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TO STUDY THE ROLE OF LIMITED SEQUENCE MAGNETIC RESONANCE IMAGING IN ASSESSMENT OF CHILDREN WITH HYDROCEPHALUS.

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ABSTRACT **Aim:** To evaluate the role of limited sequence MRI (LS MRI) in diagnosing obstructive from nonobstructive hydrocephalus for treatment planning correlating with surgical findings and in follow up cases of shunt treated hydrocephalus to predict the candidate requires revision surgery correlating with final treatment.

Materials and Methods: A total of 235 cases were included in the study underwent limited sequence MRI, 121 cases were evaluated for diagnosing obstructive from nonobstructive hydrocephalus out of which 106 cases underwent surgery were correlated with surgical findings and 114 were symptomatic follow up cases evaluated for need of revision surgery. Diagnostic measures such as sensitivity, specificity, PPV, NPV and accuracy were calculated. A p value of <0.05 was considered to be statistically significant.

Results: Obstruction was seen in 81 out of the 106 cases who underwent surgery. MRI showed obstruction in 72(88.9%) and no obstruction in 9(11.1%) cases. Out of the 25 cases with no obstruction in surgery, MRI correctly excluded obstruction in 20(80%) cases. MRI misdiagnosed obstruction in 5(20%) cases. No statistically significant difference between the limited sequence MRI and surgery (p value of 0.424 Sensitivity 88.89%, Specificity 80% PPV 93.51%, NPV 68.97% and Accuracy 86.79%). Out of the total 114 follow up cases of hydrocephalus,47 underwent surgery and 67 cases were managed conservatively. MRI criteria predicted surgical candidate in 43(91.5%) and no surgery in 4(8.5%) patients. MRI criteria predicted nonsurgical management in 64 (95.5%) out of the 67 cases and the rest of 3 (4.5%) cases MRI over rated need for surgery. (Sensitivity:91.49% Specificity:95.52% PPV: 93.5% NPV 94.1% Accuracy :93.9%.)

Conclusion: LS MRI has good accuracy in detecting an obstruction in paediatric hydrocephalus. In predicting revision surgery for follow-up cases of shunt-treated hydrocephalus, LS MRI has good accuracy.

KEYWORDS : Magnetic resonance imaging, Hydrocephalus,

INTRODUCTION:

Hydrocephalus is a common clinical disorder of abnormal accumulation of cerebrospinal fluid (CSF) within the ventricles or subarachnoid space due to the imbalance between inflow and outflow of CSF circulation. It is the feature of most of the congenital and acquired brain disorders, causing dilatation of the ventricles (1). Hydrocephalus is classified into noncommunicating and communicating type (2). The surgical modalities in practice are shunt placement and endoscopic surgeries. Still there is a confusion in choosing the treatment modality, whether shunt or endoscopic surgery (3). Routinely used conventional sequences falls short of exploring some hidden causes of hydrocephalus. 3D-constructive interference in the steady state (3D-CISS) is a fully balanced and inherently flow-compensated gradient- echo sequence providing fine anatomic details about CSF pathways (4). In particular, the value of this technique has been demonstrated in hydrocephalus and endoscopic third ventriculostomy (5,6,7).From a treatment point of view, identification of obstructive pathologic processes at any level through the CSF pathway is of significant importance because it can change the mode of management in patients with hydrocephalus, avoiding shunt insertion. Our institution, along with most radiology practices, is continually striving to minimize scan durations not only for the purpose of patient comfort but also for efficient patient throughput. In this study our primary objective is to explore the utility of limited sequence MRI in diagnosing obstructive vs non obstructive hydrocephalus for treatment planning. Our secondary objective is to explore its role in follow up cases of shunt treated hydrocephalus to predict the surgical candidate for revision surgery.

MATERIALS AND METHODS:

Institutional Review Board approval was taken for this prospective cross-sectional study. Informed consent was taken from all the patients before they underwent MRI. Data set consists of paediatric patients with suspected hydrocephalus and symptomatic follow up shunt treated hydrocephalus cases who underwent limited sequence MRI from the department of Radio-Diagnosis of Amrita Institute of Medical Sciences research Centre, Kochi and treatment from the Department of neurosurgery of Amrita Institute of Medical Sciences research Centre, Kochi during the period of 2017-2020. A total of 235 cases under age 14 was included in the study, out of which 121 were primary cases with clinical diagnosis of hydrocephalus underwent MRI before planning treatment options and 114 were secondary cases who are follow up cases of shunt treated hydrocephalus presented with neurological symptoms. Patients were excluded if image quality was very poor with significant motion artifact and uninterpretable images and Contraindications to MRI (Metal implants, pacemakers, stenting, claustrophobia etc.)

All data for this study were collected from the institutional EMR. Selected imaging and clinical notes within the EMR were searched to identify clinical indications pertinent to this study. Scanner time and total imaging time were extracted from the proprietary institutional

radiology image viewing platform. The total number of pediatric imaging examinations was extracted from the radiology information management system. For each patient record identified, the following data were collected from the EMR: Imaging indications, scan duration, presence of obstruction, level of obstruction, cause of obstruction, tip of ventricular shunt, surgical requirement, size of ventricles and demographic data including name, age, and sex. Our MRI protocol, viz. "pediatric hydrocephalus protocol," a focused MRI protocol performed using either 1.5T GE HDxT MRI (GE healthcare, Milwaukee, WI) or by the GE 3T Discovery 750W system (GE healthcare, Milwaukee, WI). Axial and sagittal fast spin-echo (FSE) T2 sequences performed with 4 mm slice thickness and 0.5 mm gap, and 3D-constructive interference in the steady state with 1 mm thickness taken at midsagittal section. FOV-230mm for axial and sagittal T2 sequence and 200mm for sagittal 3D CISS. All MRI images was interpreted by single radiologist. Utilizing the information obtained from limited sequence MRI, images were analysed for the following: Obstructive from nonobstructive hydrocephalus**:** We analysed the presence or absence of obstruction to ventricle outflow in all the sequences. Surgical candidate: LS MRI Based criteria were implemented for predicting the surgical candidate in symptomatic shunt treated hydrocephalus patients. This includes an increase in the size of the ventricle, new appearance, or progression of multiloculated hydrocephalus, slit ventricles, and Subdural haemorrhage, in comparison to baseline MRI.

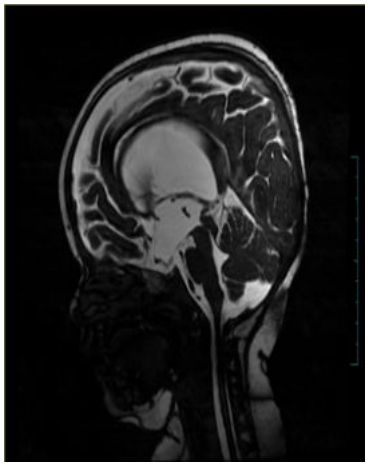

Figure 1 – A2 year old female child presented with hydrocephalus. Sagittal 3D CISS images shows cases of congenital cerebral aqueduct obstruction, Proximal aqueductal stenosis at the level of superior colliculus

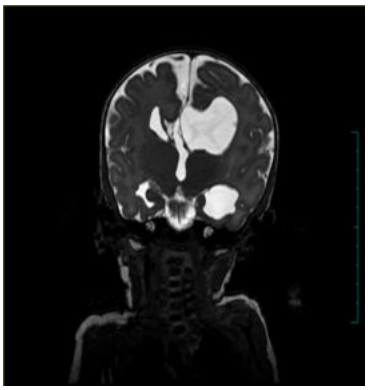

Figure 2 -A 3 year old male child presented with hydrocephalus Coronal 3D CISS images shows left side foramen of Monroe obstruction by a membrane

STATISTICALANALYSIS:

Statistical analysis was done using IBM SPSS 20.0 (SPSS Inc, Chicago, USA). Categorical variables were expressed using frequency and percentage. Numerical variables were presented using mean and standard deviation. Chi square test was used to find the statistical significance of the association of categorical variables. Diagnostic measures such as sensitivity, specificity, PPV, NPV and accuracy were calculated. A p value of <0.05 was considered to be statistically significant.

RESULTS:

In primary cases Obstruction was seen in 81 out of the 106 cases who underwent surgery. MRI showed obstruction in 72(88.9%) and no obstruction in 9(11.1%) cases. Out of the 25 cases with no obstruction in surgery, MRI correctly excluded obstruction in 20(80%) cases. MRI misdiagnosed obstruction in 5(20%) cases. No statistically significant difference between the limited sequence MRI and surgery (p = 0.424) Validity parameters for limited sequence MRI (Obstructive vs nonobstructive) with surgery as gold standard. Sensitivity 88.89% Specificity 80%PPV 93.51% NPV 68.97% Accuracy 86.79%. Out of 114 hydrocephalus, catheter tip was visualised in 109(95.6%) and not visualised in 5 cases (4.4%). Out of the total 114 follow up cases of hydrocephalus,47 underwent surgery and 67 cases were managed conservatively. MRI criteria predicted surgery in 43(91.5%) and no surgery in 4(8.5%) patients. MRI criteria predicted nonsurgical management in 64 (95.5%) out of the 67 cases and the rest of 3 (4.5%) cases MRI over rated the need for surgery. Validity parameters of limited sequence MRI in selecting potential surgical candidates Sensitivity:91.49%Specificity:95.52%PPV: 93.5%NPV 94.1% Accuracy :93.9%.

Table: 1 Demographic characteristics of the study population.

Total number of patients	235
Mean age(years)	5.2 ± 3.8
Male: Female	152:83

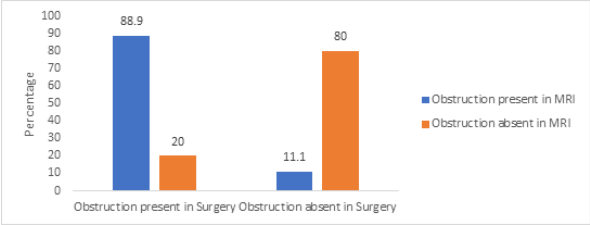

Figure 3. Comparison of MRI with surgical diagnosis (Obstructive vs nonobstructive)

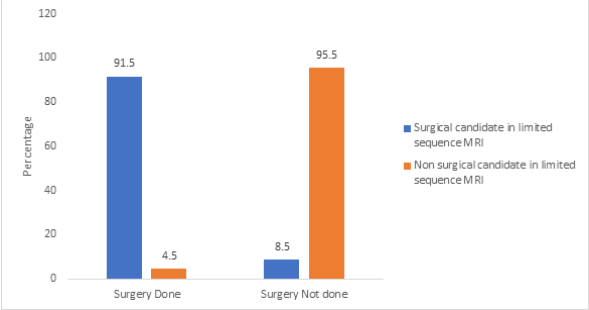

Figure 4 Comparison of MRI prediction of surgical candidate with final treatment

DISCUSSION:

Hydrocephalus is a common clinical disorder, and effective surgical treatment options are available according to the level of obstruction and etiology. The success of these treatments depends on the accurate diagnosis and classification of this disorder. Limited sequence (LS) MRI hydrocephalus protocol in this study included only Axial, sagittal T2 FSE sequences, and sagittal 3-D CISS. This pilot study is done to assess the potential role of limited sequence MRI in differentiating obstructive versus nonobstructive hydrocephalus comparing with surgical findings. Males predominated (64.7%) in our study compared to females (35.3%). Literature also states a similar higher occurrence of hydrocephalus in males than their female counterparts (8). The mean age of the patients included in this study was 5.2 years.

Obstructive hydrocephalus was surgically confirmed in 81 out of the 106 cases who underwent surgery. Limited sequence MRI accurately detected obstructive hydrocephalus in 72 out of these 81 cases. LS MRI were misdiagnosed 9 out of the 81 cases as non-obstructive hydrocephalus. The sensitivity of LS MRI in detecting obstruction was 88.9%. Partial stenosis of the cerebral aqueduct can be missed and the presence of flow void also can hinder the diagnosis of obstruction. No previous studies are available comparing LS MRI with surgery. Previous Studies by Oktay Algin in 2009, comparing 3D-CISS and MR cisternography (MRC) in obstructive hydrocephalus**,** stated that

92% of the cases showed 3D CISS results consistent with MR cisternography (MRC) (9). Five cases which was detected as obstructive on LS MRI had no obstruction on surgery.

In our study, LS MRI has a good specificity (80%) in detecting obstructive hydrocephalus .Out of the 25 cases with no obstruction detected by surgery, LS MRI correctly excluded obstruction in 20 cases. Five cases were over diagnosed as having obstruction in MRI. The banding artifacts with 3D-CISS can mimic as a thin membrane in various locations and can be misdiagnosed as obstruction (10). This occur with field inhomogeneity and is more in air-bone and soft tissue interfaces. Sensitivity to susceptibility is increased with higher magnetic field strength (3.0 T than 1.5 T) increasing the chance of this artifact.

In our study LS MRI had an accuracy of 86.79%, NPV of 68.97% and PPV of 93.5 % in detecting obstruction.

LS MRI Based criteria was implemented for predicting the surgical candidate in symptomatic shunt treated hydrocephalus patients. This includes increase in the size of the ventricle, new appearance, or progression of multilocation, slit ventricles, and Subdural haemorrhage, on comparison to baseline MRI.

Limited sequence MRI predicted the indication for shunt surgery in 43 out of the 47 cases who underwent revision surgery with a sensitivity of 91.5%. In four cases, although MRI showed a static ventricular size, shunt revision surgery was done in view of worsening of symptoms clinically. There is constraints in diagnosis of acute components of hydrocephalus in chronically shunt treated patients with severe ventricular dilation (11).

Non-surgical management was predicted accurately in 64 out of the 67cases managed conservatively by medical management. MRI showed a mild increase in ventricular size compared to the baseline study in the rest of the 3 cases, who were managed medically as there was no aggravation of symptoms. The specificity of LS MRI in predicting revision surgery was 95.5 % and accuracy was 93.86%. No previous studies are available comparing LS MRI with clinical decision on revision surgery for shunt treated hydrocephalus.

CONCLUSION:

Limited sequence MRI has good accuracy in detecting obstruction in paediatric hydrocephalus. Infection and haemorrhage were the cause of pitfalls in these cases. In predicting revision surgery for follow up shunt treated hydrocephalus, LS MRI has good accuracy.

REFERENCES:

1. Chellathurai, A., Subbiah, K., Ajis, B. N. A., Balasubramaniam, S., & Gnanasigamani, S. (2018). Role of 3D SPACE sequence and susceptibility weighted imaging in the evaluation of hydrocephalus and treatment-oriented refined classification of hydrocephalus. The Indian journal of radiology & imaging, 28(4), 385.
2. Krishnamurthy, S., & Li, J. (2014). New concepts in the pathogenesis of hydrocephalus. Translational Pediatrics, 3(3), 185.
3. Kandasamy, J., Jenkinson, M. D., & Mallucci, C. L. (2011). Contemporary management and recent advances in paediatric hydrocephalus. Bmj, 343.
4. Casselman, J. W., Kuhweide, R., Deimling, M., Ampe, W., Dehaene, I., & Meeus, L. (1993). Constructive interference in steady state-3DFT MR imaging of the inner ear and cerebellopontine angle. American journal of neuroradiology, 14(1), 47-57.
5. Kunz, M., Schulte-Altedorneburg, G., Uhl, E., Schmid-Elsaesser, R., Schöller, K., & Zausinger, S. (2008). Three-dimensional constructive interference in steady-state magnetic resonance imaging in obstructive hydrocephalus: relevance for endoscopic third ventriculostomy and clinical results. Journal of neurosurgery, 109(5), 931-938.
6. Doll, A., Christmann, D., Kehrli, P., Eid, M. A., Gillis, C., Bogorin, A., ... & Dietemann, J. L. (2000). Contribution of 3D CISS MRI for pre-and post-therapeutic monitoring of obstructive hydrocephalus. Journal of neuroradiology= Journal de neuroradiologie, 27(4), 218-225.
7. Awaji, M., Okamoto, K., & Nishiyama, K. (2007). Magnetic resonance cisternography for preoperative evaluation of arachnoid cysts. Neuroradiology, 49(9), 721-726.
8. Patel, D. M., Tubbs, R. S., Pate, G., Johnston, J. M., & Blount, J. P. (2014). Fast-sequence MRI studies for surveillance imaging in pediatric hydrocephalus. Journal of Neurosurgery: Pediatrics, 13(4), 440-447.
9. Algin, O., Hakyemez, B., & Parlak, M. (2010). Phase-contrast MRI and 3D-CISS versus contrast-enhanced MR cisternography on the evaluation of the aqueductal stenosis. Neuroradiology, 52(2), 99-108.
10. Dinçer, A., Kohan, S., & Özek, M. M. (2009). Is all "communicating" hydrocephalus really communicating? Prospective study on the value of 3D-constructive interference in steady state sequence at 3T. American journal of neuroradiology, 30(10), 1898-1906.
11. Craven, C. L., Ramkumar, R., D'Antona, L., Thompson, S. D., Thorne, L., Watkins, L. D., & Toma, A. K. (2019). Natural history of ventriculomegaly in adults: a cluster analysis. Journal of Neurosurgery, 132(3), 741-748.