Redefining MRI:
From Image to Insight

ICMRI 2026
THE 14th INTERNATIONAL CONGRESS ON MRI
& 31st ANNUAL SCIENTIFIC MEETING OF KSMRM

AUGUST 27 - 28, 2026
Grand Walkerhill Seoul, Seoul, Korea
https://icmri.ksmrm.org/2026m

iMRI Invited

SY08-1

MRI Imaging for Meningeal Lymphatic Flow and Modulation

Jun-Hee Kim

Medical Research Center, Seoul National University, Korea

The (re)discovery of meningeal lymphatic vessels (mLVs) along the dural venous sinuses has reshaped our understanding of brain waste clearance. These vessels drain cerebrospinal fluid (CSF), interstitial fluid, and immune cells to the deep cervical lymph nodes, and their dysfunction is increasingly linked to aging and neurodegenerative disease. In humans, a major CSF outflow route has been localized to skull-base mLVs; the nasopharyngeal lymphatic plexus was identified as a hub for CSF drainage to deep cervical lymph nodes, and arachnoid cuff exit points refined the anatomy of CSF-to-dura efflux. This lecture reviews how MRI can visualize and quantify meningeal lymphatic flow, and how emerging strategies aim to modulate it.

The first part surveys mLV imaging. Contrast-enhanced MRI with gadobutrol on FLAIR or T1 black-blood sequences first revealed human mLVs running alongside the dural sinuses. Because gadolinium retention and limited access constrain repeated scans, non-contrast methods have become central: inter-slice flow-saturation techniques such as ALADDIN and IR-ALADDIN map parasagittal mLV flow without any contrast agent, while heavily T2-weighted FLAIR depicts parasagittal dural lymphatic structures from intrinsic protein-rich fluid signal. These approaches enable repeatable, contrast-free assessment in healthy volunteers and patients.

The second part addresses modulation. VEGF-C can restore mLV drainage and improve cognition in aged and Alzheimer's-model animals. Targeting the nasopharyngeal–cervical outflow route, pharmacological (α-adrenergic and nitric-oxide) activation and non-invasive mechanical stimulation of cervical lymphatics can double CSF drainage and reverse age-related impairment. Transcranial focused ultrasound (FUS) is another candidate: FUS with microbubbles enhances glymphatic–lymphatic clearance of amyloid-β, and pulsed FUS augments CSF tracer movement through mechanosensitive signaling. Physiological interventions—sleep, body posture, and exercise—also modulate flow; notably, long-term exercise facilitates putative glymphatic and meningeal lymphatic flow in humans on MRI.

In conclusion, MRI now enables non-invasive, contrast-free visualization and quantification of meningeal lymphatic flow, while molecular, ultrasonic, and physiological tools can actively modulate it—together offering a path toward earlier detection and treatment of disorders associated with impaired brain waste clearance.

Keywords: *Meningeal lymphatic vessels, Brain waste clearance, Non-contrast MRI, Glymphatic system, Neuromodulation*