Reevaluation of Classic Posterior Ventricular Puncture Sites Using a 3-Dimensional Brain Simulation Model

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■ OBJECTIVE: **To revalidate the craniometric dimensions of classic posterior burr holes for ventricular catheter insertion in hydrocephalic patients, based on ideal catheter position on a 3-dimensional simulated computed tomography (CT) reconstruction model of the ventricles.**

■ METHODS: **Fifteen patients with hydrocephaly underwent multislice, thin-cut CT to geometrically determine the Cartesian coordinates of a new point for optimal posterior ventricular catheterization. The success rate for ventricular puncture and the thickness of brain traversed by the catheter with 3 approaches (Frazier, Keen, and the suggested point) were compared.**

■ RESULTS: **The suggested burr hole point for posterior ventricular catheterization is 51 and 57 mm posterior and 58 and 60 mm above the external auditory meatus parallel to the orbitomeatal plane on the right and left sides, respectively, significantly different from the classical Frazier and Keen points. The success rate was 100% for approaches using the suggested point and the Frazier point, compared with 83% using the Keen point. This 17% difference was marginally significant ($P = 0.052$). The parenchymal mantle for the Frazier point was thicker than that of the suggested point on both sides, although the difference was statistically significant only on the right side ($P = 0.006$). The parenchymal mantle was thinner in the Keen approach compared with the suggested approach, but the difference was not statistically significant.**

■ CONCLUSIONS: **The use of a suggested burr hole point for posterior ventricular catheterization may decrease the amount of parenchymal mantle of the brain transgressed by the catheter, and may marginally improve the chance of successful posterior ventricular catheterization.**

INTRODUCTION

The Frazier point, 6–7 cm above the inion and 3–4 cm lateral to the midline,[1] and the Keen point, 1.25 inch above and 1.25 inch behind the external auditory meatus in a plane perpendicular to the Reid base line,[2] have traditionally been used as entry points for cerebrospinal fluid drainage catheters. To our knowledge, since Keen and Frazier described their entry points in 1890 and 1928, respectively,[1,2] no documented trial has been conducted to revalidate and possibly update these points, even though ventricular shunting is a common neurosurgical procedure. Validation of these points in terms of the amount of the brain tissue traversed by the catheter and the location of the hole-bearing segment of the catheter is of utmost importance for shunt insertion, given that the entry point is a major determinant of final catheter location. One of the most common shunt complications is ventricular catheter obstruction.[3] Because proximity of the catheter to the choroid plexus, ependymal lining, and/or brain parenchyma may cause tissue overgrowth into the catheter,[4] proper location of the hole-bearing segment of the catheter away from these structures should have a significant impact on shunt survival.[5]

Theoretically, ventricular catheter location is a function of the catheter entry point, trajectory, and length. Some previous studies have attempted to optimize the latter 2 factors,[6-8] but to our knowledge, to date no study has specifically addressed catheter entry point. The aim of the present study was to revalidate the craniometric dimensions of posterior burr holes for ventricular catheter insertion in patients with hydrocephaly, based on ideal

Key words
- Catheterization
- Cerebral ventricles
- Cerebrospinal fluid shunt
- Computer-assisted
- Craniotomy
- Image processing
- Ventriculostomy

Abbreviations and Acronyms
CT: Computed tomography

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catheter position in a 3-dimensional simulated computed tomography (CT) reconstruction model of the ventricles.

METHODS

The study was approved by the Ethics Council of Tehran University of Medical Sciences. Informed consent was obtained from each study subject. Fifteen consecutive patients with hydrocephaly without major craniocervical anomaly or deformity were enrolled. All patients underwent multislice CT scanning with thin overlapping sections (slice thickness 0.625 mm) in the orbitomeatal plane. This plane was defined by a line in a sagittal scout image passing through the external auditory meatus and the anterior orbital roof. All patients had at least 1 intact lateral ventricle with no intraventricular mass, midline shift, porencephaly, pressure effect, or previous craniotomy for intraparenchymal tumor. Hemispheres with overlying scalp or skull defect were excluded, as were those with previous posterior ventriculostomy or shunt insertion. The Evans index was calculated for all patients.

Determination of the Coordinates for Suggested Posterior Entry Points and the Transgressed Parenchymal Mantle

A craniometry study with iNtellect Cranial Navigation (Stryker, Kalamazoo, Michigan, USA), using a soft tissue window (window width, 200; window level, 100; surface level, -200), was performed in transition from caudal to rostral in axial slices. The first cut above both thalami was chosen as the entry plane.[9] Then the bisector of the angle between the anterolateral and the posteromedial walls of the atrium in the entry plane was drawn. If those walls were parallel, then a line parallel to them and in the middle was drawn. The bisector was extended to intercept the adjacent scalp ("suggested point") (Figure 1A). The distance between the point of interception of this line with the inner table of the skull and the ventricular wall was measured (parenchymal mantle) (Figure 1B). The obtuse angle (entry angle) between the bisector and the line tangential to the external table of the skull at that point was measured (Figure 1C). In the slice in which the external auditory canal was of maximal length, its anterolateral-most point (tragus) was marked as the meatus landmark (Figure 2A). The pinna landmark was defined as the projection of the uppermost point of the helix in the orbitomeatal plane on the scalp, using a water window (window width, 200; window level, 0; surface level, -200) (Figure 2B). The inion landmark was defined as the scalp projection of the most prominent part of the external occipital protuberance, employing the bone window (window width, 2000; window level, 800; surface level, 300) (Figure 2C). Landmarks were determined bilaterally. Then the Cartesian length and width of the "suggested point" were calculated 3 times, using the pinna, meatus, and inion landmarks, respectively, as the reference points. Measurements were documented for both sides when possible.

Determination of the Parenchymal Mantle for the Frazier, Keen, and Suggested Points

Using the classical coordinates,[1,2] entry points for the Frazier and Keen approaches were determined bilaterally. The target for the Frazier point was defined as 4 cm above the contralateral medial canthus.[6] The target for the Keen point was defined as a point 2.5 inches (6.4 cm) above the external auditory meatus perpendicular to the Reid base line.[2] The parenchymal mantle between the entry point at the inner table of the skull and the ventricular entry point for the 2 approaches on each side was measured. The Euclidian

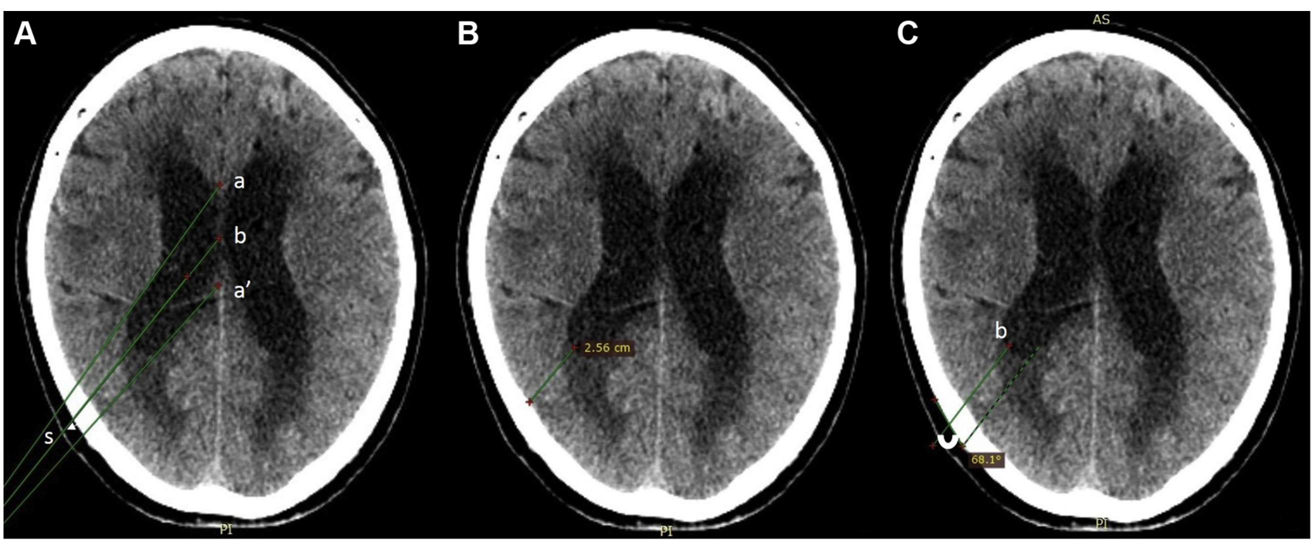

Figure 1. The first computed tomography cut above both thalami. (**A**) Here *a* and *a′* are tangents to the anterolateral and posteromedial walls of the lateral ventricles, respectively; *b* is the bisector of the angle formed by *a* and *a′*; and *s* (*arrow*) is the interception of the bisector with the scalp (our suggested point). (**B**) The parenchymal mantle thickness traversed by the catheter inserted through the suggested point. (**C**) The obtuse angle (block arc) formed by the bisector (*b*) and the tangential line to the skull at the interception of the bisector with the skull.