A review of trajectories for external cranial ventricular access

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Abstract

In literature there are many access points that can be performed either as free hand, with navigation or with the help of localizing devices. A thorough knowledge of these access points, their history, external landmarks, trajectories and indications will help to manage all cases requiring ventricular drainage. This article discusses only the points for external ventricular access for the ventricles highlighting with original diagrams where available, the different access sites. Kocher's / Tillman's / Neisser and Pollack, Von Bergman/ Kaufman's, Tubbs'/ Navarro/ Wilson point, Bohl's, Sanchez's points, Frazier's, Dandy's and Keen's points are discussed along with original drawings where available.

Key words: Cerebrospinal fluid, Dandy's point, External ventricular drain, Frazier's point, Keen's point, Kaufman's point, Kocher's point, Sanchez's point, Tillman's point, Tubbs' point

Introduction

Aristotle (384-322 BC) is credited with the description of brain cavities but it was Herophilos of Chalcedon (335-280 BC) and Galen (130-200) who dissected and described ventricles and choroid plexuses. At around 1487-1504, Leonardo da Vinci described the three-dimensional anatomy of ox ventricles using molten wax. Andreas Vesalius (1514-1564) described the presence of fluid (later called cerebrospinal fluid - CSF) in the ventricles and not spirits (as thought previously), the origin of which was described later by Thomas Willis (1621-1675) from the choroid plexuses. The first study of removal of CSF was done in 1891 by Quinke with a lumbar puncture and the ventricle was accessed in the coming years through different approaches that have been named after the surgeons.[1]

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In literature there are many access points that can be performed either as free hand, with navigation or with help of localizing devices. A thorough knowledge of these access points, their history, external landmarks, trajectories and indications will help to manage all cases requiring ventricular drainage. This article discusses only the points for external ventricular access for the ventricles, like Kocher's / Tillman's / Neisser and Pollack, Von Bergman/ Kaufman's, Tubbs'/ Navarro/ Wilson point, Bohl's, Sanchez's points, Frazier's, Dandy's and Keen's points are discussed highlighting with original diagrams where available, the different access sites.

A. Frontal horn / Anterior access sites:

Kocher's / Tillman's / Neisser and Pollack: The most common point of access to the ventricles is through this point named after the Swiss surgeon and first Swiss Neurosurgeon Emil Theodor Kocher who in 1909 was the third Swiss recipient of the Nobel Prize for Physiology or Medicine to honor his achievements in the fields of physiology, pathology and surgical treatment of the thyroid gland that helped reduce thyroid related mortality to less than 1 percent. Apart from many other contributions he is known for his studies in intracranial pressure, trauma, first trans nasal pituitary resection, tumor excision and trigeminal neuralgia management. He also developed a method of craniometry which showed two points that could be used to access the ventricles. It was also described by Tillman from Leipzig in The British Medical Journal, 1908, citing Neisser and Pollack, where he used a point 2 cm from midline and 3 cm anterior to precentral fissure from where he described the process of drilling and entering the ventricles. He also gave indications for therapeutic and diagnostic indications for ventriculostomy.[2-4]

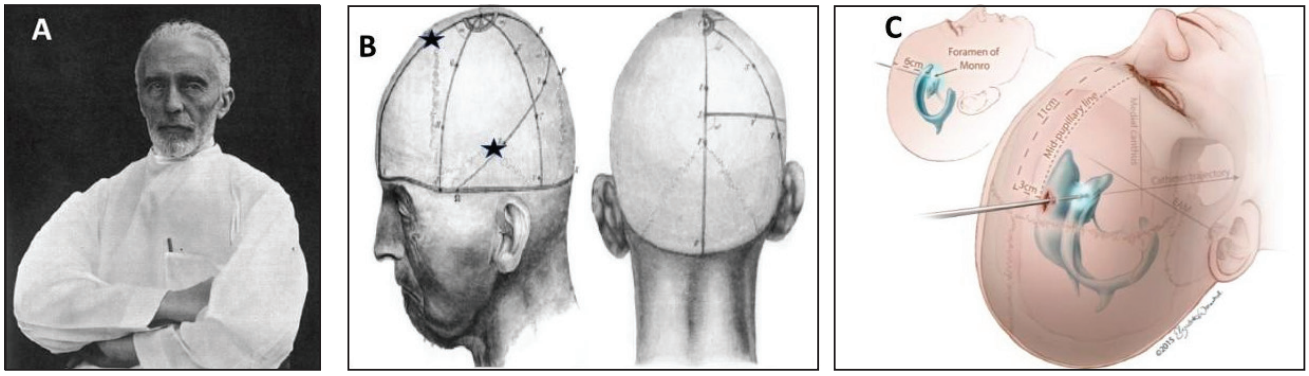

Figure 1: Photo showing (A) Emil Theodor Kocher, (B) the original craniometric markings and sites for ventricular access shown as stars and (C) modern diagram showing the point of entry.[2,3]

This point is 1or 2 cm anterior to the coronal suture or 11 -12 cm posterior and superior from the root of the nose and 3 cm lateral to the midline corresponding to the mid pupillary line. The skin can be opened in a linear fashion or as a small curvilinear flap to make a burr hole. The entry point in the cortex avoids the motor and supplementary motor areas along with the cortical veins. The catheter is directed to a junction point to perpendicular lines meeting between the ipsilateral medial canthus and external auditory meatus or towards the ipsilateral medial canthus coronally and the external auditory meatus sagitally.[3] The frontal horn of the ventricle can be entered at depth of 6 cm with a 'give away' feel. Apart from CSF drainage this point due to its safety is versatile in its use for neuro-endoscopy, intraventricular tumor excisions, evacuation of intraventricular bleed, ventriculo-peritoneal (VP shunt) or other shunts and for intracranial pressure measurement. It is commonly placed in the non-dominant hemisphere but can also be used from the left side or bilaterally.

Limitations: Although it is used worldwide it has some limitations. The number of catheter passages may range between 1-4, with 62% first passage and an accuracy of puncture between 56-84%.[4-8] To obviate this the Ghajar method was proposed wherein a plastic frame is placed after proper calculation to enter the ventricle with an accuracy of 96%. Present day neuro-navigation, although used infrequently has success rate of 95 % in tapping the ventricles.[9] Similarly, in another study, the towards the ipsilateral medial canthus coronally and the external auditory meatus sagittal direction was found to be less accurate than the perpendicular to the skull method.[10] The catheter can be placed outside the ventricles, cross to opposite side, lead to track or intraventricular bleeding or injury to surrounding structures.[11]

Von Bergman/ Kaufman's: Tillman has cited Von Bergman as using the frontal bone near the tuberositis frontalis to enter the ventricle. It was also described by Kaufman and Clark as an emergency procedure to access the frontal horn in 1970.[3,12] The ventricle can be reached with accuracy of 90% - 93% at 7 cm depth through a point 5 cm superior to the nasion- 6 cm if the frontal sinus are large and 3 cm lateral to midline in the direction to 3 cm superior to the superior occipital protuberance. The original paper reported 20 cases with one failure rate and no complications. This point has a single passage success rate of 80% with better accuracy than Kocher's point.

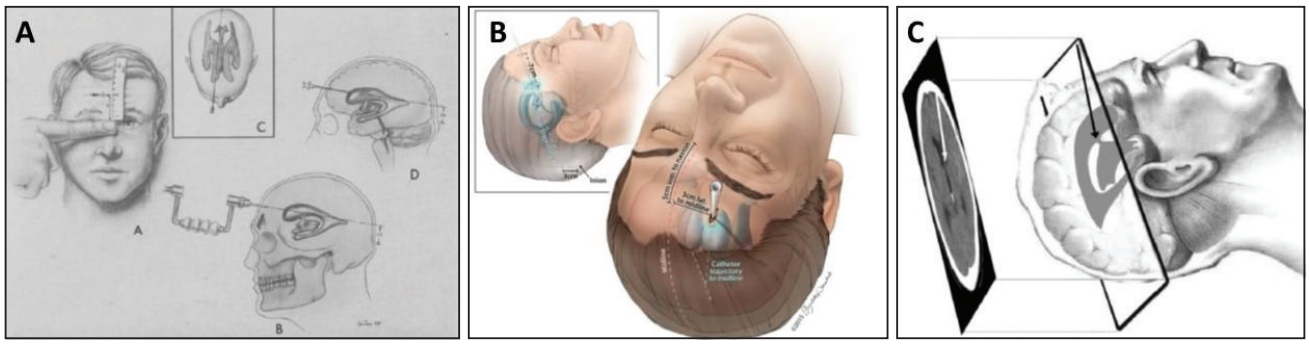

Figure 2: *(A) The original drawings of Kaufman, (B) modern diagram depicting the access point and (C) CT based planning to enter the ventricle.*[3,12]

Limitations: The frontal location with its cosmetic effects on the skin and bone has prevented its use commonly.

Tubbs'/ Navarro/ Wilson points: This was first described as transorbital ventriculostomy in cadaveric studies that underwent transorbital puncture of the ventricle through the orbital roof in a line medial to a mid-pupillary line and directed 45° from a horizontal line and 15–20° medial to a vertical line.[13] It was also described in comatose patients by Navarro and later by Wilson in their individual cases and suggested its practical use with high accuracy of tapping into the ventricles.[3,14,15] Neither a skin incision nor a burr hole is needed and can be performed with a spinal needle and hence can done faster than other external approaches.

Limitations: Due to the process of entering through the orbit and chances of injury to the eye globe, optic nerve or vessel, CSF leakage or damage to the frontal lobe vessels it has seldom been used except for case series.

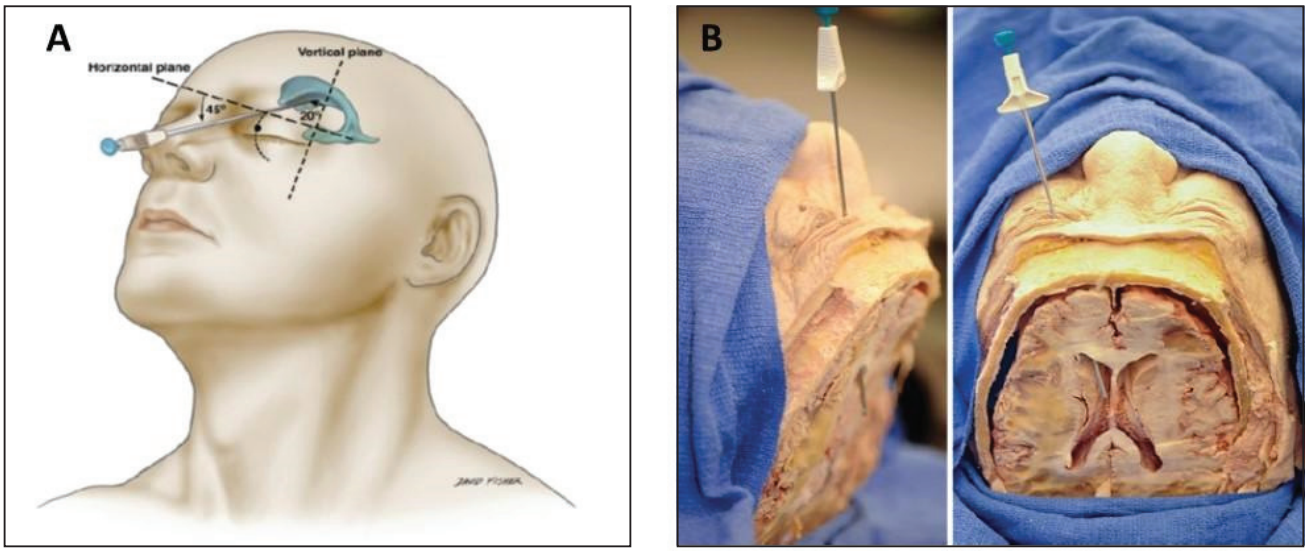

Figure 3: (A) Original drawings of Tubbs and (B) the cadaveric dissection to plan and localize the entry point.[13]

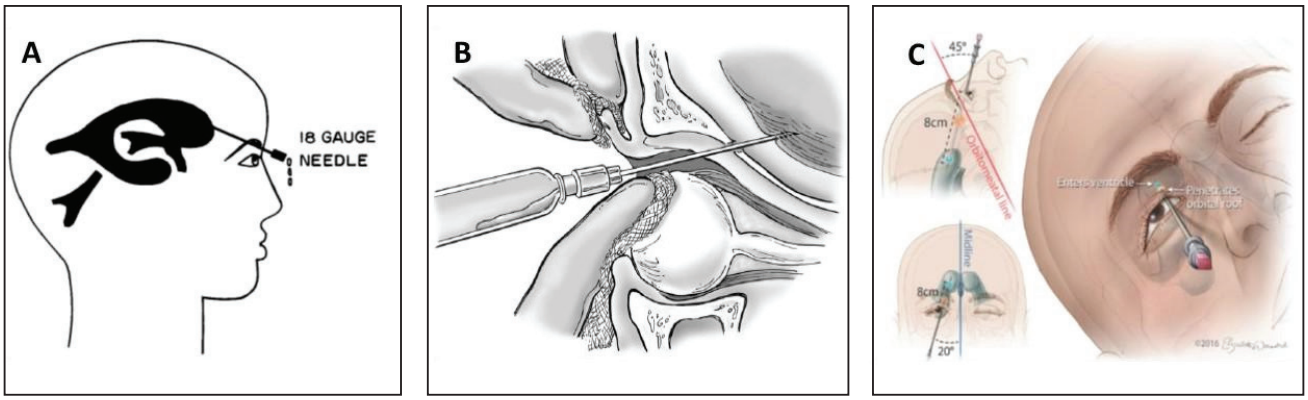

Figure 4: (A) Original drawings for orbito-ventriculostomy of Navarra and (B) Wilson and (C) modern diagram showing the same.[3,14,15]

B. Temporal horn access/Lateral Access

Bohl's Temporal horn access: The temporal horn can be tapped externally and has been described by few authors. It has been specifically used as an emergency where the temporal horn is trapped by a tumor or blood and is increasing in size. It was initially described by Kocher as an accessible point (Figure 5) where he marked it as point *Z* but was described in detail by Bohl et al in 2016. In this paper they choose three different trajectories to approach the temporal horn; Superior approach - 10 mm anterior and 0 to 10 mm superior to the superior attachment of the pinna; Lateral approach - 0 to 10 mm superior and 4 to 5 cm posterior to the vertex of the pinna and the Medial approach - 0 to 10 mm superior and 8 to 9 cm posterior to the vertex of the pinna. This was done using 3-

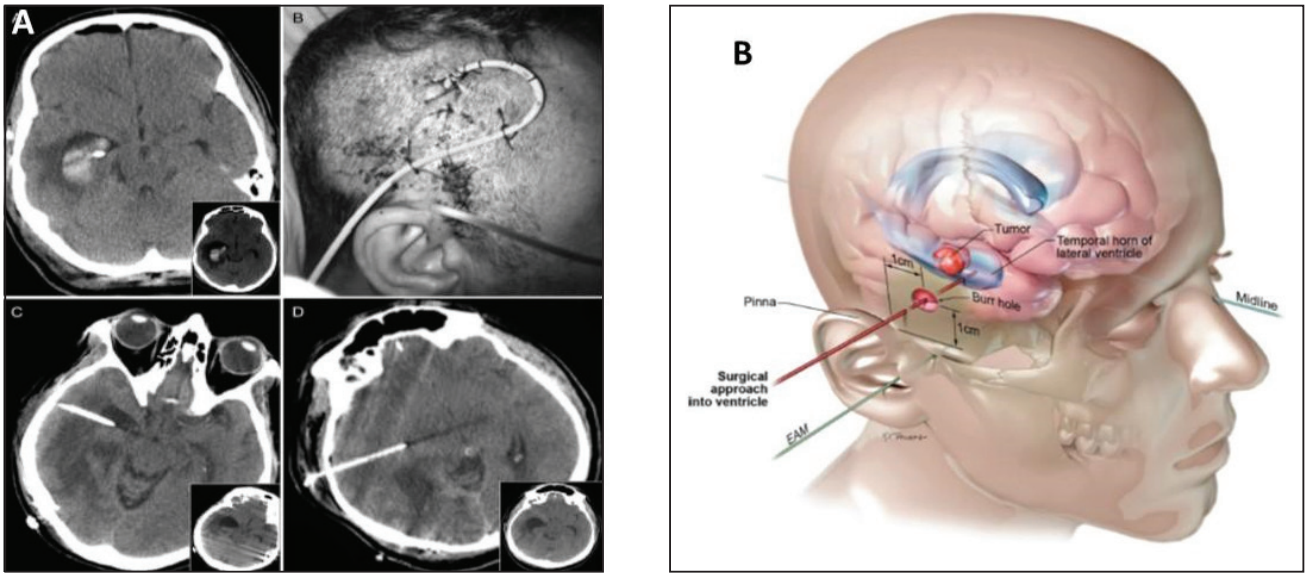

Figure 5: (A) Original drawings CT based trajectories of Bohl and (B) modern diagram depicting the access point by Burke.[3,16]

Dimensional studies of computed tomography scans. They concluded that volumetric analysis is simple and effective and the temporal horn can be punctured by this method as an emergency where EVD or shunt cannot be placed.[16] It has also been recently described for similar indications on the basis of preoperative computed scan planning with entry point 1 cm anterior and 1 cm superior to the superior attachment of the pinna to reach the ventricle.[3]

Sanchez's points: This describes a minimally invasive endoscopic approach to the temporal horn using 50 MRI studies and 18 cadaveric specimens. The endoscope was used with the entry point 2.7 ± 0.28 cm lateral to the inion and 5.6 ± 0.41 cm superior to the inion with mean trajectory angulations of 5.12 ± 0.68 degrees to the middle sagittal plane and 30.92 ± 2.57 degrees to the orbitomeatal plane.[17] The temporal horn was reached at 7 cm distance. Studies using this point for simple ventricular access by catheter are yet to be performed. It is similar to the parieto-occipital point except that its lower and more medial.[3,17]

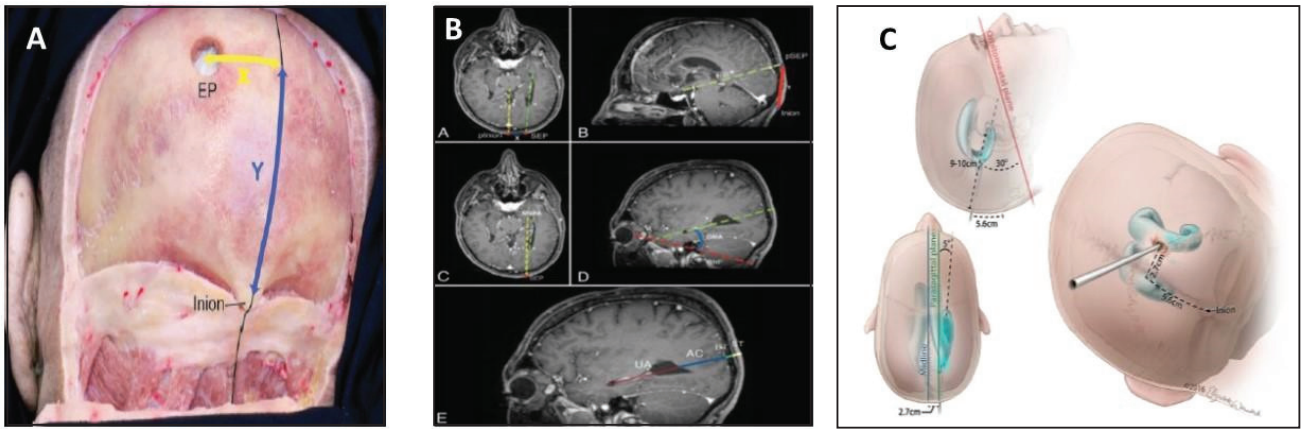

Figure 6: (A) Original cadaveric picture with markings and (B) the MRI scan to show the trajectory with (C) modern diagram depicting the same access point.[3,17]

C. Posterior Horn / Posterior approach

Frazier's: It was initially described by Frazier in his series of trigeminal neuralgia management in 1928. The entry point is 6 cm superior to the inion and 3-4 cm lateral from midline with the trajectory aimed at the opposite medial canthus. The burr hole is above the lambdoid suture. The posterior ventricle can be reached at 5-6 cm depth. This point is most commonly accessed for the placement of ventricular shunts and also occasionally for drainage.[3,18-20] A study using magnetic resonance imaging (MRI) along with stereoscopic 3-dimensional preoperative planning showed that the ventricle was best accessed when the trajectory was targeted 4 cm above the opposite medial canthus.[3,21]

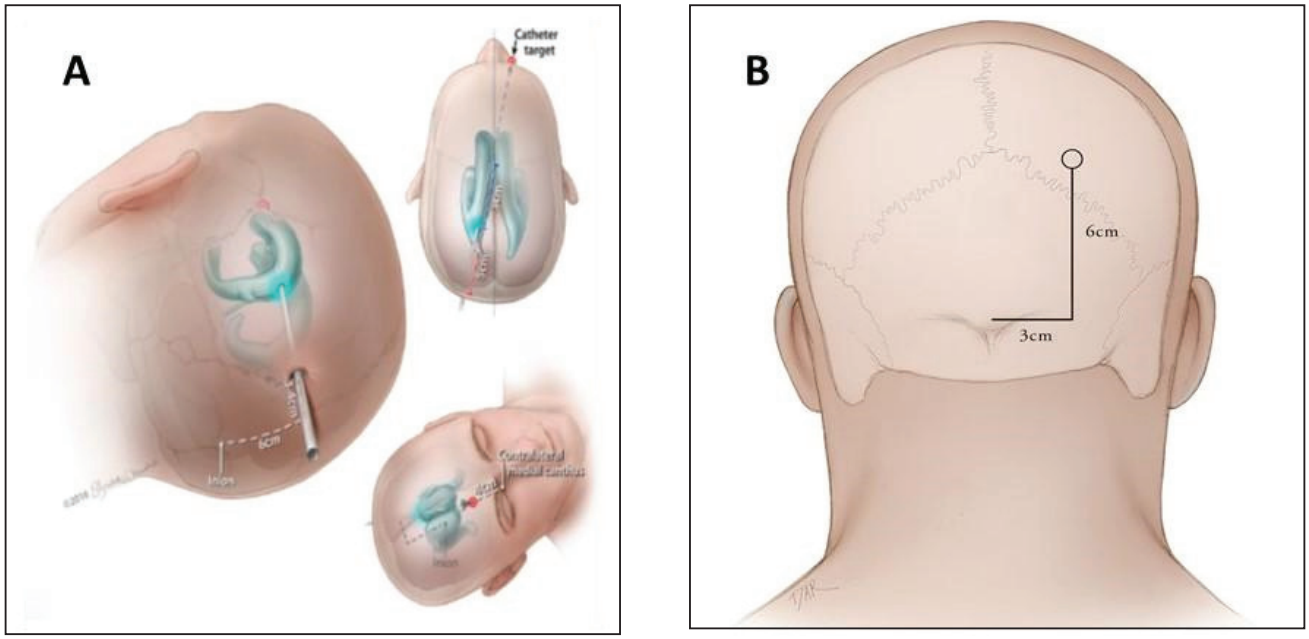

Figure 7: (A), (B) Modern diagram depicting the landmarks externally with the trajectories to access the posterior horn of lateral ventricle.[3,21]

Limitations: Due to the difficulty in head positioning it is not the preferred choice during emergent situations.

Dandy's: This is attributed to Dandy in his studies on ventriculography in children aged less than 12 years.[22] Although the original paper did not specify the exact details or markings of the point of entry-the diagram showed entry via the anterior fontanelle- it is now accepted as 3 cm above the inion and 2 cm away from midline just below the lambdoid suture (Figure 8) (c.f. to Frazier's point that is above the suture) to be directed to another point 2 cm above glabella to puncture the ventricle at 5-6 cm with a 100 % success rate.[3,23]

Keen's: It was first described by Keen for a child with hydrocephalus presumed to be due to cerebellar tumor in 1888. The entry point he described was 1.25 inch behind the ipsilateral meatus with the catheter directed to a point 2.5 inches above the opposite meatus to enter the ventricle at around 3 -4 cm.[3,24,25] It has also been described as a point approximately 2.5 -3 cm behind the pinna (Figure 9). This approach reaches the trigone of the lateral ventricle and is used commonly for ventricular shunt placement.

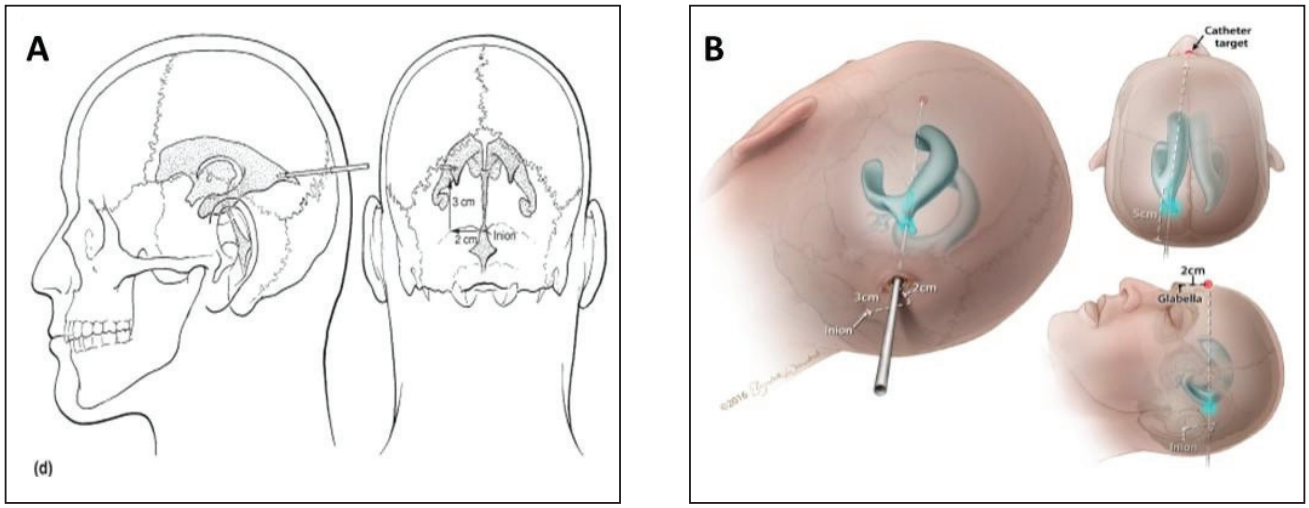

Figure 8: (A) Drawing showing the external landmark and (B) a modern diagram depicting the access point (B).[3,23]

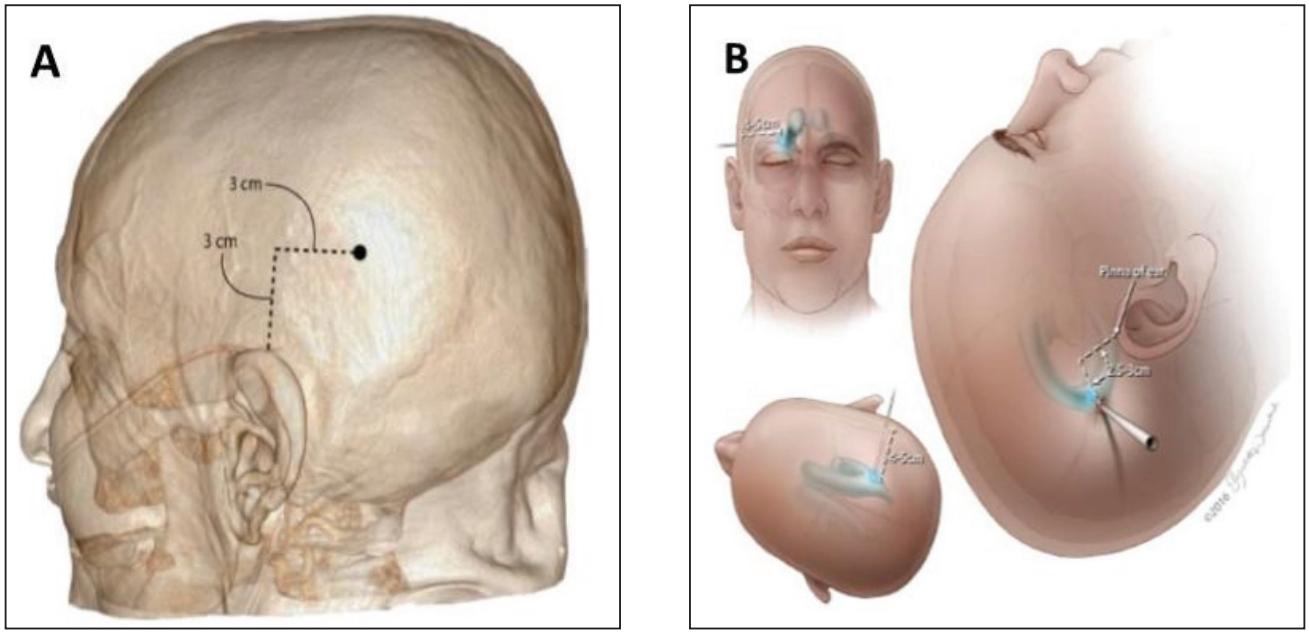

Figure 9: (A) Marking on a human skull and (B) a modern diagram depicting the access point and direction.[3,24,25]

External ventricular is an emergency procedure performed in all neurosurgical centers worldwide and thus a thorough knowledge of the different sites along with their skull land markings are important in successful tapping of the ventricles. The success rates may depend on the performer experience, the nature of injury, midline shift or compression of the ventricles. All these factors must also be included to overcome failure to access the ventricles.

Conclusion

External ventricular access can be either as an emergency, planned for Ventricular shunt or to decompress the brain prior to other intracranial procedures. As an emergency it is usually relegated to the junior neurosurgeon or trainee. Although free hand-held access can be done easily it may be challenging especially to the novice, in cases of shift of brain due to mass or edema, small ventricles, intraventricular bleeding or wrong placement of the entry point. A knowledge of the above points of access will help to improve the success rate and drainage of CSF. The frontal remains the easiest, fastest and safest point to access the ventricles although other points are equally safe with experience.

Conflict of Interest: None
Source(s) of support: None

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