Image-guided ventricular catheter placement

In a systematic review and meta-analysis, the intraoperative ventricular drainage placement techniques were ultrasound (9.1%), electromagnetic neuronavigation (21.07%), endoscope (67.32%), and combined images (2.4%). The image-guided placement of VC was not statistically associated with a lower revision rate. The pooled OR was 0.97 [CI 95% 0.88-1.07] with an I2 statistics of 34%, t2 of 0.018, and a p-value of 0.15 at heterogeneity analysis.

The analysis suggests image guidance during VC shunt placement does not statistically affect shunt survival. Nevertheless, intraoperative tools can support the surgeon, especially in patients with difficult anatomy, slit ventricles, or complex loculated hydrocephalus [1)]

A proof of concept study aimed to evaluate the registration accuracy of a novel image-based verification system “Bullseye EVD” in a preclinical cadaveric model of catheter placement.

Experimentation was performed on both sides of 3 cadaveric heads (n = 6). After a pre-interventional CT scan, a guidewire simulating the EVD catheter was inserted as in a clinical EVD procedure. 3D structured light images (Einscan, Shining 3D, China) were acquired of an optical tracker placed over the guidewire on the surface of the scalp, along with three distinct cranial regions (scalp, face, and ear). A computer vision algorithm was employed to determine the guidewire position based on the pre-interventional CT scan and the intra-procedural optical imaging. A post-interventional CT scan was used to validate the performance of the Bullseye optical imaging system in terms of trajectory and offset errors.

Optical images which combined facial features and exposed scalp within the surgical field resulted in the lowest trajectory and offset errors of 1.28° ± 0.38° and 0.33 ± 0.19 mm, respectively. The mean duration of the optical imaging procedure was 128 ± 35 s.

Conclusions: The Bullseye EVD system presents an accurate patient-specific method to verify freehand EVD positioning. The use of facial features was critical to registration accuracy. Workflow automation and development of a user interface must be considered for future clinical evaluation [2)]

Over the years, the development of the Surgical Navigation Systems has allowed the surgeon to be guided in real time during the procedures. Nevertheless, to date, the revision rate remains as high as 30-40%. The aim of this study was to investigate the role of intraoperative image guidance in the prevention of Cerebrospinal fluid shunt malfunction.

Spennato et al. reported the first literature meta-analysis of image guidance and shunt revision rate in the pediatric population.

Principal online databases were searched for English-language articles published between January, 1980, and December, 2021. Analysis was limited to articles that included patients younger than 18 years of age at the time of primary V-P shunt. Articles reporting combined results of free-hand and image-guided placement of ventricular catheter (VC) were included. The main outcome measure of the study was the revision rate in relation to the intraoperative tools. Secondary variables collected were the age of the patient and ventricle size. Statistical analyses and meta-analysis plots were done via R and RStudio. Heterogeneity was formally assessed using Q, I2, and τ2 statistics. To examine publication bias was performed a funnel plot analysis.

A total of 9 studies involving 2017 pediatric patients were included in the meta-analysis. 55.9% of procedures were carried out with the aid of intraoperative tools, while 44.1% procedures were conducted free hand. The intraoperative tools used were ultrasound (9.1%), electromagnetic neuronavigation (21.07%), endoscope (67.32%), and combined images (2.4%).The image-guided placement of VC was not statistically associated with a lower revision rate. The pooled OR was 0.97 [CI 95% 0.88-1.07] with an I2 statistics of 34%, t2 of 0.018 and a p-value of 0.15 at heterogeneity analysis.

The analysis suggest images guidance during VC shunt placement does not statistically affect shunt survival. Nevertheless, intraoperative tools can support the surgeon especially in patients with difficult anatomy, slit ventricles or complex loculated hydrocephalus [3).].

Percutaneous CT-controlled ventriculostomy (PCV)

52 interventions with PCV was prospectively analyzed with regard to technical success, procedural time, time from the initial cranial computed tomography (CCT) until procedure and transfer to the intensive care unit (ICU). Additionally, the data was compared with a retrospective control group of 12 patients with 13 procedures of conventional burr-hole ventriculostomy (OP-ICP). The PCV was successful in all cases (52 of 52; 95% CI 94-100%). In 1 case a minor hemorrhage into the ipsilateral lateral ventricle was observed on CT scans due to an initially unsuccessful puncture (95% CI 0-6%). No infections occurred (95% CI 0-6%). In the control group with OP-ICP one catheter infection and one unsuccessful catheter placement occurred (each 8%, 95% CI 0-20%). The PCV led to a significant decrease of procedure time from 45 +/- 11 min (OP-ICP) to 20 +/- 12 min (PCV). The interval from the initial CCT until procedure (PCV 28 +/- 11 min, OP-ICP 78 +/- 33 min) and transfer to the ICU (PCV 69 +/- 34 min, OP-ICP 138 +/- 34 min) could also be significantly reduced (each with p<0.05, Mann-Whitney U-test). Percutaneous CT-controlled ventriculostomy is a safe and efficient method for ICP catheter placement during initial trauma room management. It significantly reduces the time of initial trauma room treatment [4)].

Electromagnetic guided ventricular catheter placement

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1) , 3)
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