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Brief Report

Ventricular Peritoneal Shunting Using Modified Keen's Point Approach: Technical Report and Cases Series

Elena Virginia Colombo [1,*], Daniele Bongetta [1], Fabio Cofano [2], Alessandro Versace [1], Diego Garbossa [2], Alessandro Bertuccio [3], Daniele Armocida [4], Patrizia d'Auria [5], Lisa Maria Farina [6], Roberto Assietti [1] and Fulvio Tartara [6]

1 Neurosurgery Unit, Ospedale Fatebenefratelli e Oftalmico, 20121 Milano, Italy
2 Neurosurgery Unit, Department of Neuroscience, University of Turin, 10126 Torino, Italy
3 Neurosurgery Unit, Azienda Ospedaliera Nazionale SS Antonio e Biagio e Cesare Arrigo, 15121 Alessandria, Italy
4 Neurosurgery Unit, Department of Human Neuroscience, University Sapienza of Rome, 00185 Roma, Italy
5 Neurosurgery Unit, Istituti Ospitalieri, 26100 Cremona, Italy
6 IRCCS Istituto Neurologico Nazionale C. Mondino, 27100 Pavia, Italy
* Correspondence: elenavirginia.colombo@gmail.com; Tel.: +39-339-2734763; Fax: +39-02-63632415

Abstract: Background: Ventricular peritoneal shunting (VPS) is a frequent procedure in neurosurgery, unfortunately still burdened with a significant rate of complications. The frontal Kocher's point is the most frequently used landmark for ventricular puncture. Keen's point (posterior parietal approach) seems to be a valid alternative. We report a newly described access to the lateral ventricle located in posterior temporal area and the results of a large series of adult patients. **Methods:** Retrospective analysis of a series of 188 cases of VPS performed with this approach. **Results:** Mean surgical time was 51.5 +/− 13.1 min (range 25–90 min). Twenty-one patients (11.2%) were subjected to revision surgery: eight cases (4.3%) for displacement or malfunction of ventricular catheter, eight cases (4.3%) for abdominal issues, three cases (1.6%) for hardware failure, and two cases (1.1%) for infection. Optimal catheter placement was reached in 90.1%. **Conclusions:** The modified Keen's point approach seems to be safe, technically feasible, and reproducible, showing some potential advantages such as short surgical time, precision in ventricular catheter placement, and short tunneling tract. The need for surgical revision is similar to that reported in the literature, while the rate of catheter malpositioning and infections seems to be low; hemorrhages around catheter and seizures were not reported.

Keywords: ventriculo-peritoneal shunt; communicating hydrocephalus; ventricular landmark; shunt infection; shunt revision surgery

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1. Introduction

Ventricular peritoneal shunting (VPS) for hydrocephalus is one of the most frequent procedures in neurosurgery; the incidence of adult-onset hydrocephalus being 82–88 cases per year per 100,000 [1,2]. Vascular disorders, central nervous system (CNS) tumors, CNS infections, normal pressure hydrocephalus (NPH), pseudotumor cerebri, and head injury are the most common etiologies in adult hydrocephalus [1,3,4]. VPS has a significant rate of complications, which is higher in the first year after surgery [5–8].

Catheter misplacements (ventricular or abdominal), obstructions, and infections are the most frequently cited occurrences. Other reported complications include seizures, hematomas around the catheter, mechanical dysfunctions such as disconnections or ruptures, and abdominal issues such as infections and pseudocysts [5–7,9–20].

Several sites have been described for lateral ventricle puncture and catheter placement, all of them pinpointed by an external cranial landmark. For adult VPS surgery, the most common used and reported site is the Kocher's (frontal pre-coronal), followed by parietal Keen's point (parietal approach) [21–23]. Although Keen's point is used in several Neurosurgical Units, large series have rarely been reported [10,11,16,22].

The aim of this paper is to describe a new ventricular access point to the lateral ventricle located in the lower posterior temporal area (Figure 1), which could be called "posterior temporal access" or "modified Keen's point", and report the results in a significant series of adult patients. We discuss the potential use of this technical option in relation to the occurrence of complications as reported in the recent literature.

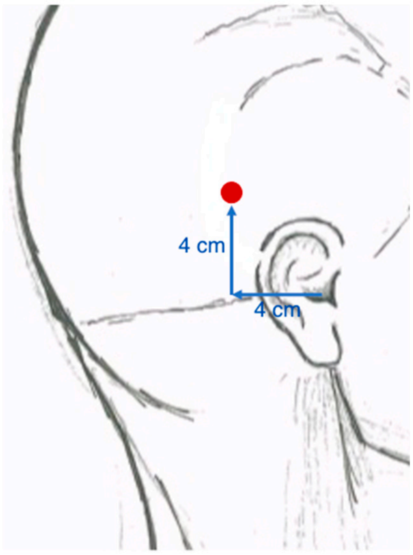

Figure 1. Posterior temporal access or modified Keen's point (red dot) is taken 4 cm posteriorly and superiorly to the external auditory meatus.

2. Materials and Methods

We retrospectively collected a series of VPS procedures performed between 2010 and 2017 in which the ventricle was accessed through the modified Keen's point. This paper represents a purely observational historical cohort study, and since both the outcome and exposure of patients occurred and consolidated before the start of the study, the approval of the ethical committee was therefore not required.

The procedure was designed by the senior author in standard steps and performed by four fully trained neurosurgeons in different hospitals. Patients with previous ventriculo-atrial shunt, or VPS surgery, or with follow-up of less than 1 year were not included in the present series.

The clinical efficacy of VPS was evaluated as an improvement in neurological performances after procedure. Postoperative CT head scans were performed on every patient to evaluate the occurrence of complication and the accuracy of ventricular shunt placement. The radiological data were verified by an independent neuroradiologist. Effectiveness of VPS was also measured as an adequate reduction in ventricular size (except for normal-pressure hydrocephalus). Catheter placement was graded according to the Hayhurst classification: Grade 1 defines a fully intraventricular catheter tip without any contact with the ependymal wall; Grade 2 defines a catheter tip in touch with the ependymal lining of the ventricle; Grade 3 defines a significant portion of the catheter tip in the brain parenchyma or complete misplacement with catheter outside of the ventricle [24]. Hakim programmable valves were used in all patients. The valve management strategy was to initially set high opening pressures (140 mm H_20) so as to avoid overdrainage and then proceed to progressively lower the pressure until an adequate symptomatic and/or radiological control of the hydrocephalus was achieved. Diagnosis of shunt infection was made from examining the clinical symptoms (fever, drowsiness, meningeal irritation), routine CSF examination (increased cells, protein, reduced glucose), as well as the positive CSF culture. The distal abdominal catheter was verified by plain abdominal X-ray. Revision surgery was considered in infection, in catheter misplacement and in patients without clinical benefit or ventricular size reduction.

Surgical Technique

Patients were lying supine with their heads rotated to the opposite site of the ventricular puncture. Their heads were maintained in position on a horseshoe headrest and secured by surgical tape, in mid position with their shoulder. Their hair was shaved in the temporal–occipital area posteriorly and superiorly to the auricle (see Figure 1). All patients received standard intravenous antibiotic prophylaxis with 2 g of cefazoline at the time of skin incision. Neither silver- nor antibiotic-impregnated catheters were used. Neuronavigation was never used. The skin was prepped with Iodopovidine and chlorhexidine. Scrubbing was performed on a unique surgical cranial–cervical–thoracic–abdominal field. The ventricular access point was marked 4 cm posteriorly and 4 cm superiorly to the external auricular conduct, and a small skin incision was performed above the point (incision was performed in a linear, horizontal fashion). Cranial bone was exposed, and a subcutaneous pouch was created distally in the retrosigmoid space for valve positioning. Firstly, a burr hole was performed, then the dura was coagulated and opened in a cross-like fashion and the cortex was gently coagulated with the arachnoidal opening. The ventricular catheter was positioned perpendicularly to the brain surface. The ventricle was reached at 3–4 cm depth. Once the stylet had been removed, the catheter was bluntly inserted with an irrigation aid up to 5–6 cm, in order to reach a correct positioning in the trigone part of the right ventricle (Figure 2). A paraumbilical, horizontal abdominal incision was performed. Tunneling of the catheter was then performed in a distal-to-proximal direction, directly or with the aid of a small lateral cervical incision. The valve was then connected with both catheters and subsequently inserted in the subcutaneous retromastoid pouch. Once the correct functioning of the system was checked, the distal catheter was inserted in the peritoneum. A no-touch technique was mainly employed for shunt handling, as was described by Choux et al. [25].

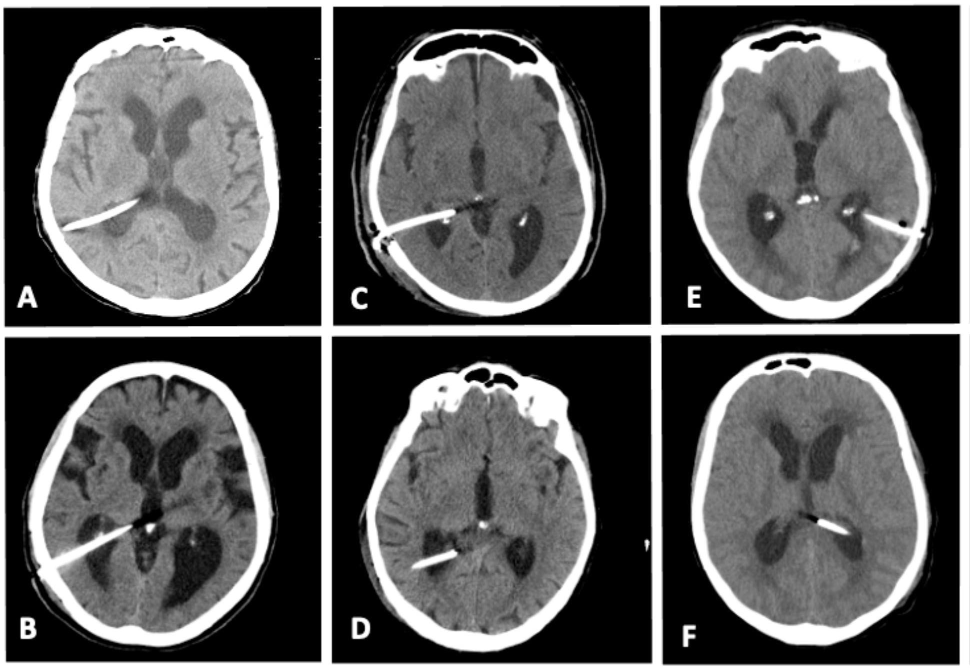

Figure 2. CT images of correct positioning of the ventricular catheter; (**A**–**D**) catheters are inserted in the right ventricle; (**E**,**F**) catheters are inserted in the left ventricle.

3. Results

Data from 188 consecutive patients that meet the inclusion criteria were analyzed. The mean age was 63.97 +/− 16.4 years (range 17–84 years), gender distribution was almost even (M:F = 96:92). The mean follow-up was 21 +/− 6 months (12–60). The catheter was positioned on the right side in 178 patients (94.7%). Left-side positioning was chosen in 10 patients because of presurgical issues (ventricles asymmetry, mass effect, hemorrhage on catheter route, wound problems). The most common etiology of hydrocephalus was posthemorrhagic (88 patients, 46.8%), followed by NPH (65, 34.6%), malformative (13, 6.9%), post-traumatic (11, 5.6%), CNS tumors (7, 3.7%), or previous CNS infections (4, 2.1%). The average surgical time was 51.5 +/− 13.1 min (25 to 90 min). In nearly half of the cases (96, 51.1%), a small laterocervical incision was necessary to allow direct passage to the abdominal region. Twenty-one patients (11.2%) were subjected to revision surgery: eight cases (4.3%) for displacement or malfunction of ventricular catheter, eight cases (4.3%) for abdominal issues (five misplacement, two cases of capsulated CSF collection, one catheter kinking), three cases (1.6%) for hardware failure, and two cases (1.1%) for infection. According to Hayhurst grading, 171 (90.1%) catheters had optimal positioning (Grade 1), 9 of them (4.8%) had suboptimal positioning (Grade 2), whereas a further 8 (4.3%) had wrong positioning (Grade 3). Each Grade 3 case was subjected to surgical revision with catheter replacement. Five out of eight (62.5%) ventricular catheter displacements occurred in the first 50 patients (relative incidence 10%), probably because of the limited experience in the technique. The relative incidence in the latest stages of the series was detected as 3 out of 138 (2.2%). Both cases of infection occurred within 2 months after surgery and needed surgical revision. No cases of overdrainage requiring surgical revision occurred in this series. The data are summarized in Table 1.

Table 1. Summaries of epidemiologic data and results.

Epidemiologic Data	Number of Patients (Percentage on the Total)
Age	63.97 +/− 16.4 years (range 17–84 years)
Gender	M: 96 (51.1%) F: 92 (48.9%)
Side of shunt	Right: 178 (94.7%) Left: 10 (5.3%)
Etiology of Hydrocephalus	Posthemorrhagic: 88 (46.8%) NPH: 65 (34.6%) Malformative: 13 (6.9%) Posttraumatic: 11 (5.6%) CNS tumors: 7 (3.7%) Post infections: 4 (2.1%)
Complications needing revision surgery	21 (11.2%)
Causes of revision surgery	Ventricular catheter issues: 8 (4.3%) Abdominal issues: 8 (4.3%) Hardware failure: 3 (1.6%) Infection: 2 (1.1%)
Ventricular catheter positioning according to Hayhurst grading	Grade 1: 171 (90.1%) Grade 2: 9 (4.8%) Grade 3: 8 (4.3%)

4. Discussion

VPS implantation remains a very frequent surgery used in different clinical situations. VPS insertion is burdened by a significant rate of complications, ranging between 17% and 46% in the adult population, that may lead to longer hospitalizations, readmissions, morbidity, and economic expenditure [5–7,9,10,16–19]. Unfortunately, there have been few improvements in the rate of VPS complications over the last decades, with ventricular catheter displacement, infection, and obstruction still being the most frequently described. [18,26,27]. Therefore, improving the management and outcome of VPS remains a current topic. Different technical options are available for ventricular catheter placement, and recently, Morone et al. summarized the described ventricular access points [22]. We report a further technical option with a newly described temporal posterior ventricular catheter insertion point. It was developed a few years ago with the aim to reach the ventricle at its most superficial point and to facilitate a quick and simple VPS procedure. We focus discussion on the occurrence of surgical complications.

There are limited analyses comparing complications and revision rates in relation to the different surgical ventricular access options [10,16,28–30] showing no significant differences.

The occurrence of complications reported in this series using modified Keen's point access is comparable to the lower rates reported in the literature.

By analyzing the occurrence of ventricular catheter displacement, we report an overall rate of 4.2% with an even better 2.2% rate considering the cases after the first 50 (initial learning curve). The malpositioning rates reported in the literature vary from 4.5% to 32.5% [11,16,30,31]. We theorize some potential advantages of the temporal access: firstly, the catheter placement does not require the patient's head to be rotated during procedure, as for frontal access, leaving the landmarks fixed and reproducible; secondly, the lateral ventricle can be found as close as 3–4 cm from the cortical surface and a simpler access to the wide area of the ventricular trigone is possible, reducing potential parallax errors and allowing blunt catheter positioning.

Moreover, as far as postoperative infections are concerned, we report a rate of 1.1%, whereas a range between 2% and 10% is reported in the literature, with more consistent estimates from larger studies reporting rates of 6% to 8% [5,6,8,10,11,16,18,20,32–41]. Interestingly, the prospective BASICS trial reports 6% incidence of infection in patients with standard catheter.

Considerable attention has been paid to age, gender, etiology and type of hydrocephalus, comorbidities, perioperative variables, surgery duration, number of surgeons, and number of skin incisions, since they can be independent risks factors for postoperative infections [11,25,39,40,42–48]. The use of a temporal access, in this regard, allows to reduce the size of the surgical field. The linear incision is easier to prep and drape. Another advantage is represented by the shorter distance, allowing a direct single passage of the catheter from the abdominal to the retroauricular incision. This also entails reduced surgical time and reduced implant manipulations.

Moreover, neither hemorrhages nor seizures were reported in this series. Although the occurrence of a hemorrhage along the catheter pathway is a rare complication with a reported rate in literature ranging from 0 to 8%, its incidence may be underreported, as it is often a subclinical event [33,49–53]. Nevertheless, hemorrhage can also be related to surgical revision and shunt infection, and their frequency may be increased to up to 32% for those patients with aneurysmal subarachnoid hemorrhage treated endovascularly in the acute phase [52,54,55]. The increasing use of devices such as flow diverters and stents even in the acute posthemorrhagic phase implies the need for a relevant antiplatelet regimen, increasing the risk of bleeding on the catheter route [52,54,55]. This will become more frequent and may lead surgeons to focus more on these aspects when carrying out VPS. In the present case series, the absence of a hemorrhagic event related to shunt positioning may be potentially related to the short parenchymal course of the catheter as well as to a favorable venous anatomy of the area. The posterior temporal approach using the modified Keen's point indeed passes through a safe skull, dural, and cortical site: the risk of lesioning a venous structure such as Pacchioni's granulation or cortical veins may be smaller compared to the risk when using Kocher's point. Similarly, anatomo-physiological characteristics may be favorable in a posterior approach rather than in a frontal one dealing with seizures. The seizure threshold for both posterior temporal and parietal areas has already been suggested to be higher than the one for the frontal lobe [16,56–61]. Moreover, there are no eloquent structures to be found at the access point we described. In particular, the Arcuate fascicle is located anteriorly and superiorly so that the procedure can spare the fascicle on either side.

Finally, in the posterior temporal approach, the valve is positioned in the retromastoid area and the drill hole almost behind the ear, resulting in aesthetic improvements for the patient. This may represent a real advantage especially in bald patients. It also allows the patients not to perceive the presence of the valve in daily life activities, e.g., when combing or running their fingers through their hair.

This study has important limitations even if it represents only a technical note and preliminarily reports on the occurrence of related complications. Firstly, it is a retrospective study without a control group. The population size is too small to evaluate the definitive occurrence percentage of complications to achieve relevant evidence. Different etiologies of hydrocephalus may influence the incidence of complications and would probably require differentiated analysis. The rate of infections may be related to several other variables that we have not considered in our analysis. A larger population and longer follow-up may be needed to evaluate long-term functioning and complications.

5. Conclusions

The use of a posterior temporal approach through a modified Keen's point in ventriculo-peritoneal shunting seems to be safe, easy, and reproducible. The occurrence of complication and need for surgical revision are similar to those reported in the literature. The rate of catheter malpositioning and infections seems to be in the low range, while hemorrhages around the catheter and seizures did not occur. Further prospective and comparative studies are needed to evaluate this technical option.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Conflicts of Interest: The authors declare no conflict of interest.

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