Revision of Paine’s technique for intraoperative ventricular puncture

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Abstract

Background: The aim of this study was to determine the ideal point for a ventricular puncture in pterional craniotomies.

Methods: Using a circle that had its center around the junction of the columns of the fornix and conforming to the surface of the frontal lobe on an axial computed tomography scan 2.5 cm superior to the lateral orbital roof, we simulated the introduction of a catheter perpendicular to the cortex by drawing the radii of the circle in 70 patients with an acute subarachnoid hemorrhage. The cortical point at which perpendicular puncture provides the best trajectory for ventricular access, traversing the least brain tissue and avoiding important brain structures, such as the head of the caudate nucleus, anterior limb of the internal capsule, and Broca’s cortex in the dominant hemisphere, was measured.

Results: The new landmark was located at the point 44 ± 4 mm anterior to the sylvian fissure on the level of 2.5 cm superior to the lateral orbital roof and was consistent regardless of the ventricular dimensions and sex. Clinical trial of the ventriculostomy in 32 patients with a ruptured aneurysm approved the new landmark.

Conclusions: An intraoperative ventriculostomy can be performed safely and reliably using the new landmark 2.5 cm superior to the lateral orbital roof and 4.5 cm anterior to the sylvian fissure in aneurysm surgery using a pterional craniotomy.

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Keywords: Aneurysm; Pterional craniotomy; Ventricular puncture; Ventriculostomy

1. Introduction

Adequate brain relaxation is necessary for exposure of aneurysms of the circle of Willis and is achieved by opening the arachnoid of the optic cistern, enabling drainage of cerebrospinal fluid, in addition to intraoperative maneuvers such as positioning, hyperventilation, and osmotic diuresis. However, in some patients after recent subarachnoid hemorrhage, the edematous brain may limit retraction to safely expose the optic cistern. Instead, a ventricular catheter can be placed using the Paine’s point, although it may be very difficult even in experienced hands in cases of a red, angry, and swollen brain.

Paine’s point, which is defined as “the intersection at right angles of the lines measured 2.5 cm superior from the floor of the anterior cranial fossa (lateral orbital roof) and 2.5 cm anterior to the sylvian fissure,” was devised to puncture the frontal horn of the lateral ventricle after dural opening during pterional craniotomies [5], and it has been widely used in aneurysm surgery [1,2,7], despite concerns about its proximity to the Broca’s speech cortex in the dominant hemisphere and lack of further investigation [6,10,11]. Accordingly, the current study was performed to determine the ideal point for a ventricular puncture in a pterional craniotomy to improve the Paine’s technique.

2. Materials and methods

2.1. Patient population and data collection

From July 2005 to June 2006, 177 Korean patients with an acute subarachnoid hemorrhage were admitted to the authors’ hospital. For the CT examination of the cranium,
axial images were taken parallel to the floor of the anterior cranial fossa at a thickness of 5 mm. The CT scans showing the ventricles with a BI of 0.14 or greater before intracranial procedures such as craniotomies, ventriculostomies, and ventriculoperitoneal shunts were selected at first. The BI was measured using an axial CT scan including the foramen of Monro. Among these, axial scans 2.5 cm superior to the lateral orbital roof, showing a remarkable sylvian fissure owing to hyperdensity caused by a subarachnoid hemorrhage or hypodensity for a remarkable sylvian fissure, were chosen for the present study. As such, CT scans of 80 hemispheres of the 70 patients (26 males, 44 females; age, 60.9 ± 12.3 years) were identified as suitable for this study. The BI of the patients ranged from 0.14 to 0.23 (mean, 0.19; SD, 0.02).

2.2. Determination of the ideal landmark on the basis of CT scans

The Paine’s technique involves the introduction of a ventricular catheter perpendicular to the convexity of the

Table 1
Evaluation of ideal point for ventricular puncture with respect to sylvian fissure using CT scans 2.5 cm superior to lateral orbital roof *

<table>
<thead>
<tr>
<th>BI</th>
<th>No. of hemispheres</th>
<th>BI 0.14 - 0.18</th>
<th>BI 0.19 - 0.23</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total hemispheres</td>
<td>32</td>
<td>48</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>BI</td>
<td>0.19 ± 0.02</td>
<td>0.16 ± 0.01</td>
<td>0.21 ± 0.01</td>
<td>0.19 ± 0.03</td>
<td>0.19 ± 0.02</td>
</tr>
<tr>
<td>S-A distance (mm)</td>
<td>33 ± 5</td>
<td>35 ± 5*</td>
<td>32 ± 4*</td>
<td>34 ± 5</td>
<td>33 ± 5</td>
</tr>
<tr>
<td>S-B distance (mm)</td>
<td>55 ± 5</td>
<td>54 ± 5</td>
<td>55 ± 5</td>
<td>55 ± 4</td>
<td>55 ± 5</td>
</tr>
<tr>
<td>A-B distance (mm)</td>
<td>22 ± 6</td>
<td>19 ± 3**</td>
<td>24 ± 6**</td>
<td>21 ± 5</td>
<td>22 ± 6</td>
</tr>
<tr>
<td>S-m distance (mm)</td>
<td>44 ± 4</td>
<td>44 ± 5</td>
<td>44 ± 4</td>
<td>44 ± 4</td>
<td>44 ± 4</td>
</tr>
<tr>
<td>Ventricular depth at new landmark (mm)</td>
<td>33 ± 3***</td>
<td>34 ± 4</td>
<td>33 ± 2</td>
<td>33 ± 2</td>
<td>34 ± 3</td>
</tr>
<tr>
<td>Ventricular depth at Paine’s point (mm)</td>
<td>44 ± 4***</td>
<td>46 ± 4*</td>
<td>43 ± 3*</td>
<td>45 ± 3</td>
<td>44 ± 4</td>
</tr>
</tbody>
</table>

A indicates intersection of a circle conforming to the surface of the frontal lobe and its radius along the lateral wall of the frontal horn; B, intersection of a circle conforming to the surface of the frontal lobe and its radius along the medial wall of the frontal horn; m, midway between points A and B; S, sylvian fissure.

* Values are expressed as mean ± SD.
* P < .05 between the patients with smaller ventricles (BI, 0.14-0.18) and larger ventricles (BI, 0.19-0.23).
** P < .01 between the patients with smaller ventricles and larger ventricles.
*** P = .000 between the values at Paine’s point and the landmark.
surface of the brain at the point 2.5 cm superior to the lateral orbital roof and 2.5 cm anterior to the sylvian fissure (Fig. 1A) and can be simulated using the CT scans. The fifth slice after the axial image scanned at the lateral orbital roof was used (Fig. 1B and C). A circle was drawn that had its center around the junction of the columns of the fornix and conforming to the surface of the frontal lobe. The perpendicular introduction of a ventricular catheter was then simulated by drawing the radii of the circle.

The best trajectories for ventricular access should traverse the least brain tissue and keep away from any important deep brain structures, such as the head of the caudate nucleus and anterior limb of the internal capsule, in addition to Broca’s cortex in the dominant hemisphere. Thereby, they are the trajectories perpendicular to the range between points A and B on the circle and correspond to the radii along the lateral and medial walls of the frontal horn of the lateral ventricle. Thus, the distances between the sylvian fissure and points A and B were measured, and the ideal point for a ventricular puncture determined as midway between points A and B.

With the use of the radii to the Paine’s point and to the new landmark (the mean of the sylvian fissure–midway distance), the depth of the lateral ventricle was measured and the incidence of violating the head of the caudate nucleus evaluated.

2.3. Clinical trial

From July 2006 to March 2007, intraoperative ventriculostomy using the new landmark was performed in 32 patients (13 males, 19 females; age, 52.1 ± 13.2 years) with a ruptured aneurysm. The BI of the patients ranged from 0.11 to 0.23 (mean, 0.16; SD, 0.03) in the preoperative CT scans. During the ventriculostomy, attempts to puncture the ventricle were counted. Postoperative CT scans were used to evaluate the catheter position (trajectory of the ventricular access) and occurrence of intracerebral hemorrhage related to the catheter insertion.

2.4. Statistical analysis

The data in this report are presented as the mean ± SD. The data of this study between patients with smaller (BI, 0.14-0.18) and larger (BI, 0.19-0.23) ventricles, and male and female patients were compared using a t test, whereas
the results of simulation using the radii to the Paine’s point and the new landmark were compared with a paired t test. A probability value of less than .05 was considered statistically significant.

3. Results

3.1. Ideal point for ventricular puncture on the basis of CT scans

The results of the present study are summarized in Table 1. In 80 hemispheres, the distances from the sylvian fissure (point S) to points A and B were 33 ± 5 and 55 ± 5 mm, respectively. The midway between points A and B, considered as the ideal point for the ventricular puncture, was 44 ± 4 mm apart from the sylvian fissure, whereas the range between points A and B, considered as the safety range for the ventricular puncture, was 22 ± 6 mm.

The location of point m with respect to the sylvian fissure was consistent at 44 ± 4 mm regardless of the ventricular dimensions or sex. The ideal point for the ventricular puncture did not differ between the patients with smaller ventricles (BI, 0.14-0.18) and larger ventricles (BI, 0.19-0.23), or between the male and female patients. For the patients with larger ventricles, the safety range for the ventricular puncture, that is, the distance between A and B, was greater than that for the patients with smaller ventricles (24 ± 6 vs 19 ± 3 mm; \( P < .01 \)).

3.2. Comparison between Paine’s point and the new landmark

The new landmark for the ventricular puncture was 44 mm anterior to the sylvian fissure and farther away from Broca’s cortex than the Paine’s point. The ventricle was located deeper at the Paine’s point at 45 ± 4 mm in contrast to 33 ± 3 mm at the new landmark \(( P = .000)\) (Table 1).

A perpendicular line (radius) at the Paine’s point violated the head of the caudate nucleus in 72 (90.0%) of the 80 hemispheres and passed through the safety range between A and B in a total of 8 (10.0%) hemispheres. Meanwhile, at the new landmark, a perpendicular line violated the head of the caudate nucleus in only 1 (2.5%) hemisphere and passed through the safety range in 78 (97.5%) of the 80 hemispheres \(( P = .000)\).

3.3. Clinical trial

After performing a standard pterional craniotomy, the round dural flap with its base on the sphenoid ridge was tightly secured with sutures anteroinferiorly. If the brain was edematous and limited retraction to safely expose the optic cistern, the intraoperative ventriculostomy was performed. At first, the point was measured 2.5 cm superior to

Fig. 4. Preoperative and postoperative CT scans showing the trajectories of the ventriculostomy using the new landmark. The BI is 0.14 (A), 0.15 (B), 0.16 (C), and 0.19 (D), respectively, in the illustrated cases.
the lateral orbital roof and 4.5 cm anterior to the sylvian fissure as marked by the superficial sylvian vein (Fig. 2). Then, the pial surface was cauterized and catheterized perpendicular to the convexity of the surface of the brain to a depth of 5 to 6 cm depending upon the brain swelling. The ventricular catheter was kept open until optimal brain relaxation was obtained.

In 4 of the 32 cases in which the beginning of the dural incision at the frontal lobe revealed severe brain swelling, the dural incision was halted and the ventriculostomy was performed ahead. In this situation, the location of the sylvian fissure was presumed as the cleft between dural coverings of the frontal and temporal lobes, and the new landmark was located at or near the frontal dural incision. This technique relaxed the brain early and avoided the occurrence of external brain herniation after completion of the dural incision (Fig. 3).

The intraoperative ventriculostomy at the new landmark was performed successfully in all 32 patients. The landmark was exposed well in standard pterional craniotomies. The frontal horn of the lateral ventricle was accessed with one perpendicular puncture in all but 2 patients, as confirmed by the outflow of cerebrospinal fluid. In the remaining patients, the ventricle was punctured with 2 attempts.

In postoperative CT scans, the catheter position was in the safety area between the caudate nucleus and the corpus callosum for all patients (Fig. 4). In 1 case, intracerebral hemorrhage along the path of the ventricular catheter occurred without any symptoms. The new landmark was also confirmed as the ideal puncture point using a neuronavigation system in 3 cases of a pterional craniotomy.

4. Discussion

The Paine’s point as a ventricular puncture landmark was originally reported as a technical note in 1988 [5], and since then it has become a popular technique in aneurysm surgery for its reliable ventricular access [1,2,7]. Nonetheless, there are still several unresolved problems related to the Paine’s technique, such as the proximity of the puncture site to Broca’s cortex and violation of the caudate nucleus [6,10].

Tominaga et al [9] previously reported a surprisingly high incidence of brain injury complicating ventricular puncture performed during craniotomy in the acute stage of subarachnoid hemorrhage. Magnetic resonance imaging showed brain injury after a ventricular puncture in 81% and large hematomas with a diameter greater than 3 cm in 4% of their patients. Thus, the potential risk of brain injury from the puncture requires a safer and reliable cortical point used for a ventriculostomy.

The neurobehavioral role of the caudate nucleus is anatomically and functionally related to the prefrontal cortex, and effects of caudate lesions may resemble prefrontal lesions [3,8,10]. Mendez et al [3] reported acute behavioral change characterized by apathy, disinhibition, or a major affective disturbance developed in 12 patients with caudate nuclei lesions, 11 unilateral and 1 bilateral.

An intraoperative ventricular puncture [11] technique during supraorbital craniotomy via an eyebrow incision was recently reported by Menovsky et al [4]. The cerebral puncture point was located directly under the key burr hole at the base of the frontal lobe, and the catheter was directed 45° to the midline and 20° up from an imaginary line parallel to the orbitomeatal line. Although their trajectory of the catheter insertion directs upwards from the base of the frontal lobe, it is similar to ours in location between the head of the caudate nucleus and the corpus callosum.

In the present study, although the ideal ventricular puncture point with respect to the sylvian fissure was found to be consistent regardless of the ventricular dimensions and sex in hydrocephalic patients, racial differences still need to be considered.

5. Conclusions

For aneurysm surgery with pterional craniotomies, an intraoperative ventriculostomy can be performed safely and reliably using a new landmark 2.5 cm superior to the lateral orbital roof and 4.5 cm anterior to the sylvian fissure. The new landmark is more distant from the Broca’s cortex than the point of Paine, and perpendicular puncture at that point provides the trajectory of the catheter between the caudate nucleus and the corpus callosum.

Appendix A. Supplementary video

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.surneu.2007.09.018.

References

Commentary

The research is a good sample for the young neurosurgeons to think about their learned knowledge and surgical techniques and to develop a criticizing mind. In my opinion, if one predicts difficulty in reaching a deep-seated cerebral aneurysm in the situation of a too early aneurysm surgery with rather dilated ventricles, one might better perform a wider fronto-pterional craniotomy to have more inferior frontal gyri available. Then wholly discarding the moderately complex measurements and the dictated distances extracted from the data of the other analyses, one can select the shorter radii connecting the tip of the ipsilateral frontal horn to the nearest cerebral cortex, reviewing the available recent CT scan more than twice and more accurately! This kind of approach might rule out all the biases such as sex, race, the site of intracerebral hematoma, the type of midline shift, and the dominancy of the hemispheres.

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Opening of the optic cistern and lamina terminalis may not always initially be possible in a red, angry, and swollen brain of patients with subarachnoid hemorrhage. Puncturing the ventricles via the pterional approach to have a slack brain may also be very difficult even in experienced hands. Therefore, obtaining anatomic landmarks to make this easier is welcome, and the authors have described the technique very well. In having more space one should not forget the help of modern neuroanesthesiology [2] together with using the general principles of microneurosurgery [1] as well.

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References
