan, 2013). Hypertension is the most common cause of hemorrhagic stroke. Persistent hypertension damages blood vessels by stressing the elastic lamina and smooth muscles of arteries (Unnithan, M Das, & Mehta, 2023). Normal blood vessels are continuous and possess intact adventitia, media, and endothelium to ensure smooth and uninterrupted blood flow as shown in ***Illustration 1*** (Caplan, 2013).

Causes of ischemic stroke are divided into embolic and thrombotic infarcts. Embolic infarcts originate in one area and travel through the bloodstream to suddenly lodge in a cerebral blood vessel and prevent blood from flowing past it. Thrombotic infarcts occur locally as a blood clot is formed on the blood vessel wall. This typically occurs at the site of an existing atherosclerotic plaque and leads to blockage of the vasculature as shown in ***Illustration 2***. Hypercholesterolemia and atherosclerosis are underlying medical conditions commonly associated with ischemic stroke (Blumenfeld, 2018).



There are countless symptoms of a stroke, but general symptoms of a cerebrovascular event include but are not limited to: vision loss, a weak limb or extremity, uneven smile, slurred speech, or sudden loss of balance. A stroke patient will typically exhibiting deficits in eye responses, motor responses, and/or verbal responses (Larson, Wilcox, & Fairbanks, 2019). As expected, the part of the brain impacted by the stroke presents as a failure of the part of the body that is controlled by that portion of the brain. For example, failure of the visual cortex of the occipital lobe from interrupted vascular supply of the posterior cerebral artery will present as sudden loss of vision (Markus, Pereira, & Cloud, 2017). Symptom analysis can help identify the cerebral vasculature that is impacted, but brain imaging paints the clearest picture, allowing doctors to diagnose, plan treatment, track progress, and identify the cause of the stroke. Modern imaging typically involves computer tomography scan (CT Scan) or magnetic resonance imaging (MRI) to assist doctors in stroke management(Markus, Pereira, & Cloud, 2017). An example of a CT Scan of a stroke patient is shown in ***Figure 1,*** highlighting the areas of the brain that have been damaged.

Lack of noiceptors in neural tissue prevents ischemia stroke from presenting with pain, but innervation of cerebral vasculature from the trigeminal nerve will present pain as a sharp headache during a hemorrhagic stroke (Larson, Wilcox, & Fairbanks, 2019). The neurological pathway of pain associated with hemorrhagic stroke, shown in ***Figure 2***, begins in nociceptive innervation of intracranial vasculature originating in peripheral nerve branches of the trigeminal nerve and collecting in the trigeminal ganglion. The path continues through the brainstem to the spinal trigeminal nucleus where the second order neurons ascend to the thalamus. The thalamus relays the information to the primary somatosensory cortex and the sensation of pain is realized by the patient (Noseda & Burstein, 2013; Bista & Imlach, 2019).

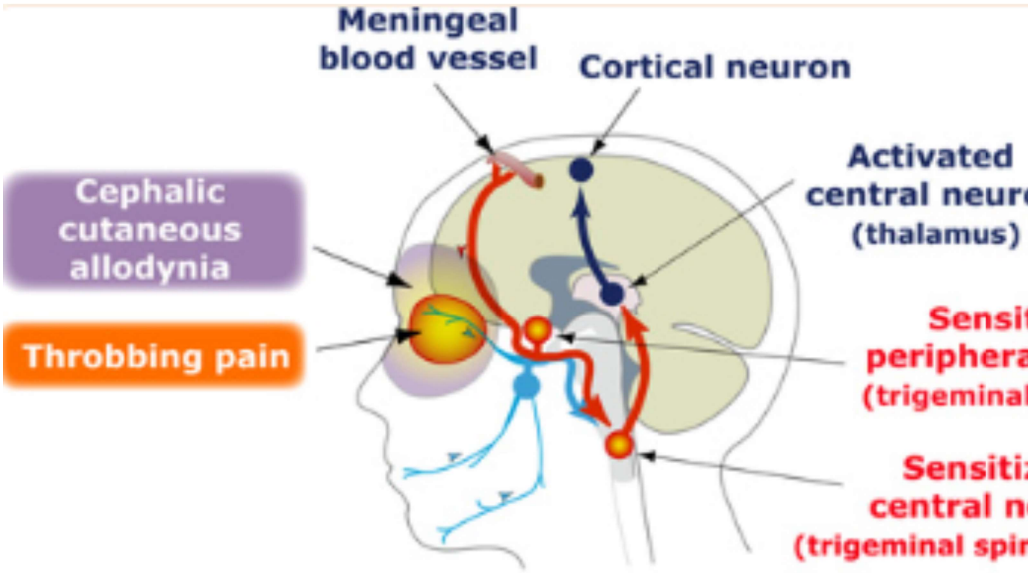


Figure 2*: Pathway of pain associated with hemorrhagic stroke ((Noseda & Burstein, 2013)*

Treatment of stroke varies for each patient based on many criteria. Acute stroke treatment includes general emergency treatment, such as checking and securing the airway, monitoring blood pressure, checking circulation, and setting up IV access (Markus, Pereira, & Cloud, 2017). Severity of

stroke is related to the extent of brain damage caused by the stroke and the size and area of the brain impacted by the stroke (Li, et al., 2014). There are, however, some common approaches to treating stroke. It is important to note that distinction exists in the treatment of ischemic versus hemorrhagic.

Ischemic stroke treatment must address the blockage that is preventing blood from reaching the brain. In these situations, surgical techniques may be employed to address the blockage. Using imaging technology to identify and locate penumbra and differentiate it from ischemic core can help determine patients that may benefit from a thombectomy or thrombolysis. Patients fitting the criteria will undergo surgery in which the goal of successful removal of the blood clot from the blood vessels aims to rapidly restore perfusion to the affected area of the brain to lead to a stronger recovery (Sodaei & Shahmaei, 2020). Afterwards, patients are evaluated for a mechanism of the ischemia to determine what caused it. Many patients are prescribed anticoagulant medications to prevent recurrent strokes. At the cellular level, the action of blood thinning aims to prevent new thrombus or embolisms from forming to prevent vascular blockage (Blumenfeld, 2018).

Hemorrhagic stroke treatment must address the cause of the bleeding in the brain. Once the source of the bleeding is located, surgery can be performed to clip it shut, and catheters can be placed to deliver blood to the areas that were disrupted (Caplan, 2013). Once the stroke is under control, patients are evaluated to determine the cause of the bleeding in the brain. Most commonly, it stemmed from hypertension, so managing blood pressure becomes a critical aspect of preventing future strokes (Blumenfeld, 2018). A unique challenge that surfaces in the treatment of acute stroke is that the utilization of anticoagulants can be appropriate in treating ischemia and can be detrimental to treating hemorrhage stroke, underlining the importance of early and accurate diagnosis.

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