

MORNING CATEGORICAL COURSE

Hot Clinical Topics and Research Areas for Physicists and Engineers

Brain: anatomy, function, pathology and challenges

Stroke: "A Brain Attack"

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Stroke, or brain attack, is a major cause of death and disability. It is characterized by the sudden loss of neurologic function. There are two main types of stroke: ischemic and hemorrhagic. Ischemic stroke is caused by arterial obstruction, which results in ischemia. Hemorrhagic stroke is caused by bleeding from ruptured blood vessels. Since ischemic stroke accounts for over 80 percent of all cases, we will focus on this entity during this categorical course. We will discuss the pathophysiology of ischemic stroke, its symptomatology, and, finally, the future direction of imaging studies.

Types of ischemic infarction

There are two major mechanisms of ischemia: embolic and thrombotic. Embolic stroke is caused by an embolus, which often originates from the heart or aorta. About 15 percent of embolic strokes occur in patients with atrial fibrillation. These patients form blood clots in the left atrium of the heart. An embolic stroke occurs when such a blood clot travels to neck or brain blood vessels.

When a blood clot forms in a blood vessel in the brain or neck, this is called a thrombotic infarction. These blood vessels have underlying pathology that causes narrowing of the vessel, known as atherosclerosis. The inner lining of the artery, called the endothelium, can be damaged due to high blood pressure, cholesterol, triglyceride, blood sugar, cigarette smoke, and other factors. Once the endothelium is damaged, the process of atherosclerosis begins. As the arterial damage continues, a plaque is formed. Plaques can narrow the arterial diameter, decreasing the blood flow and reducing the oxygen supply to the brain.

Patient presentation

Patients with ischemic stroke present to hospital with various symptoms. Some of them arrive in a coma, while others have very mild symptoms. The symptoms of ischemic stroke depend on the area of the brain involved. Even a small lesion can

cause overt clinical symptoms when it affects an important area. On the other hand, a large infarct affecting a so-called silent part of the brain may cause only nonspecific symptoms, which may delay the diagnosis.

Depending on the stroke type, the patient's clinical course can differ significantly. Embolic strokes usually present with sudden onset of symptoms, while thrombotic infarction often presents with stepwise worsening of symptoms.

What imaging can and cannot do

Recent advances in imaging studies have led to effective assessment of patients with ischemic stroke. Examples of current imaging studies include diffusion/perfusion imaging and MR angiography (MRA). Diffusion-weighted imaging (DWI) has enabled early detection of ischemic stroke, whereas perfusion-weighted imaging using bolus injection of contrast agents enables the perfusion status of ischemic tissue to be assessed [1,2]. The ability to obtain such information is vital, but there are some issues that need to be elucidated to facilitate even better patient care.

Currently, perfusion-weighted imaging (PWI) is only capable of capturing a single time point; it is typically obtained on admission. However, it is well known that blood flow in ischemic brain tissue can rapidly evolve over minutes or hours. Thus, a single sampling point is ineffective in many cases. A tool that would enable continuous monitoring of perfusion status would be ideal; this has been partially accomplished using near-infrared spectroscopy, though this technique is limited by poor spatial resolution. To do repeat MR-PWI, one may have to use an arterial spin labeling (ASL) technique to avoid repeated injection of contrast. The absolute quantification of perfusion parameters may be of clinical value, and many studies have attempted this. However, a recent review pointed out that quantified values were not as effective as had been expected in assessing stroke patients [3].

The risk of hemorrhagic complications is a matter of debate. Microbleeds detected by susceptibility-weighted imaging studies are shown to have little effect, if any, upon the risk of post-treatment symptomatic hemorrhage [4]. Assessment of the type of embolus (white vs. red clot) within the middle cerebral artery (MCA) has been attempted, but this has also been only partially successful [5]. The oxygen extraction fraction (OEF) is an important perfusion parameter that can be currently calculated only on positron emission tomography (PET) studies; attempts to assess this parameter using MR have just started [6,7].

Conclusion

MR imaging has contributed substantially to improving the assessment of ischemic stroke patients. Nevertheless, there is still some information that needs to be obtained to allow better patient care. Future research in this field will hopefully fill in these gaps.

References

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