Intraoperative Ventriculostomy Using K Point in Surgical Management of Aneurysmal Subarachnoid Hemorrhage

Jae Hoon Kim and Hee In Kang

BACKGROUND: **Intraoperative ventriculostomy in the surgical management of aneurysmal subarachnoid hemorrhage (SAH) is frequently performed to reduce increased intracranial pressure. The previously suggested ventriculostomy points have some limitations because the dura mater must be opened to be accessed and it is difficult to measure the exact entry point in patients with brain edema. We propose a new intraoperative ventriculostomy point (K point) for use in the surgical management of aneurysmal SAH patient with severe brain edema.**

METHODS: **We performed intraoperative ventriculostomy using the K point on 155 patients with aneurysmal SAH between January 2012 and August 2016. Before opening the dura mater following standard pterional craniotomy, we inserted the ventricular catheter through a small dural incision perpendicular to the middle frontal gyrus toward the ipsilateral medial epicanthus. We simulated the catheter trajectory using a commercial navigation system on 2 patients with brain tumor.**

RESULTS: **Ventriculostomy related hemorrhage occurred in 12 patients (7.7%), but there were no large hemorrhages causing neurologic deterioration or requiring evacuation. No language impairment was observed in these patients. Analysis using the navigation system revealed that the trajectory of K point ventriculostomy avoided critical periventricular brain structures and passed through the space between the genu of the corpus callosum and head of the caudate nucleus.**

CONCLUSIONS: **K point ventriculostomy allows for easy access to a target point and protects the brain during opening of the dura mater and drilling of the sphenoid bone.**

INTRODUCTION

Since Paine et al[1] first suggested an intraoperative ventricular puncture point for the pterional approach during aneurysm clipping, intraoperative ventriculostomy has been widely used to facilitate cerebrospinal fluid (CSF) drainage in patients with brain edema. However, this point can be only accessed after dural opening, and brain injury may occur during dural opening or sphenoid bone resection. In addition, kinking of the ventricular catheter may occur during dural or bone closure due to the length of the subdural passage. We suggest a new intraoperative ventriculostomy point (K point) on the middle frontal gyrus (MFG) and discuss the advantages of the K point.

METHODS

The study protocol was approved by the appropriate institutional review board, and the requirement to obtain written informed consent to participate in this study was waived by the institutional review board. We performed K point ventriculostomy on 155 patients with aneurysmal subarachnoid hemorrhage (SAH) before surgical clipping via the pterional approach between January 2012 and August 2016. In this study, we analyzed K point–related hemorrhagic complications via postoperative computed tomography (CT). In addition, we simulated the trajectory of K point ventriculostomy in 2 patients with a brain tumor using a magnetic resonance navigation system (StealthStation Treon Plus, Medtronic, Inc. Minnesota, USA).

Key words
- Aneurysm
- Subarachnoid hemorrhage
- Ventriculostomy

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
CT: Computed tomography
IFG: Inferior frontal gyrus
MFG: Middle frontal gyrus
SAH: Subarachnoid hemorrhage

Department of Neurosurgery, Eulji University Eulji Hospital, Seoul, South Korea

To whom correspondence should be addressed: Hee In Kang, M.D., Ph.D. [E-mail: khi2303@eulji.ac.kr]

Citation: World Neurosurg. (2019) 122:e248-e252.
https://doi.org/10.1016/j.wneu.2018.09.228

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

1878-8750/$ - see front matter

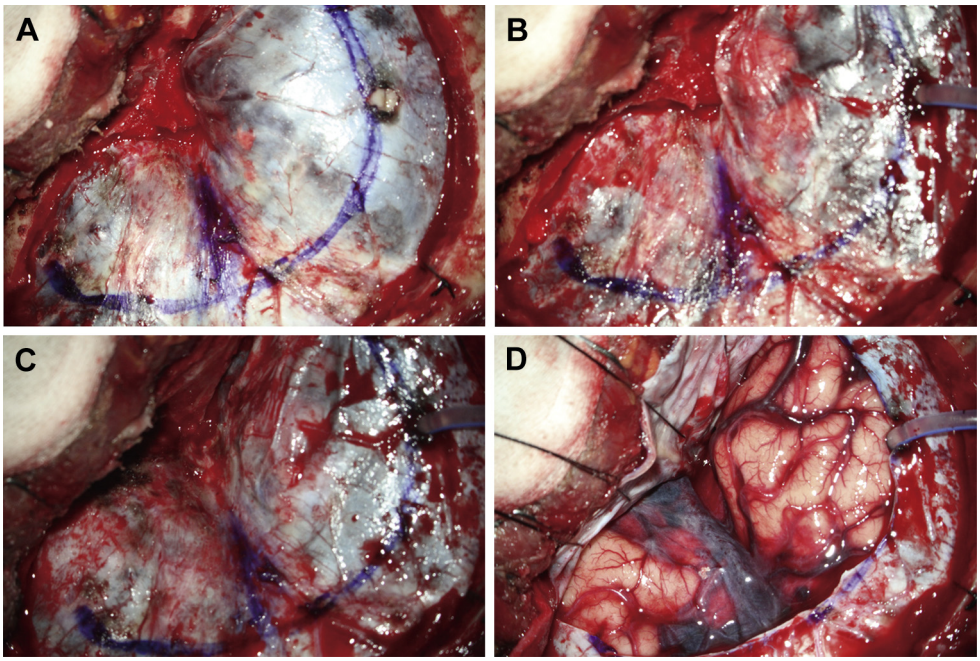

Figure 1. The steps of K point ventriculostomy. (**A**) A small dural incision is made on the imaginary line of the dural opening. (**B**) A ventricular puncture catheter is inserted perpendicular to the middle frontal gyrus toward the ipsilateral medial epicanthus. Note that dura mater is redundant after cerebrospinal fluid drainage. (**C**) Sphenoid bone resection is performed. (**D**) The dura mater is opened completely.

The K point is located on the MFG, and K point ventriculostomy involves the following procedures (Figure 1). Following a standard pterional craniotomy over the superior temporal line, a small cruciate dural incision is made on the imaginary line of the dural opening. A 7.5-French ventricular puncture catheter is inserted perpendicular to the MFG (depth: 6–6.5 cm depending of the ventricle size) toward the ipsilateral medial epicanthus, following which the CSF is drained until the brain returns to an appropriate size. Next, sphenoid bone resection is performed and the dura mater is opened completely. An external ventricular drainage catheter is maintained for 3–5 days to monitor intracranial pressure and CSF drainage, if needed.

RESULTS

The mean age of the study population was 55.7 ± 12.9 years, and 91 patients (58.7%) were women. We successfully placed a ventriculostomy catheter in 1 attempt in most of the cases, and none of the patients required more than 2 passes. Ventriculostomy-related hemorrhage occurred in 12 patients (7.7%), but there were no large hemorrhages causing neurologic deterioration or requiring evacuation. No language impairment was observed in these patients. Analysis using the navigation system revealed that the trajectory of the procedure avoided critical periventricular brain structures (Figure 2). Postoperative CT scans indicated that the ventricular puncture catheter was located well within the frontal horn of the lateral ventricle through the trajectory between the genu of the corpus callosum and head of the caudate nucleus (Figure 3).

DISCUSSION

In the present study, we evaluated the usefulness of K point ventriculostomy on 155 patients with aneurysmal SAH. The results of the study indicated that there were no serious complications associated with the procedure.

Kocher's point is a commonly used entry point for ventriculostomy. However, it requires additional skin incision. Moreover, it is difficult to identify the degrees of brain edema through small burr hole, because we make decision whether to perform a ventriculostomy after identifying the degrees of brain edema following pterional craniotomy in aneurysmal SAH patients.

The intraoperative ventriculostomy point used by Paines et al[1] is located on the inferior frontal gyrus (IFG). Thus opening of the dura mater is necessary to expose the IFG. However, in patients with brain edema, incisions of the compressed dura mater may cause injury to the brain parenchyma. Drilling of the sphenoid bone may also cause injury in patients with brain edema.

Previous studies have investigated the use of various ventriculostomy points during a standard pterional approach, which are briefly summarized in Table 1.[1-3] Location of these previously

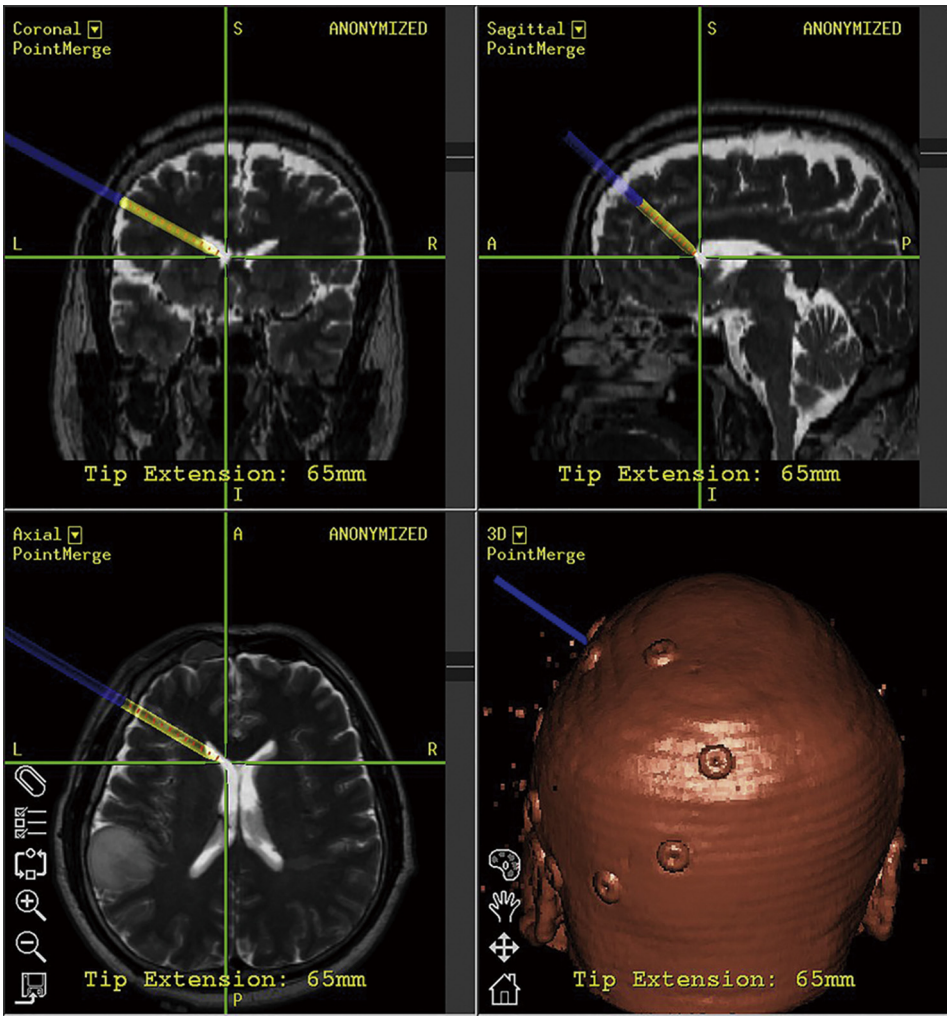

Figure 2. Navigation simulation image showing the trajectory of K point ventriculostomy.

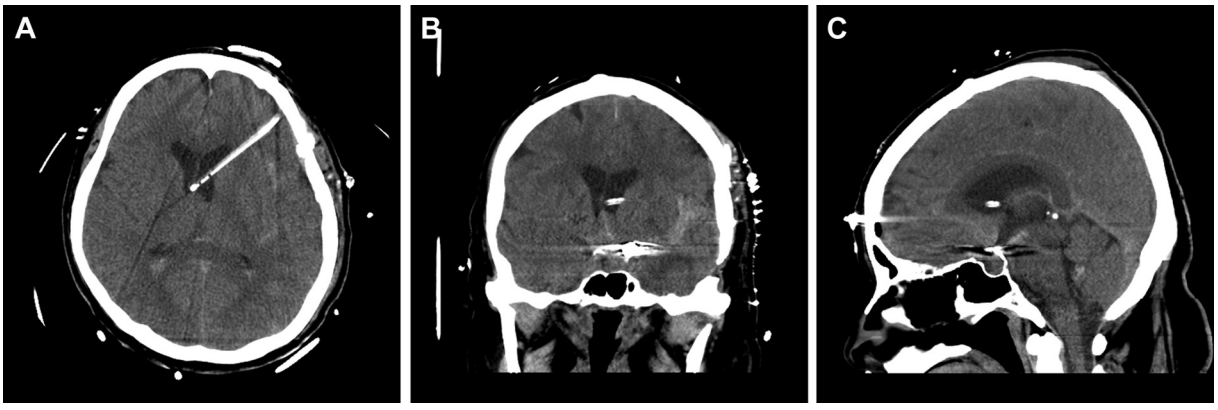

Figure 3. Postoperative computed tomographic scan of the brain showing the ventricular puncture catheter within the frontal horn of the lateral ventricle. Axial (**A**), coronal (**B**), and sagittal (**C**) plane.

Table 1. Comparison of Previously Suggested Points for Intraoperative Ventriculostomy

Authors, Years	Ventriculostomy Point	Location of Catheter Tip	Comments
Paine et al., 1988[1]	Intersection at right angle of the lines measured 2.5 cm superior from the floor of the anterior cranial fossa and 2.5 cm anterior to the sylvian fissure (inferior frontal gyrus)	Frontal horn of the lateral ventricle	Damage to motor speech area in the dominant hemisphere
Hyun et al., 2007[2]	2 cm beyond a line extending from the anterior limb of the triangle described by Paine (inferior frontal gyrus)	Upper frontal horn of the lateral ventricle	Greater margin of safety than Paine point and more angled on the coronal plane
Park et al., 2008[3]	2.5 cm superior to the lateral orbital roof and 4.5 cm anterior to the sylvian fissure (inferior frontal gyrus)	Frontal horn of the lateral ventricle	Greater margin of safety than Paine point and more angled on the axial plane
Present study	Middle frontal gyrus along the incision line of the dura mater	Frontal horn of the lateral ventricle	Flexible point depending on the craniotomy size and no need to measure

suggested points, including that of the K point, are presented in Figure 4. Hyun et al[2] proposed a landmark located 2 cm beyond the line extending from the anterior limb of the triangle described by Paine et al. Because this point is located on the upper part of the IFG, the trajectory of the catheter lies at a greater angle to the anterior skull base in the coronal plane, relative to that observed for the point described by Paine et al. In contrast, Park et al[3] recommended a point located on the more anterior part of the IFG, resulting in a more angled trajectory in the axial plane when compared with that of Paine et al. Therefore both trajectories may reduce the risk of damage to the head of the caudate nucleus, while the dura mater must be opened to access these points and the exact location cannot always be measured in patients with brain edema.

On the other hand, some investigators suggested intraoperative ventriculostomy techniques during aneurysm surgery.[4,5] Lehto et al[4] performed ventriculostomy via the fenestrated lamina terminalis in 78 patients. However, catheter occlusion or displacement occurred in 8 patients (10%). Also brain retraction injuries may happen during the exposure of the lamina terminalis in the poor Hunt-Hess grade patients. In 2006, Menovsky et al[5] suggested a new entry point of the ventriculostomy during supraorbital craniotomy via an eyebrow incision. This point is located under the key hole, just behind the zygomatic process of the frontal bone. This technique is innovative and demonstrates its trajectory by navigation system. However, supraorbital craniotomy via an eyebrow incision may be limited by its small surgical window in an aneurysm surgery.

The MFG is a well-known surgical corridor in the transcortical approach of lateral ventricle tumors.[6,7] We presumed that the brain surface is round and that the cannulation perpendicular to the brain surface would allow access to the lateral ventricle. On the basis of these assumptions, we devised K point ventriculostomy to facilitate CSF drainage before a dural opening to ensure easy access to the lateral ventricle. The K point is located on the MFG along the imaginary curvilinear incision line of the dura mater. In our study, we simulated the trajectory of K point ventriculostomy on 2 patients with brain tumors, verifying its safety.

K point ventriculostomy has some advantages in that it allows for easy access to the target point, reduces compressive brain injuries during dural opening and brain retraction injury during sphenoid bone resection by allowing sufficient CSF drainage prior to the dural opening, and prevents kinking of the drainage catheter during the closure of bone and the dura mater.

CONCLUSIONS

According to our findings, we recommend the K point for intraoperative ventriculostomy as an alternative for CSF drainage in patients with brain edema undergoing surgical treatment for aneurysmal SAH.

ACKNOWLEDGMENT

The authors thank Professor Kwang Myeong Kim, M.D., Ph.D., for the fruitful idea regarding the K point ventriculostomy.

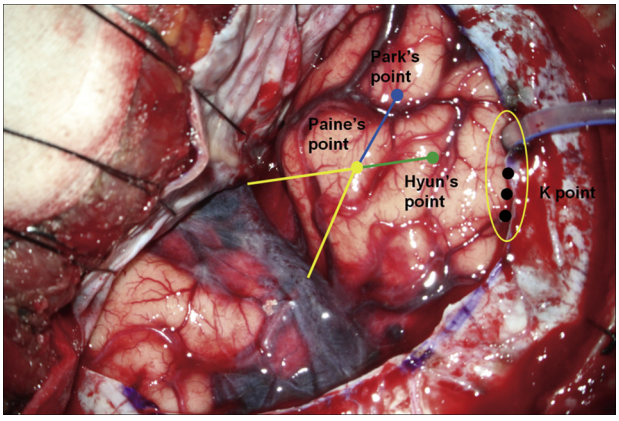

Figure 4. Intraoperative image showing each ventriculostomy point, including the K point.

REFERENCES

1. Paine JT, Batjer HH, Samson D. Intraoperative ventricular puncture. *Neurosurgery*. 1988;2: 1107-1109.

2. Hyun SJ, Suk JS, Kwon JT, Kim YB. Novel entry point for intraoperative ventricular puncture during the transsylvian approach. *Acta Neurochir (Wien)*. 2007;149:1049-1051.

3. Park J, Ham IS. Revision of Paine's technique for intraoperative ventricular puncture. *Surg Neurol*. 2008;70:503-508.

4. Lehto H, Dashti R, Karataş A, Niemelä M, Hernesniemi JA. Third ventriculostomy through the fenestrated lamina terminalis during microneurosurgical clipping of intracranial aneurysms: an alternative to conventional ventriculostomy. *Neurosurgery*. 2009;64: 430-435.

5. Menovsky T, De Vries J, Wurzer JA, Grotenhuis JA. Intraoperative ventricular puncture during supraorbital craniotomy via an eyebrow incision. *J Neurosurg*. 2006; 10:485-486.

6. D'Angelo VA, Galarza M, Catapano D, Monte V, Bisceglia M, Carosi I. Lateral ventricle tumors: surgical strategies according to tumor origin and development—a series of 72 cases. *Neurosurgery*. 2005;56(suppl 1):36-45.

7. Yaşargil M, Abdulrauf SI. Surgery of intraventricular tumors. *Neurosurgery*. 2008;62(suppl 3):1029-1041.

Conflict of interest statement: The authors have no personal, financial, or institutional interests with regards to the authorship and/or publication of this manuscript. This research did not receive any specific grants from funding agencies in the public, commercial, or not-for-profit sectors.

Received 27 July 2018; accepted 28 September 2018

Citation: World Neurosurg. (2019) 122:e248-e252.
https://doi.org/10.1016/j.wneu.2018.09.228

Journal homepage: ***www.journals.elsevier.com/world-neurosurgery***

Available online: ***www.sciencedirect.com***

1878-8750/$ - see front matter