Intraventricular catheter

An intraventricular catheter is a medical device that can be inserted in the ventricle to treat hydrocephalus and intracranial pressure monitoring.

Ventriculostomy is a common neurosurgical technique and accurate placement of the ventricular catheter is one of the most important variables in the longevity of shunt survival [1] [2].

They allow drainage, administration of fluids and is normally inserted on the right lateral ventricle.

This so-called ventricular catheter is a standard-size, flexible tubing with a number of holes placed symmetrically around several transversal sections or “drainage segments”. Three-dimensional computational dynamics shows that most of the fluid volume flows through the drainage segment closest to the valve. This fact raises the likelihood that those holes and then the lumen get clogged by the cells and macromolecules present in the cerebrospinal fluid, provoking malfunction of the whole system.

In order to better understand the flow pattern, Galarza et al. have carried out a parametric study via numerical models of ventricular catheters.

The parameters chosen are the number of drainage segments, the distances between them, the number and diameter of the holes on each segment, as well as their relative angular position.

These parameters were found to have a direct consequence on the flow distribution and shear stress of the catheter. As a consequence, we formulate general principles for ventricular catheter design.

These principles can help develop new catheters with homogeneous flow patterns, thus possibly extending their lifetime [3].

Types

Hydrogel coated catheter.

Silver impregnated catheter

Antibiotic impregnated catheter

Placement

see Ventricular drainage placement.

Complications

Ventricular catheter obstruction

Ventricular catheter misplacement

Catheter-related infection of CSF is a potentially life-threatening complication of external ventricular drainage (EVD). When using EVD catheters, contact between the ventricular system and skin surface occurs and CSF infection is possible.

EVD catheters impregnated with silver nanoparticles and an insoluble silver salt may reduce the risk of catheter-related infections in neurosurgical patients [4].

Ventricular catheters can cause epileptic seizures as a result of adhesion and can also be the nidus for infection. In such cases, the ventricular catheter should be removed. Usually, catheter can be endoscopically removed. However, a craniotomy may be required in cases where the catheter is adhered to the parenchyma [5].

Although the placement of an intraventricular catheter remains the gold standard technique for measuring intracranial pressure (ICP), the method has several limitations. Therefore, noninvasive alternatives to ICP (ICPni) measurement are of great interest. The main objective of a study of de Moraes et al. was to compare the correlation and agreement of wave morphology between ICP (standard intraventricular ICP monitoring) and a new ICPni monitor in patients admitted with stroke. The second objective was to estimate the discrimination of the noninvasive method to detect intracranial hypertension.

They prospectively collected data of adults admitted to an intensive care unit with subarachnoid hemorrhage, intracerebral hemorrhage, or ischemic stroke in whom an invasive ICP monitor was placed. Measurements were simultaneously collected from two parameters [time-to-peak (TTP) and the ratio regarding the second and first peek of the ICP wave (P2/P1 ratio)] of ICP and ICPni wave morphology monitors (Brain4care). Intracranial hypertension was defined as an invasively measured sustained ICP > 20 mm Hg for at least 5 min.

They studied 18 patients (subarachnoid hemorrhage = 14; intracerebral hemorrhage = 3; ischemic stroke = 1) on 60 occasions with a median age of 52 ± 14.3 years. A total of 197,400 waves (2495 min) from both ICP (standard ICP monitoring) and the ICPni monitor were sliced into 1-min-long segments, and we determined TTP and the P2/P1 ratio from the mean pulse. The median invasively measured ICP was 13 (9.8-16.2) mm Hg, and intracranial hypertension was present on 18 occasions (30%). The correlation and agreement between invasive and noninvasive methods for wave morphology were strong for the P2/P1 ratio and moderate for TTP using categoric (κ agreement 88.1% and 71.3%, respectively) and continuous (intraclass correlation coefficient 0.831 and 0.584, respectively) measures. There was a moderate but significant correlation with the mean ICP value (P2/P1 ratio $r = 0.427$; TTP $r = 0.353$; $p < 0.001$ for all) between noninvasive and invasive techniques. The areas under the curve to estimate intracranial hypertension were 0.786 [95% confidence interval (CI) 0.72-0.93] for the P2/P1 ratio and 0.694 (95% CI 0.60-0.74) for TTP.

The new ICPni wave morphology monitor showed a good agreement with the standard invasive method and an acceptable discriminatory power to detect intracranial hypertension. Clinical trial registration: NCT05121155 [6].

1)

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