Clinical Decision Making With Advanced Techniques: Perfusion MRI (ASL)

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This talk will be a case-based review of Arterial Spin Label (ASL) MRI with emphasis on the clinical decision making process. ASL imaging has been in development for over a decade [1-3]. During this time, it has remained predominantly a research tool. With the recent availability of the technique from a variety of MRI vendors, ASL is now entering more broadly into the clinical realm. Unlike conventional bolus gadolinium techniques, ASL does not require intravenous contrast, is quantitative, and is readily repeatable. ASL applications are evolving as clinical experience is gained with this technique. At Wake Forest University School of Medicine, we have implemented an automated processing pipeline capable of handling a substantial clinical volume of perfusion acquisitions, allowing us to perform over 15,000 clinical ASL examinations in the past 3 years [4]. These studies have revealed many pathologic and physiologic processes readily identified with quantitative perfusion imaging [4-13]. This talk will highlight portions of this large clinical experience with ASL. Cases will include the use of ASL in brain tumor evaluation, cerebrovascular disease, and case-based interpretation of hyper and hypo-perfusion patterns.

Artifacts. There are several frequently encountered artifacts in the clinical population with ASL [5]. Susceptibility artifacts are present as is typical for any fast imaging based technique. ASL relies on a subtraction of imaging pairs to obtain the perfusion signal, also making it highly susceptible to slight motion artifacts, or transient gradient hardware instability. These artifacts can manifest in a variety of ways, most typically as rings of high signal, low signal, or signal in CSF spaces and can make the resulting images uninterpretable. Filtering is an effective method for detecting and discarding bad subtraction pairs related to large movements or transient hardware gradient malfunction [14]. This filtering procedure has been effective in minimizing these artifacts more typical in clinical populations, and in restoring interpretability to many of these studies. Post-gadolinium ASL should be avoided. Circulating gadolinium-based contrast agents significantly shorten T1 in all tissues in both the control and label conditions. The effect of this T1 shortening is to minimize the measurable differences between the spin tag and control conditions producing maps with almost no usable signal.

Normal Perfusion Patterns. ASL perfusion patterns demonstrate age-related changes in perfusion signal. Pediatric patients in the 5-15 year old range demonstrate high perfusion values [15-18]. Adults demonstrate a gradual age-related decline in brain perfusion. The use of bipolar crusher gradients can have an effect on perfusion patterns in elderly subjects. In these patients, the anterior and posterior watershed territories are frequently hypoperfused because of prolonged transit times in these regions.

Perfusion Patters in Stroke with ASL. There are three patterns of cerebral perfusion associated with cerebral infarction [6] that are primarily based upon the use of bipolar crusher gradients to suppress intravascular signal. In the setting of slow flow and the use

of crusher gradients, hypoperfusion is typically seen in the affected territory. If crusher gradients are not employed in the setting of slow flow, high intravascular signal will be observed with linear areas of high signal along the cortex. Finally, hyperperfusion can be seen with luxury perfusion, or lysis/autolysis of clot in a previously occluded vessel. Anoxic or hypoxic ischemic injury represents an extreme form of this third pattern, with significant global hyperperfusion [6, 13].

Tumor Evaluation: Tumor grade frequently correlates with a variety of perfusion parameters based predominantly on bolus gadolinium techniques [19-22]. Tumor studies using ASL are now emerging. Hypoperfused tumors on ASL are frequently of lower histologic grade [19], and for malignant neoplasms, the higher the perfusion of the mass, the higher the histologic grade [19-22]. High ASL perfusion can be seen frequently in non-malignant tumors such as meningiomas and hemangioblastomas. Metastatic lesions demonstrate a variety of perfusion patterns, with solid tumors tending to be hyperperfused.

Infections. Most infections demonstrate hypoperfusion. Cortical hyperperfusion however, can be seen adjacent to epidural abscesses, and with conditions such as herpes encephalitis. Intracerebral abscess usually remains hypoperfused.

Hyperperfusion Patterns

Seizure: Imaging performed in the immediate post-ictal state with ASL demonstrates regional hyperperfusion [9]. In the inter-ictal state, ASL can demonstrate a regional hypoperfusion pattern.

Migraine: Migraine headaches imaged during the acute phase can demonstrate regional cortical hypoperfusion [8]. During the headache phase, hyperperfusion can be seen in the cortex corresponding to the prior aura symptoms [8, 23-26].

Posterior Reversible Encephalopathy Syndrome: PRES on ASL can have a variety of appearances. Patients who are imaged acutely show hyperperfusion in the affected occipital and frontal hemispheres and patients who are imaged in the subacute phase show hypoperfusion in these regions [27]. The variability and apparent discrepancies between studies investigating perfusion changes related to PRES may be secondary to the time-course of the disease.

Hypercapnia: Hypercapnia is a potent cerebral vasodilatory stimulus. In the clinical population, common conditions which can result in arterial blood gas disturbances include chronic obstructive pulmonary disease, adult respiratory distress syndrome, and pulmonary edema. Increases of 30mmHg or more from baseline can occur in these patients and may significantly increase global CBF demonstrating a typical superscan ASL appearance [10].

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