Journal of Clinical Neuroscience 21 (2014) 578–582

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Sonication of catheter tips for improved detection of microorganisms on external ventricular drains and ventriculo-peritoneal shunts

Gregory F. Jost [a,*], Morten Wasner [a], Ethan Taub [a], Laura Walti [b], Luigi Mariani [a], Andrej Trampuz [c]

[a] Department of Neurosurgery, University Hospital Basel, Spitalstrasse 21, 4031 Basel, Switzerland
[b] Septic Surgery Unit, Department of Surgery and Anesthesiology, University Hospital Lausanne, Lausanne, Switzerland
[c] Charité, University Medicine, Free and Humboldt-University of Berlin, Berlin, Germany

ARTICLE INFO

Article history:
Received 22 May 2013
Accepted 31 May 2013

Keywords:
External ventricular drain
Infection
Meningitis
Shunt
Sonication

ABSTRACT

The diagnosis of infections involving internal or external neurosurgical drainage devices is challenging, and to our knowledge no single reliable microbiological test exists. We used sonication to study bacterial colonization in 14 explanted external ventricular drains (EVD) and 13 ventriculo-peritoneal shunt (VPS) devices. This technique dislodges biofilm bacteria from the surface of implanted materials before culture. Removed devices were sonicated in saline (40 kHz, 1 minute, 0.25 W/cm^2), the resulting fluid was cultured aerobically and anaerobically at 37 °C, and bacterial growth was counted. Ventricular cerebrospinal fluid (CSF) was cultured separately. In the EVD group, sonication cultures grew significantly more bacteria (64%, 9/14) than cultures of aspirated ventricular CSF (14%, 2/14). In the VPS group the difference was not significant. Positive sonication cultures of EVD catheters yielded a median of >100 colony forming units (CFU) (range, 60–800). For positive sonication cultures of VPS, the median was 1000 CFU (range, 20–100,000). All patients with bacteria in their CSF also had positive sonication cultures from the removed device. Of the five patients with sterile or presumably contaminated CSF cultures but positive sonication cultures of removed shunts, one became afebrile after removal of the EVD, two developed meningitis and two remained asymptomatic. Sonication culture of EVD appears to improve the microbiological assessment of device-related infection and it corroborates with CSF cultures of revision surgery for VPS. Sonication of the removed EVD tip may raise awareness for the onset of meningitis.

1. Introduction

External ventricular drain (EVD) and ventriculo-peritoneal shunt (VPS) devices are indispensable in the treatment of acute and chronic hydrocephalus. Such indwelling catheters may become colonized by bacteria, which may lead to catheter obstruction [1], catheter-related meningoventriculitis, or both. Five to 27% of EVD eventually become infected [2–5]. Bacteria adhere firmly to the implant surface and form a biofilm that protects them from many antimicrobial agents and from the defense mechanism of the immune system, as well as shielding them from diagnostic tests. The manifestations of meningoventriculitis include fever, obtundation, headache, photophobia, neck stiffness and pleiocytosis, a low glucose concentration, and high concentrations of lactate and protein in the cerebrospinal fluid (Table 1). In patients requiring EVD, these findings are unreliable markers of an infection, as they can also be caused by the underlying disease for which the catheter was inserted, such as subarachnoid or intraventricular hemorrhage [6]. Suspected catheter-related infections are confirmed if bacterial cultures of ventricular cerebrospinal fluid (CSF) become positive [7]. Culture results from explanted ventricular catheter tips or VPS devices may not be considered or reported [5,8]. Sonication is a technique for the removal of biofilm-forming bacteria from the surface of implanted materials before culture [9]. Our preliminary findings on sonicated EVD and VPS devices reveal a significantly higher rate of bacterial colonization on EVD than the rate of positive CSF cultures and suggests that consideration of the former may aid to diagnose or anticipate meningoventriculitis.

2. Methods

This study was approved by the Institutional Review Board of the University of Basel. Patients were enrolled from January 2008 to July 2009 and September 2011 to September 2012.

2.1. Catheter insertion and removal

EVD were inserted under sterile conditions in the operating room with the patient under general anesthesia. A single

* Corresponding author. Tel.: +41 78 698 77 32; fax: +41 61 265 71 38.
E-mail address: gregoryjost@gmx.ch (G.F. Jost).

0967-5868/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jocn.2013.05.025

Table 1
Centers for Disease Control criteria for diagnosis of meningitis or ventriculitis [7]. Patients must meet at least criteria 1 or 2

1. Patient has organisms cultured from CSF
2. Patient has at least *one* of the following signs or symptoms with no other recognized cause:
   a. fever (>38°C)
   b. headache
   c. stiff neck
   d. meningeal signs
   e. cranial nerve signs, or
   f. irritability
   and

at least *one* of the following:

   a. increased white cells, elevated protein, and/or decreased glucose in CSF
   b. organisms seen on Gram's stain of CSF
   c. organisms cultured from blood
   d. positive antigen test of CSF, blood, or urine
   e. diagnostic single antibody titer (IgM) or four-fold increase in paired sera (IgG) for pathogen
   and

if diagnosis is made antemortem, physician institutes appropriate antimicrobial therapy

CSF = cerebrospinal fluid, IgG = immunoglobulin G, IgM = immunoglobulin M.

Table 2
Data from patients with an external ventricular drain

Patient	Age, sex	Dx	EVD type	Drainage (days)	Sonication (organism/CFU)	CSF culture (organism/quantity)	Meningitis by CDC[3]
1	16, M	IVH	NK	13	*Corynebac.sp*/>100 CoNS/60	*P. acnes*/(+)	Yes
2	66, F	SAH	SL	10	Sterile	Sterile	No
3	55, F	SAH	SL	7	CoNS/>100	Sterile	No[1]
4	60, M	SAH	NK	3	CoNS/>100	CoNS/(+)	Yes
5	35, F	IVH	SL	13	CoNS/>100	CoNS/+++	Yes
6	51, F	SAH	SL	12	CoNS/>100	CoNS/(+)	No
7	51, M	SAH	SL	8	CoNS/800	Sterile	No[2]
8	79, F	SAH	SL	NK	Sterile	Sterile	No
9	69, F	IVH	SL	NK	Sterile	*P. acnes*/(+)	No
10	71, M	SAH	SL	13	Sterile	Sterile	Yes
11	39, F	SAH	SL	29	Sterile	Sterile	No
12	49, M	TBI	SL	11	CoNS/>100	Sterile	No
13	53, F	SAH	SL	18	CoNS/>60	Sterile	No[2]
14	53, M	SAH	SL	10	CoNS/>100	CoNS/+++	Yes

CDC = Centers for Disease Control criteria, CFU = colony forming units, CoNS = coagulase-negative *staphylococcus*, *Corynebac.sp* = *Corynebacterium species,* CSF = cerebrospinal fluid, Dx = diagnosis, EVD = external ventricular drain, F = female, IVH = interventricular hemorrhage, M = male, NK = not known, *P. acnes* = *Propionibacterium acnes*, SAH = subarachnoid hemorrhage, SL = Silverline (Spiegelberg GmbH & Co. KG, Hamburg, Germany), TBI = traumatic brain injury, (+) = evidence of bacteria after culture enrichment only and considered as contamination, +++ = massive number of bacteria.

[1] Fever subsided after EVD removal.
[2] Developed meningitis soon after.
[3] Meningitis by CDC at the time of EVD removal (see Table 1).

intravenous dose of 1.5 g of cefuroxime, or 1 g of vancomycin for repeat shunt procedures, was given preoperatively. For EVD, the skin was shaved over the area of catheter insertion and over the cutaneous exit site. For VPS, the abdomen was also shaved if necessary. The skin was prepped with an alcoholic povidone-iodine solution (Betaseptic; Mundipharma, Cambridge, UK) and sterilely draped. EVD were inserted frontally (anterior to the coronal suture in the midpupillary line) and subcutaneously tunneled at least 5 cm to a separate cutaneous exit site. The external portion of the catheter was connected to a closed collection system (Becker External Drainage and Monitoring System; Medtronic Sofamor Danek, Memphis, TN, USA). The incision was closed with sutures and covered with a sterile dressing. EVD were removed later in the intensive care unit or in the intermediate care unit when CSF drainage was no longer needed, or when infection was suspected. When the EVD was removed, the cutaneous exit site was disinfected with 80% ethanol (Braun Melsungen AG, Melsungen, Germany) before the catheter was pulled out. A 3 cm length of catheter tip was aseptically cut off and placed in a sterile polystyrene tube (Greiner Bio-One, Gloustershire, UK). VPS devices were removed in the operating room with the patient under general anesthesia. The explanted device was placed in a sterile polyethylene container. The removed catheter tips and VPS devices were sent to the microbiology laboratory for further study.

2.2. Catheter sonication and ventricular CSF culture

Catheters were sonicated within 6 hours of removal. The container with the catheter was vortexed for 30 seconds, then sonicated for 60 seconds in containers to which 100 ml of sterile Ringer's solution was added. Sonication was performed at 40 ± 2 kHz and a power density of 0.22 ± 0.04 W/cm [2], under the control of a calibrated hydrophone (8103; Brüel and Kjær, Nærum, Denmark). An ultrasound bath (BactoSonic; Bandelin GmbH, Berlin, Germany) was used for sonication. The container was subsequently vortexed for an additional 30 seconds to remove any residual microorganisms and to homogeneously distribute them in the sonication fluid. Then 0.1 ml aliquots of the sonication fluid were plated in aerobic and anaerobic sheep blood agar, incubated at 37 °C for 7 days, and inspected daily for bacterial growth. Colony-forming units (CFU) were counted and microorganisms were classified with routine microbiologic techniques.

Fresh ventricular CSF was aspirated daily and sent for cell count, protein, glucose, lactate, and aerobic and anaerobic cultures.

2.3. Data collection

We used a standardized case-report form to review patient charts and extract age, sex, primary diagnosis and comorbidities,