Use of Magnetic Resonance Imaging to Quantitatively Assess Inflammation and Blood Labyrinth Barrier Integrity in Inner Ear Disease

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INTRODUCTION

Cochlear injury or disease is the major cause of hearing loss [1,2]. There is evidence that inflammation and disruption of the Blood-Labyrinth Barrier (BLB) contributes to cochlear injury, for example after cochlear implantation [3]. As yet no approach is available to identify inflammatory changes in the intact, living inner ear of humans.

Recent developments in Magnetic Resonance Imaging (MRI), using Dynamic Contrast Enhanced-MRI (DCE-MRI) offer opportunities to study structure, function and metabolism of the intact, living cochlea.

The large amount of MRI data can be automatically analysed with image registration to produce accurate spatial and temporal results.

STUDY OBJECTIVES

1. Develop and apply DCE-MRI to quantify changes in vascular permeability in normal and inflamed guinea-pig cochlea.
2. Investigate the translation of these DCE-MRI techniques to study the vascular permeability of the human inner ear.

METHODS

Animal model of cochlear inflammation: Guinea-pigs (GP n=8) were sensitised with bacterial lipopolysaccharide (LPS, 0.8mg/kg, ip) followed by (24 hrs) bilateral intra-tympanic injection (LPS, 30µl). Controls (n=5) were either not treated with LPS (3) or injected with saline (0.8mg/kg, ip), followed by intra-tympanic saline (30µl).

Human participants: Volunteers (30 years old, n=2) with normal hearing and no otological disease. All received a single dose of contrast agent (Dotarem, Guerbet, 0.1ml/kg, bolus injection 2.5mL/s).

MRI protocol for animals (Fig 1): LPS-treated GP were scanned at 4 (n=7), 7 (n=4) and 10 days (n=3) after injection. Control GP were scanned once (untreated, day 0) or at 4, 7 and 14 days (saline-treated) after injection. To estimate early changes in vascular permeability and GBCA plasma concentration LPS (n=2) and control (n=1) GP were scanned once after 4 days.

All scans were based on a slab-selective 3D Gradient Echo sequence: T1-w coronal, acquisition matrix=512x256x16 and FOV=80mmx50mmx12mm, TR=20ms, TE=4.5ms, FA=50°, single average, total acquisition time=81s using a Varian 4.7T MRI.

MRI protocol for human (Fig 2): All subject had DCE-MRI (VIBE sequence, TR/TE=20/3.7ms, spacing=3(0.3x0.3x0.3) mm, matrix=512x125x44, FOV=132mmx75mmx75mm acquisition time: approx. 9 min) before DGBCA injection, 2 minutes and 30s/5 to 40s post-injection (using (Skrya Magnetom, Siemens)). The spatial resolution shows different turns of the cochlea, but is not sufficient to differentiate fluid compartments.

RESULTS

Normal MRI: Animal Studies

Reproducible proton density-weighted MR image demonstrates cochlear position and structure (Fig.1).

Normal MRI: Human Studies

MRI image with a T1-w VIBE sequence before injection of the contrast agent (Fig.2).

CONCLUSIONS

DCE-MRI can qualitatively monitor reversible changes in cochlear vascular permeability (Blood-Labyrinth Barrier) in a guinea pig model of inner ear inflammation.

DCE-MRI can quantitatively assess BLB in humans and establish DCE-MRI as a promising diagnostic tool for assessing BLB in inner ear disease.

The VIBE sequence enables good spatial resolution and a rapid acquisition time. The registration pipeline sets together all the measurements, allowing us to estimate temporal changes of the contrast agent inside the inner ear.

REFERENCES:


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