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Weekend Education Session: Quantitative Physiology Course
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Vascular Permeability Imaging and Quantitative ASL

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Highlights

- Arterial spin labeling (ASL) techniques use magnetically labeled blood water as endogenous tracer
- Water exchanges across the Blood-Brain Barrier (BBB) through water channels (aquaporin), and is not 100%
- It is possible to estimate water exchange rate (Kw) across BBB by differentiating labeled water in the vascular and extravascular compartments
- Several methods have been proposed for in vivo estimation of Kw based on T1, T2 and diffusion differences between vascular and extravascular compartments
- These methods yielded reasonable Kw estimation in healthy subjects
- Preliminary studies in aging and obstructive sleep apnea (OSA) subjects showed reduced water exchange across BBB
- Validation study in a piglet model of BBB destruction failed to demonstrate diffusion weighted ASL signal changes
- Promises and challenges remain for water permeability imaging with ASL

Talk Title: Vascular Permeability Imaging and Quantitative ASL

TARGET AUDIENCE:

Students and researchers interested in ASL perfusion imaging and water permeability measurement.

OUTCOME/OBJECTIVES:

To introduce the principles of in vivo estimation of water permeability across BBB using ASL techniques and to update the state-of-the-art developments in the field

PURPOSE/BACKGROUND:

Arterial spin labeling techniques use magnetically labeled arterial blood water as endogenous tracer for cerebral blood flow (CBF) measurements. Water is traditionally treated as a freely diffusible tracer that instantaneously exchanges into brain tissue. Recent development in

neurobiology demonstrates that water molecules have restricted exchange rate across the BBB through water channels or aquaporins. This phenomenon has implications for CBF quantification and allows in vivo estimation of water exchange or permeability across the BBB.

METHODS:

To date, three categories of methods have been proposed for in vivo estimation of water exchange or permeability across the BBB:

1) Tracer kinetic modeling based on dynamic ASL acquisitions with multiple delays (mainly based on T1 difference between blood and tissue)
2) Measuring the T2 of ASL signals at multiple delays to differentiate labeled water in the vascular and tissue compartments
3) Diffusion weighted ASL (DW-ASL) acquisitions with multiple b values and post-labeling delays to differentiate labeled water in the vascular and tissue compartments

RESULTS:

The above 3 methods yielded reasonable measurements of water exchange rate or permeability across the BBB in healthy volunteers.

Validation study in a piglet model of BBB destruction failed to demonstrate DW ASL signal changes.

Preliminary studies in aging and obstructive sleep apnea (OSA) subjects showed reduced water exchange across BBB.

DISCUSSION:

In vivo estimation of water exchange rate or permeability across the BBB is feasible but requires long scan time due to the requirement of multiple delay, TE or diffusion weightings.

The confounding effect of arterial transit times (ATT) should be taken into account for estimation of water exchange.

The clinical value and interpretation of findings await further evaluations.

CONCLUSION:

In vivo estimation of water exchange rate or permeability across the BBB using ASL is a promising technique. However, challenges remain for performing measurement within a clinically acceptable time as well as for the demonstration of its clinical value.

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