



# Metal External Ventricular Drainage Catheters in the Treatment of Persistent Ventriculitis – An Old Story Made New: Technical Note and Preliminary Results

## *Persistan Ventrikülit Tedavisinde Metal Eksternal Drenaj Kateterleri – Eski Bir Hikaye Yeniden: Teknik Not ve Ön Sonuçlar*

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### ABSTRACT

**AIM:** Conventional ventricular catheters have proven to be ineffective in the drainage of the cerebrospinal fluid in the long run in terms of infection rates. Consequently, the development and clinical evaluation of new catheters is urgently needed.

**MATERIAL and METHODS:** We implanted a ventricular needle made of stainless steel in 3 neurosurgical patients in whom multiple conventional (silicon) ventricular catheters had been previously implanted. All of them developed persistent ventriculitis during the first 30 days post-admission. The infection did not respond to antibiotics neither intravenously nor intrathecally via conventional catheters. After the implantation of the needle, colistin mesilate sodium was administered (150,000IU/day for 21 days) intrathecally, cerebrospinal fluid white blood cells were measured and cerebrospinal fluid cultures were obtained.

**RESULTS:** Within 15 days after the implantation of the metal catheter, a significant decrease of the cerebrospinal fluid white blood cell count was noted and all cultures were negative. No operation related complications were observed.

**CONCLUSION:** Our technique of a metal catheter implantation is safe and requires fewer reoperations. Moreover, it is cost-effective since metal catheters can be used for longer periods of time, can be reused in other patients, and are of low cost.

**KEYWORDS:** Cerebrospinal fluid, Colistin (polymyxin E), External ventricular drain, Metal ventricular catheter, Ventriculitis

### ÖZ

**AMAÇ:** Geleneksel ventriküler kateterlerin uzun dönemli serebrospinal sıvı drenajında enfeksiyon oranları açısından etkisiz olduğu gösterilmiştir. Bu nedenle yeni kateterlerin geliştirilmesi ve klinik olarak değerlendirilmesi acilen gereklidir.

**YÖNTEM ve GEREÇLER:** Çok sayıda konvansiyonel (silikon) ventriküler kateterin daha önce implante edilmiş olduğu 3 nöroşirürji hastasında paslanmaz çelikten yapılmış ventriküler bir iğne implante ettik. Tümünde hastaneye yattıktan sonraki 30 günde persistan ventrikülit gelişti. Enfeksiyon konvansiyonel kateterler yoluyla intravenöz veya intratekal antibiyotiklere cevap vermedi. İğne implantasyonundan sonra intratekal olarak kolistin mesilat sodyum uygulandı (21 gün boyunca 150.000 IU/gün), beyin omurilik sıvısında lökosit sayımı yapıldı ve serebrospinal sıvı kültürleri alındı.

**BULGULAR:** Metal kateterin implantasyonundan sonra 15 gün içinde beyin omurilik sıvısı lökosit sayımında önemli bir azalma görüldü ve tüm kültürler negatifti. Ameliyatla ilgili herhangi bir komplikasyon gözlenmedi.

**SONUÇ:** Metal kateter implantasyonu tekniğimiz güvenlidir ve daha az tekrar operasyon gerektirmektedir. Ayrıca metal kateterler daha uzun süre, başka hastalarda da kullanılabilmesi ve maliyeti düşük olması nedeniyle maliyet açısından daha etkin kullanımlıdır.

**ANAHTAR SÖZCÜKLER:** Beyin omurilik sıvısı, Kolistin (polimiksin E), Eksternal ventriküler dren, Metal ventriküler kateter, Ventrikülit

### INTRODUCTION

Catheter-associated infection of the cerebrospinal fluid (CSF) is a well-known and eventually devastating complication of external ventricular drainage (EVD) (2, 13). The infection rate can be as high as 30% and increases three-fold more than 18 days after implantation of conventional (silicon) catheters (23, 25). Even though it is standard practice to administer antibiotics prophylactically (15), the CSF infection cannot

be totally excluded (13, 25). On the other hand, the average infection rate of ventriculostomy via metal needles has been reported to be less than 1% (18).

In order to minimize the risk of ventriculitis several approaches have been proposed both for adults (9, 13, 17, 21) and children (20, 22, 24, 25); percutaneous needle puncture (25), 'Duisburger Nadel' (10), endoscopic third ventriculostomy alone or combined with choroid plexus

cauterization (24), antibiotic-impregnated catheters (AIC) (17, 21, 22), nanoparticles (silver)-impregnated catheters (9, 13) and flexible metal ventricular catheters (23) represent only some of the current practices. In the case of verified ventriculitis the choice of the appropriate catheter to use is far more troublesome.

The scope of this report is to highlight the enhanced therapeutic potential of metal catheters as compared to the conventional (silicon) ones in selected cases of protracted ventriculitis in patients with extended length of stay in an intensive care unit (ICU). To the authors' knowledge there are only 2 articles in the English literature commenting on the superiority of a metal catheter in treating complicated infection of the ventricles (23, 25). The efficacy of colistin in eradicating multidrug-resistant bacteria such as *Acinetobacter baumannii* is additionally underlined (7, 12).

## MATERIAL and METHODS

### Patients

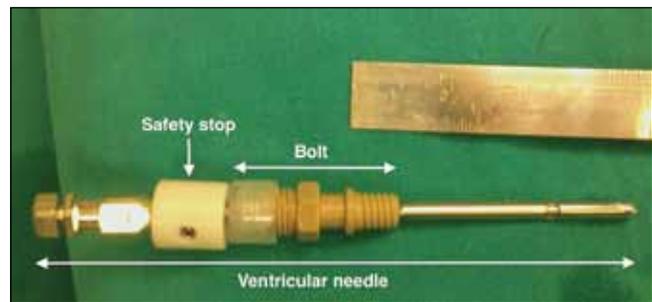
Three patients were treated in the Department of Neurosurgery of Democritus University of Thrace, Greece. All of them (3 males) were diagnosed with chronic ventriculitis as a result of a prolonged length of stay in the ICU. They had already undergone an average of 6 operations for revision (range: 5-7) with concomitant administration of intravenous and intrathecal antibiotics based on CSF cultures. The isolated bacteria were multidrug-resistant *Acinetobacter baumannii* and *Klebsiella pneumoniae*. Yet, this treatment plan did not eradicate the infection. Patient demographics and disease-specific characteristics are presented in Table I.

### Description of the Home-Made Device

Our home-made device consists of 3 components. The first one is the metal catheter; it is a non-porous stainless steel (AV4) ventricular needle of Cone type with a length of 89 mm (3.5 inches) and a diameter of 12 Gauge. The needle is composed of 2 lateral wide holes in the distal end, while in the proximal end a Luer Lock hub is found. The second component is a bolt with compression cap, which allows insertion to the desired predefined depth and reliable fixation to the skull. The third component is composed of one safety stop to prevent an accidental catheter migration (Figure 1).

### Operative Technique

One cm anterior to the coronal suture and 2.5 cm lateral to the midline on the right side is the location where the burr-hole is made under general anaesthesia (23). If previous attempts on the right side have been made, then the operation is carried out on the left side. The preferred site of implantation is the frontal horn of the right lateral ventricle for two reasons; first, because of the clinically 'silent' frontal lobe and second because of the lack of choroid plexus in this region (eliminating thus the possibility of haemorrhage during the withdrawal of the catheter) (1). The catheter is advanced 6-7 cm under sterile technique (16). The needle is then fixed to the skull with the aid of a bolt. Standard sutures are used



**Figure 1:** The non-flexible home-made metal external ventricular catheter made of medical stainless steel.

for skin closure. Alternatively, Michel clips are preferred in order to keep the danger of infection low (5). A non-occlusive dressing is applied. The CSF is allowed to drain freely into a graduated flow chamber, which is connected to the EVD catheter via a 3-way stopcock. The whole system is then attached to a collection drainage bag (15). Long-term care includes meticulous site care by a nurse. Topical antiseptics are daily applied to reduce local bacterial skin count around the catheter insertion site (13).

### Microbiologic Testing

Samples of CSF were examined in the Laboratory of Clinical Microbiology of our Hospital for direct examination, Gram stain, and culture. Susceptibility testing was performed by the agar dilution replicate plating method (15). *Acinetobacter baumannii* isolates were considered susceptible to colistin if the minimum inhibitory concentration (MIC) was  $\leq 2$  mg/L and resistant if the MIC was  $\geq 4$  mg/L (12).

## RESULTS

Mean operating time for the procedure including fixation and connection to the drainage system was 27 minutes (range 25-30). In all three patients 5mg=150,000 IU/day Colistin/Norma<sup>®</sup> (polymyxin E) (colistin mesilate sodium 1,000,000 IU/vial, Norma Hellas S.A., Greece) were injected intrathecally via the EVD catheter for 3 weeks (12). This route was chosen due to the poor blood-brain barrier penetration of polymyxins and the nephrotoxicity described via the intravenous administration (14). During this period the CSF white blood cell counts and CSF cultures were followed to assess efficacy. As illustrated in Table I and Figure 2, the decline of CSF cells was obvious even from the 10<sup>th</sup> post-implantation day. The mean duration of drainage in the 3 patients was 30 days (range 21-40). No intraparenchymal haematomas, no CSF leakage or EVD disconnection were noted.

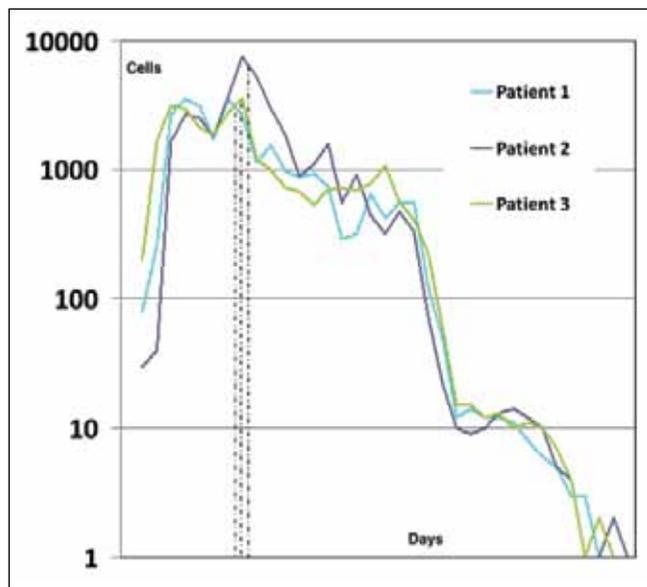
### Case Illustration: Patient 1

This 56-year-old male presented with subarachnoid haemorrhage (Hunt & Hess grade 3-4). On admission his Glasgow Coma Scale (GCS) score was 7/15. He had a history of uncontrolled hypertension. The CT and CT-angiography revealed subarachnoid haemorrhage, hydrocephalus, and an aneurysm of the anterior communicating artery. The patient was taken to the operating room, where an EVD was inserted

**Table I:** Ventriculitis: Patient Demographics, Primary Diagnosis, CSF Cells Count, Treatment Options, Antibiogram

	Patient 1	Patient 2	Patient 3
Age (years)	56	62	52
Gender	M	M	M
Primary diagnosis	SAH – IVH (ACoA aneurysm rupture)	Intracerebellar hemorrhage – IVH	SAH – IVH (PCoA aneurysm rupture)
Surgical treatment (primary diagnosis)	Clipping of the ACoA aneurysm + EVD	Evacuation of the haematoma + EVD	Clipping of the PCoA aneurysm + EVD
Antibiogram	AB (MDR)	AB+KP (MDR)	AB (MDR)
Intrathecal treatment (through the MC)	Colistin 150,000 IU/day	Colistin 150,000 IU/day	Colistin 150,000 IU/day
Previous or co-administered antibiotics	MER, VAN, GEN	MER, VAN, GEN	MER, VAN, GEN
Nr of CSF cells 1 day before the implantation of the MC (/mm <sup>3</sup> )	3,530	7,500	3,560
Nr of CSF cells 10 days after the implantation of the MC (/mm <sup>3</sup> )	650	440	780
Nr of CSF cells 21 days after the implantation of the MC (/mm <sup>3</sup> )	11	14	10
Nr of CSF cells 27 days after the implantation of the MC (/mm <sup>3</sup> )	1	2	1

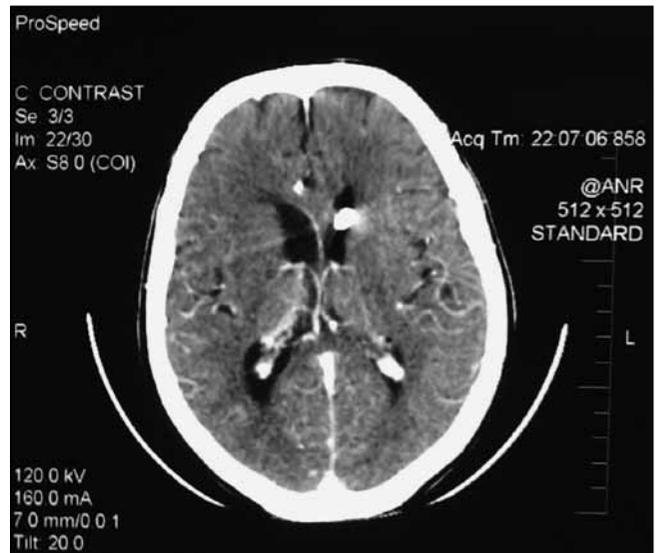
**AC** *Acinetobacter baumannii*; **AcoA** anterior communicating artery; **AVM** arteriovenous malformation; **CSF** cerebrospinal fluid; **EVD** external ventricular drainage; **GEN** gentamicin; **IU** international units; **IVH** intraventricular hemorrhage; **KP** *Klebsiella pneumoniae*; **MC** metal catheter; **MDR** multidrug resistant; **MER** meropenem; **Nr** number; **PCoA** posterior communicating artery; **SAH** subarachnoid hemorrhage; **VAN** vancomycin.



**Figure 2:** Triple line graph illustrating the drop of the number of cells in the cerebrospinal fluid (CSF) in the 3 patients after the implantation of the metal catheter (dotted vertical lines represent the time of implantation).

and the aneurysm was successfully clipped. Postoperatively his neurological status did not improve and he had to remain in the ICU for 2 months. During these months the EVD catheter was exchanged 5 times to prevent contamination. However, persistent fever and consecutive CSF cell counts suggested

infection of the central nervous system which was confirmed by new CT scans (ventriculitis) and positive CSF cultures. At that time appropriate (based on CSF cultures) antibiotics were administered intrathecally and intravenously (meropenem, vancomycin, and gentamicin). In spite of our treatment efforts the cultures remained positive (with additional appearance of *Acinetobacter baumannii*) and the patient was febrile. The CSF cells reached a maximum number of 3,530/mm<sup>3</sup>. We then decided to proceed with the insertion of a non-porous metal catheter, which is a well-tolerated material in cases of infection. A new contrast-enhanced cranial CT scan (Figure 3A) showed ependymal enhancement and diffuse brain swelling. Once again the patient was taken to the operating room and a metal catheter was placed on the left side under general anaesthesia (Figure 3B). The drainage system was leveled as shown in Figure 3C. Via this catheter 5 mg=150,000 IU/day colistin were injected intrathecally for 3 weeks. At the same time colistin was administered intravenously due to the concurrent diagnosis of pneumonia (also caused by *Acinetobacter baumannii*) at a dose of 160mg/8hr. Consecutive daily CSF cell counts showed a continuous drop from 650/mm<sup>3</sup> (day 10) to 11/mm<sup>3</sup> (day 21) and finally to 1/mm<sup>3</sup> (day 27). Twenty-four days after the implantation of the AV4 needle a new CT scan was obtained; the EVD catheter in situ in the left lateral ventricle can be seen in Figure 4. The neurological status of the patient improved progressively (GCS=10/15), he had no fever and he was transferred to the Neurosurgical wards.



**Figure 4:** CT image (post-contrast) 24 days after the implantation of the metal catheter.



**Figure 3:** **A)** CT image (post-contrast) of Patient 1 before the implantation of the metal catheter. **B)** Intra-operative image. **C)** Patient 1 in the ward. The tragus of the ear is used as the standard landmark for the external ventricular drainage system level estimation.

## DISCUSSION

It is apparent that the diagnostic and therapeutic approach to nosocomial ventriculitis is difficult to standardize (3), especially if one takes into account that the antimicrobial drug resistance rates in many southern European countries are among the highest in Europe (19). Of note, an over-administration of meropenem, vancomycin and gentamicin has been observed in several ICUs, especially after the publication of studies supporting the enhancement of the killing action of meropenem against *Pseudomonas aeruginosa* and staphylococci by the addition of gentamicin or vancomycin respectively (4, 26).

From the microbiological point of view, the preponderance of gram-negative infections raises substantial concern (3). Traditionally, gram-positive microorganisms represented by *Staphylococcus aureus* and coagulase-negative *Staphylococcus* species have been the most common pathogens originating from skin flora (3, 15, 25). On the other hand, pandrug-resistant Gram-negative infections are associated with a higher mortality rate, which approaches 58% in some studies (8, 15). Luckily, polymyxin-resistant *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Klebsiella pneumoniae* clinical isolates are currently relatively rare (6).

The gram-negative microbial colonization could be attributed to the prolonged hospitalisation of the patients coupled with the policy at our Hospital to administer prophylactic antibiotics before EVD catheters' insertion to protect against skin flora contamination of the wound site but not against gram-negative ones (2, 15).

*Acinetobacter baumannii* was isolated in all 3 patients in this report. This bacterium is typically a health-care-associated pathogen (7). Colistin has been shown to be efficacious as either primary (as in our case) or adjunct treatment of

multidrug-resistant or pandrug-resistant *Acinetobacter baumannii* (7, 12). It has been reintroduced into clinical practice as a last resort for the treatment of such nosocomial infections with a dosage ranging from 1.6 mg/day to 20 mg/day and duration of treatment ranging from 17 to 56 days (14). The intraventricular use is adequate achieving a cure rate of 100%. The concurrent intravenous administration does not seem to benefit the patient (2). On the contrary, toxicity appears only in those patients who receive additional colistin intravenously (14, 20). However, the intravenous administration is indicated and strongly advised whenever additional sites of infection (i.e. lungs, kidneys) are also identified (3, 14).

Many devices have been tested over the last 15 years in a continuous effort to address the problem of infection. Antibiotic-impregnated catheters (AIC) seem to be an effective way of reducing the incidence of EVD infections (21, 22). In a study of Soleman et al. it was found that time until remission of CSF pleocytosis was significantly longer in patients undergoing EVD with rifampin- and clindamycin-impregnated silicon catheters than in patients who underwent standard EVD. Yet, there was no significant difference between both groups for the time until polymorphonuclear cells dropped below 50% of peak value, C-Reacting Protein dropped below 10 mg/l, the time of plasma neutrophil remission and hospitalisation time. The data supported only the prophylactic use of AIC for prevention of EVD-related infections (21). A meta-analysis of one randomized controlled trial and three observational studies suggested that AIC reduce the incidence of EVD infections (22). Another study including 75 patients in which 97 EVD were inserted verified the delay of infection in the group of patients treated with AIC (17). However, AIC have raised concerns over bacterial multiresistance (9).

An alternative could be the silver-impregnated EVD catheters. One study addressing the efficacy of such catheters found in 20 control patients 5 catheter-related ventriculitis, while no positive CSF cultures were observed in the treatment group (19 patients) (13). Similar results were published by other authors in a retrospective analysis of 164 patients (9). A possible explanation for this finding could be that silver ions compete with copper ions for cellular entry for certain enzymatic sites at which silver exerts its toxic action (13). Moreover, silver concentrations in the brain tissue were found to be far below accepted levels (9, 11).

Endoscopic third ventriculostomy with adjunctive use of choroid plexus cauterisation could be another approach. A study of 179 Ugandan children with post-infectious hydrocephalus due to malaria reported a success rate of 81% among patients older than 1 year of age. The procedure was successful in 59% among those patients younger than 1 year of age. The mean follow-up period was 15.2 months (24). Whether this technique could be also applied in adults with ventriculitis in addition to the standard EVD catheter approach remains to be proven.

In the past several studies had focused on the usage of devices made of metal (10, 18, 23, 25, 27). In children, a metal needle has been used in the past ('Duisburger Nadel') in emergency situations enabling an immediate and reliable ventriculostomy with a minimal risk of infection (10). Other researchers reported on external CSF drainage by percutaneous metal needle puncture in newborn children (25). The authors implanted a Cytocan® port needle with a 20G diameter in 7 infants and no intracerebral haemorrhage or accompanying ventriculitis were encountered. Actually, in two cases a pre-existing ventriculitis was cured by this needle and antibiotic treatment. They also proposed a new needle holder system that could be mounted safely on the thin skull of newborn children (25). Research supports the percutaneous needle implantation for external CSF drainage in adults too, so that the risk of infection can be reduced (18, 23, 27). Several important drawbacks of drainage needles could be mentioned; first, they are rigid systems. Second, they loosen with time and must be exchanged. Third, they cannot be converted to an internalized shunt. Fourth, their use is not indicated in paediatric patients (23).

A more flexible system was reported in 1996. It was made of implantation steel and consisted of a corrugated tube that rendered it flexible. It was implanted as a temporary and later permanent CSF drainage in 7 males aged from 4 to 60 years. The infection was successfully eliminated in 6 patients. In the 7<sup>th</sup> patient, the metal catheter had to be removed after 4 days due to a CSF leakage. The average duration of drainage was 27 days. Secondary infection or intracerebral haemorrhage did not occur (23).

Our technique was not associated with any complications such as intracerebral haemorrhages, infections or CSF leakage as noted in various other procedures (18, 23, 27). The employed device presents three important advantages; first, metal catheters safely stay in the ventricles for a prolonged time period (up to 40 days) presumably due to their non-porous material that renders the bacterial adhesion and colonization limited (23). This is one of the longest implantation durations ever reported. Second, they can be sterilised and thus reused. And third, their financial impact on the budget of Hospitals is negligible.

It is our belief that metal catheters deserve a place in the armamentarium of neurosurgeons and intensivists. Indeed, they could not be the first option for all neurosurgical patients who need an EVD. However, the implantation of such catheters should definitely be considered in specific patient subgroups (extremely poor neurological status on admission, extended length of stay in the ICU, several revisions of conventional ventricular catheters, protracted infections of the CSF pathways that are resistant to treatment with the usual EVD devices, complicated infections, prolonged CSF drainage) (23).

## CONCLUSION

Our technique provides direct access to the ventricular system and satisfactory treatment of ventriculitis in cases where the

conventional catheters fail. It is easily and safely performed while at the same time requires less reoperations. Last but not least it does not cause a severe financial strain on the health system.

#### CONFLICTS of INTEREST

None.

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