

# **Cerebral CT- and MRI perfusion: Techniques and clinical application in iNPH**

## **Akademisk avhandling**

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademien, Göteborgs Universitet, kommer att offentlig försvaras i Hjärtats aula, Sahlgrenska Universitetssjukhuset, Huvudingången, fredagen den 5 juni 2015 kl. 9:00

av

**Doerthe Constantinescu Ziegelitz**

Legitimerad läkare

Fakultetsopponent:

**Docent Johan Wikström**

Avdelningen för radiologi, Akademiska sjukhuset/Uppsala Universitet

Avhandlingen baseras på följande arbeten:

I. Ziegelitz D, Starck G, Mikkelsen IK, Tullberg M, Edsbagge M, Wikkelsø C, Forssell-Aronson E, Holtås S, Knutsson L.

Absolute quantification of cerebral blood flow in neurologically normal volunteers: dynamic susceptibility contrast MRI-perfusion compared with computed tomography (CT)-perfusion  
*Magn Reson Med. 2009 Jul;62(1):56-65*

II. Ziegelitz D, Starck G, Kristiansen D, Jakobsson M, Hultenmo M, Mikkelsen IK, Hellström P, Tullberg M, Wikkelsø C.

Cerebral perfusion measured by dynamic susceptibility contrast MRI is reduced in patients with idiopathic normal pressure hydrocephalus

*J Magn Reson Imaging. 2014 Jun;39(6):1533-42*

III. Ziegelitz D, Arvidsson J, Hellström P, Tullberg M, Wikkelsø C, Starck G.

In patients with idiopathic normal pressure hydrocephalus postoperative cerebral perfusion changes measured by dynamic susceptibility contrast MRI correlate with clinical improvement

*Submitted and accepted for publication in JCAT 2015*

IV. Ziegelitz D, Arvidsson J, Hellström P, Tullberg M, Wikkelsø C, Starck G.

Pre-and postoperative cerebral blood flow changes in patients with idiopathic normal pressure hydrocephalus measured by CT-perfusion

*Submitted*



**UNIVERSITY OF GOTHENBURG**

Göteborg 2015

# Cerebral CT- and MRI perfusion: Techniques and clinical application in iNPH

Doerthe Constantinescu Ziegelitz, MD

Department of Radiology, Institute of Clinical Sciences  
Sahlgrenska Academy at University of Gothenburg,  
Sweden

## ABSTRACT

Idiopathic normal pressure hydrocephalus (iNPH) is a disorder of the elderly, defined by slowly progressive impairment of gait and balance, cognitive decline, and incontinence. Disturbance of the cerebrospinal fluid (CSF) dynamics results in ventriculomegaly without intracranial pressure increase. Treatment by CSF diversion is successful in about 80% of the cases. Better preoperative identification of non-responders is required.

The pathophysiology of iNPH is obscure, but linked to cortical and especially subcortical cerebral blood flow (CBF) reductions. The association between perfusion and the severity of the clinical features is not clearly established and a predictive perfusion pattern has not been identified. CT-perfusion (CTP) and Dynamic susceptibility contrast MRI perfusion (DSC MRI) offer advantages compared to traditional perfusion techniques, but are so far not of significant use in iNPH.

The aim of this thesis was to compare CTP and DSC MRI in iNPH and to study their potential role as investigational techniques by exploring the pre- and postoperative CBF changes, how these correlate to the severity of the symptoms and, subsequently, the prognostic value of CBF.

Fifty-one patients with suspected iNPH and 24 age-matched healthy individuals (HI) were recruited. At baseline all subjects had CTP and DSC MRI on 2 consecutive days. Patients repeated the perfusion measurements 3 months after shunting. Probable iNPH was diagnosed corresponding to the European-American iNPH guidelines and clinical performance was scored according to a recently published scale. After drop-outs, omission secondary to unsuccessful imaging and exclusion of non iNPH patients, 20 HI and 21 patients with complete preoperative imaging remained. One patient died prior to shunting. Postoperative DSC MRI was successful in all 20 cases and CTP in 17. Deconvolution generated absolute CBF estimates that eventually were normalized against an internal reference. Region of interest analysis was used for evaluation. Seventy-five percent of the patients were shunt responders.

Correction of partial volume effects (PVE) of the arterial input function increased the accuracy of DSC MRI in HI. Despite PVE correction the linear relationship on the group level and the agreement between the modalities was limited. In iNPH, preoperative global and regional perfusion deficits, most pronounced in the periventricular white matter (PVWM), were measured by DSC MRI and, in spite of a limited spatial coverage, also by CTP. After shunting, DSC MRI and CTP demonstrated CBF restoration in responders in all anatomical regions and remaining hypoperfusion in the PVWM of non-responders. Postoperative metallic valve artefacts restricted the DSC MRI evaluation to one hemisphere, but were no issue in CTP. A valid prognostic CBF threshold was not identified. Regional and global CBF correlated with the severity of symptoms of iNPH. Patients with higher preoperative perfusion performed better in clinical tests and a lower preoperative perfusion resulted in a more marked postoperative improvement.

Although the agreement of CTP and DSC MRI is limited, both methods contain perfusion information. The good general consistency of the results of CTP and DSC MRI measurements in the same material indicates reliability of both methods. DSC MRI and CTP might be used as investigational tools in iNPH.

**Keywords:** *Idiopathic normal pressure hydrocephalus, Dynamic susceptibility contrast MRI, Computed tomography perfusion, Cerebral perfusion*

**ISBN:** 978-91-628-9372-9 (tryckt)

**ISBN:** 978-91-628-9373-6 (e-pub)