Functional ultrasound imaging

Functional ultrasound (fUS) imaging is a medical imaging technique that uses ultrasound waves to visualize and assess the function of tissues and organs, particularly in the brain. Unlike traditional ultrasound that is commonly used for imaging structures like organs or developing fetuses, functional ultrasound focuses on real-time monitoring of physiological processes.

Here are some key points about functional ultrasound imaging:

Principle:

Functional ultrasound relies on the Doppler effect, which involves the change in frequency of sound waves as they bounce off moving objects (like blood cells) in the body. This allows the visualization of blood flow and other dynamic processes. Brain Imaging:

In the context mentioned earlier, functional ultrasound is used to monitor changes in cerebral blood volume (CBV) in different regions of the brain. It enables researchers and clinicians to observe how blood moves through the brain's blood vessels and how this might change in response to events like a stroke or other stimuli. Real-time Monitoring:

One of the advantages of functional ultrasound is its ability to provide real-time imaging, allowing researchers to observe dynamic processes as they occur. This is particularly valuable in studying the brain's response to various stimuli or events. Awake Conditions:

In the passage you provided, functional ultrasound is used in awake animals to avoid the confounding effects of anesthesia. This allows researchers to study the brain's natural responses without the influence of sedation. Applications:

Functional ultrasound has various applications beyond stroke research, including the study of neurovascular coupling (the relationship between neural activity and blood flow), brain development, and the effects of different interventions on brain function. Advancements in Research:

The use of functional ultrasound has advanced our understanding of brain function and its alterations in various conditions. It contributes valuable information that can aid in the development of therapeutic interventions for neurological disorders. In summary, functional ultrasound imaging is a powerful tool that enables the observation of dynamic processes, particularly in the brain, by utilizing the Doppler effect to visualize blood flow in real-time. Its application in awake conditions, as mentioned in the passage, enhances its utility in studying the natural responses of the brain to different stimuli and conditions.

Anesthesia is a major confounding factor in preclinical stroke research as stroke rarely occurs in sedated patients. Moreover, anesthesia affects both brain functions and the stroke outcome acting as neurotoxic or protective agents. So far, no approaches were well suited to induce stroke while imaging hemodynamics along with simultaneous large-scale recording of brain functions in awake animals. For this reason, the first critical hours following the stroke insult and associated functional alteration remain poorly understood. Here, we present a strategy to investigate both stroke hemodynamics and stroke-induced functional alterations without the confounding effect of anesthesia, i.e., under awake condition. Functional ultrasound (fUS) imaging was used to continuously

monitor variations in cerebral blood volume (CBV) in +65 brain regions/hemispheres for up to 3 hr after stroke onset. The focal cortical ischemia was induced using a chemo-thrombotic agent suited for permanent middle cerebral artery occlusion in awake rats and followed by ipsi- and contralesional whiskers stimulation to investigate on the dynamic of the thalamocortical functions. Early (0-3 hr) and delayed (day 5) fUS recording enabled to characterize the features of the ischemia (location, CBV loss), spreading depolarizations (occurrence, amplitude) and functional alteration of the somatosensory thalamocortical circuits. Post-stroke thalamocortical functions were affected at both early and later time points (0-3 hr and 5 days) after stroke. Overall, our procedure facilitates early, continuous, and chronic assessments of hemodynamics and cerebral functions. When integrated with stroke studies or other pathological analyses, this approach seeks to enhance our comprehension of physiopathologies towards the development of pertinent therapeutic interventions [1)]

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Brunner C, Montaldo G, Urban A. Functional ultrasound imaging of stroke in awake rats. Elife. 2023 Nov 21;12:RP88919. doi: 10.7554/eLife.88919. PMID: 37988288.