Perioperative Management Of Extra-Ventricular Drains (EVD)

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Disclosures

- None
Outline

• To understand the common indications & complications with extra-ventricular drain (EVD) placement
• Pre-operative assessment of patients presenting with EVD
• To suggest management of patients with EVD in the perioperative setting including monitoring and CSF drainage
Introduction

- Temporary devices placed to facilitate external CSF drainage and to monitor ICP
- Between 1988-2010 around 500,000 ventriculostomies placed\(^1\)
- Majority in SAH, ICH or Obstructive Hydrocephalus\(^1\)
- Encountered in OR setting by clinicians with limited experience
- Mismanagement can be catastrophic

\(^1\) Rosenbaum et al; J Clin Neurosci. 2014
Clinical Study


Benjamin P. Rosenbaum a,b,* , Sumeet Vadera a , Michael L. Kelly a , Varun R. Kshettry a , Robert J. Weil a,c

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c Rose Ella Burkhardt Brain Tumor and Neuro-Oncology Center, Cleveland Clinic, Cleveland, OH, USA

Fig. 2. Estimated national hospitalizations with ventriculostomy versus (vs.) year. Note that the Healthcare Cost and Utilization Project revised discharge weight (DISCWT) corrected for years 1988–1997 was used as instructed. Source: National Inpatient Sample data element DISCWT. This figure is available in colour at www.sciencedirect.com.
Table 2
Most commonly associated principal diagnoses and in-hospital mortality rates for all combined ventriculostomy procedures of admissions analyzed from 1988–2010

<table>
<thead>
<tr>
<th>ICD-9-CM principal diagnosis name (code)</th>
<th>Occurrences in NIS database</th>
<th>Percentage of total (101,577)</th>
<th>In-hospital mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Subarachnoid hemorrhage (430)</td>
<td>19,409</td>
<td>19.1%</td>
<td>32.1%</td>
</tr>
<tr>
<td>2 Intracerebral hemorrhage (431)</td>
<td>15,176</td>
<td>14.9%</td>
<td>42.5%</td>
</tr>
<tr>
<td>3 Obstructive hydrocephalus (331.4)</td>
<td>3,873</td>
<td>3.8%</td>
<td>5.3%</td>
</tr>
<tr>
<td>4 Infection and inflammatory reaction due to nervous system device, implant, and graft (996.63)</td>
<td>2,849</td>
<td>2.8%</td>
<td>2.6%</td>
</tr>
<tr>
<td>5 Secondary malignant neoplasm of brain and spinal cord (198.3)</td>
<td>2,697</td>
<td>2.7%</td>
<td>12.8%</td>
</tr>
<tr>
<td>6 Secondary malignant neoplasm of other parts of nervous system (198.4)</td>
<td>2,470</td>
<td>2.4%</td>
<td>12.5%</td>
</tr>
<tr>
<td>7 Mechanical complication of nervous system device, implant, and graft (996.2)</td>
<td>2,289</td>
<td>2.3%</td>
<td>4.3%</td>
</tr>
<tr>
<td>8 Subdural hemorrhage (432.1)</td>
<td>1,595</td>
<td>1.6%</td>
<td>20.6%</td>
</tr>
<tr>
<td>9 Cerebral artery occlusion, unspecified with cerebral infarction (434.91)</td>
<td>1,245</td>
<td>1.2%</td>
<td>33.3%</td>
</tr>
<tr>
<td>10 Malignant neoplasm of cerebellum nos (191.6)</td>
<td>1,106</td>
<td>1.1%</td>
<td>5.2%</td>
</tr>
<tr>
<td>11 Closed fracture of base of skull with subarachnoid, subdural, and extradural hemorrhage, with prolonged (more than 24 hours) loss of consciousness, without return to pre-existing conscious level (801.25)</td>
<td>1,055</td>
<td>1.0%</td>
<td>66.4%</td>
</tr>
<tr>
<td>12 Cerebral cysts (348.0)</td>
<td>1,029</td>
<td>1.0%</td>
<td>–</td>
</tr>
<tr>
<td>13 Benign neoplasm of cerebral meninges (225.2)</td>
<td>1,000</td>
<td>1.0%</td>
<td>10.8%</td>
</tr>
<tr>
<td>14 Closed fracture of base of skull with subarachnoid, subdural, and extradural hemorrhage, with loss of consciousness of unspecified duration (801.26)</td>
<td>855</td>
<td>0.8%</td>
<td>14.5%</td>
</tr>
<tr>
<td>15 Other malignant lymphomas, unspecified site, extranodal and solid organ sites (202.80)</td>
<td>826</td>
<td>0.8%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Total</td>
<td>57,474</td>
<td>56.6%</td>
<td>–</td>
</tr>
</tbody>
</table>

ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification, N/A = not available, NIS = National Inpatient Sample, nos = not otherwise specified.
History of EVD Placement

• 4 eras of progress\(^1\):
  - Development of technique (1850-1908)
  - Technological Advancements (1927-1950)
  - Expansion of Indications (1960-1995)
  - Accuracy, Training, Infection control (1995-Present)

\(^1\) Srinivasan et al; J Neurosurg 2014
Fig. 7. A brief summary timeline of the development and use of EVD. TBI = traumatic brain injury.

1 Srinivasan et al; J Neurosurg 2014
# EVD Materials

<table>
<thead>
<tr>
<th>Material Used</th>
<th>First Published Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>horsehairs</td>
<td>Keen, 1890</td>
</tr>
<tr>
<td>catgut wick</td>
<td>1899</td>
</tr>
<tr>
<td>metal cannula</td>
<td>1911</td>
</tr>
<tr>
<td>silver cannula secured by beef bone washer</td>
<td>Adson &amp; Lillie, 1927</td>
</tr>
<tr>
<td>flanged silver cannula</td>
<td>Ingraham &amp; Campbell, 1941</td>
</tr>
<tr>
<td>rubber tubing</td>
<td>Crawford &amp; Munslow, 1943</td>
</tr>
<tr>
<td>silk urethral catheter</td>
<td>Robinson, 1948</td>
</tr>
<tr>
<td>Silastic catheter</td>
<td>White et al., 1969</td>
</tr>
</tbody>
</table>

1 Srinivasan et al; J Neurosurg 2014
ICP Monitoring

Outline

• To understand the common indications & complications with extra-ventricular drain (EVD) placement

• Pre-operative assessment of patients presenting for or with EVD

• To suggest management of patients with EVD in the perioperative setting including monitoring and CSF drainage
EVD Placement Indications
Indications for Placement of EVD

1. Acute Symptomatic Hydrocephalus

- Aneurysmal SAH
- ICH and IVH with decreased level of consciousness
- Acute ischemic cerebellar stroke in concurrence with decompressive craniectomy

1 Lele et al; J Neurosurg Anesthesiol 2017
Indications for Placement of EVD

2. ICP monitoring in TBI

- TBI with post resuscitation GCS of 3-8 and abnormal CT
- Severe TBI with a normal CT scan if >2 of features present (age>40, motor posturing or SBP<90)
- Management of Intracranial Hypertension after TBI

1 Lele et al; J Neurosurg Anesthesiol 2017
Indications for Placement of EVD

3. Malfunctioning or infected V-P Shunts

4. Facilitation of intraoperative brain relaxation

5. Targeted Therapeutic Interventions
   ✓ rTPA in patients with IVH and SAH?
   ✓ Treatment of vasospasm after SAH
   ✓ Antibiotics in management of CNS infections

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1 Lele et al; J Neurosurg Anesthesiol 2017
Indications for placement of EVD

Subarachnoid Hemorrhage (1) with hydrocephalus (2)

Intracerebral hemorrhage (1) with ventricular extension (2)

Cerebellar stroke (1) with hydrocephalus (2)
Site for EVD Placement

- Placed either electively in OR/IR or emergently at bedside\(^1,2\)
- Frontal horn of right lateral ventricle - Preferred Destination
- Non-Dominant side for speech & language for most patients

\(^1\) Foreman et al; Clin Neurol Neurosurg. 2015
\(^2\) Kakarla et al; Neurosurgery 2008
Selection of the three levels of the critical points: entry point (a), tip of the catheter (b) and foramen of Monro (c)
## Complications Associated with EVD Placement

1. Hemorrhage
   Intracerebral hemorrhage, tract hematoma or tract hemorrhages (0-41%)

2. Infection (0-28% EVD)

3. Malposition

4. Occlusion and malfunction

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1. Lele et al; J Neurosurg Anesthesiol 2017
2. Miller C: J Neurosurg. 2017
Complications Associated with EVD Placement¹,²,³

5. Over Drainage of CSF

- Subdural or epidural hematoma
- Re-bleed from a ruptured cerebral aneurysm
- Intracranial hypotension
- Cerebellar tonsillar herniation
- Paradoxical herniation
- Pneumocephalus

¹ Lele et al; J Neurosurg Anesthesiol 2017
² Miller C: J Neurosurg. 2017
³ Niiumara et al; BMJ Case Rep. 2015
Complications Associated with EVD Placement$^{1,2,3}$

6. Iatrogenic vascular injury (arteriovenous fistula, cerebral pseudo aneurysm)

7. Fracture of catheters, with retained fragment of catheters

8. Inadvertent injections of drugs

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$^1$ Lele et al; J Neurosurg Anesthesiol 2017
$^2$ Miller C: J Neurosurg. 2017
$^3$ Niiumara et al; BMJ Case Rep. 2015
Complications with EVD Placement

Hemorrhage (1) along EVD (2) track
EVD System

Antimicrobial-impregnated EVD
Clindamycin and Rifampin

Non-antimicrobial impregnated EVD
EVD System

Antibiotic Impregnated EVD

35 cm catheter

Markings on EVD

Tip of EVD

Connection to collecting system

Proximal access port
EVD System
EVD System

1. Stopcock 1
2. Flushless transducer
3. Stopcock 2 (used to zero)
4. Stopcock 3 clamped to drain
5. EVD set at +10 cm H2O
6. Graduated drip chamber (burette) for collecting CSF
7. Stopcock 4 to stop flow of CSF in collection bag

CSF flow from patient

[Image of EVD system with numbered components]
EVD Setup

Leveling

External Auditory Meatus
EVD Setup

Carpenter’s Level
Bubble Level

Laser Level

Bubble
Laser

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SOCIETY FOR NEUROSCIENCE IN ANESTHESIOLOGY AND CRITICAL CARE
MICHIGAN MEDICINE
UNIVERSITY OF MICHIGAN
EVD Setup
Do not connect EVD system to a high pressure system such as pressure bag used for arterial or central venous catheter
Why Do We Need Guidelines?
51% of transports resulted in secondary insults

Commonest were Arterial Hypertension & Intracranial Hypertension
Outline

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• Pre-operative assessment of patients presenting for or with EVD

• To suggest management of patients with EVD in the perioperative setting including monitoring and CSF drainage
Pre-Operative Evaluation

• Inspection of EVD System

• Understanding Drain Dynamics

• ICP Waveforms

• Results of Clamp Trial
Understanding Drain Dynamics

- CSF drainage under controlled settings
- CSF drain volume goals <10-20ml/hr
- Setting of EVD depends on indication for its placement
- Aneurysmal SAH (typical EVD settings)¹,²
  - Pre Repair.: +20cm H₂O
  - Post Repair: +10cm H₂O

¹ Sakowitz et al; Neurosurg 2006
² Chung et al; Neurocrit Care 2017
Management of External Ventricular Drains After Subarachnoid Hemorrhage: A Multi-Institutional Survey

David Y. Chung¹ • Thabele M. Leslie-Mazwi¹ • Aman B. Patel² • Guy A. Rordorf¹

Neurocrit Care (2017) 26:356–361
ICP Waveforms

Normal ICP waveform

- P1
- P2
- P3

P1
Percussion wave ~ reflections off choroid plexus

P2
Tidal wave ~ brain compliance

P3
Dicrotic wave ~ aortic valve closure

Abnormal ICP waveform

- P1
- P2
- P3

P2 wave is taller than P1 wave ~ reduced cerebral compliance

Lele et al; J Neurosurg Anesthesiol 2017
Clamping Trials

• Tolerance to any period of clamping depends on:
  1. Indication for EVD placement
  2. ICP trends
  3. Dependency on external CSF diversion

• At Risk Patients:
  ➢ External CSF diversion dependency
  ➢ Elevated ICP
Risks of Routinely Clamping External Ventricular Drains for Intrahospital Transport in Neurocritically Ill Cerebrovascular Patients

Nophanan Chaikittisilpa¹,² · Abhijit V. Lele¹ · Vivian H. Lyons²,³ · Bala G. Nair¹ · Shu-Fang Newman¹ · Patricia A. Blissitt⁴ · Monica S. Vavilala¹,²

- 11.8% of patients with post-IHT ICP>20
- 18.5% of patients with escalation of ICP category

- **Risk Factors**
- Pre-IHT ICP>20, Therapeutic Procedures.
SNACC Guidelines Summary

• Thorough Pre-Op evaluation
• Inspection of EVD system
• ICP values, trends and other multimodal monitoring data
• Drain Dynamics
• Clamping Trials
• Standard pre-operative handoff between NICU and Anesthesia providers

1 Lele et al; J Neurosurg Anesthesiol 2017
Outline

• To understand the common indications & complications with extra-ventricular drain (EVD) placement

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Intra-Hospital Transport (IHT) of Patients with EVD
Intra-Hospital Transport (IHT) of Patients with EVD

- At risk for secondary insult from intracranial complications
- Change in patient position may lead to CSF over drainage
  - Rebleeding of Aneurysm
  - Subdural Hemorrhage
  - Paradoxical Brain Herniation
SNACC Guidelines Summary

1. EVD system Mounted on IV Pole
2. EVD Leveled at External Auditory Meatus
3. EVD clamped (proximal & distal)

Lele et al; J Neurosurg Anesthesiol 2017
Intraoperative Management of EVD
Intraoperative Management of EVD

1 Rosner et al; JNS 1986
2 Birch et al: Neurocrit Care 2006
3 Wilkinson et al; Neurosurgery 1986
Management of EVD in Special Scenarios

- Visual aids and labeling
- Accidentally disconnected EVD tubing should be clamped immediately
- All distal parts of device replaced with a new sterile tubing (Not the EVD catheter)
- Routine flushing of catheter should not be performed
- Notify neurosurgery team immediately if there is an accidental injection via EVD

Lele et al; JNA 2017
# Checklists

**TABLE 5. Perioperative Checklist for Patients With External Ventricular and Lumbar Drain**

**Preoperative assessment**
- Obtain baseline neurological examination
- Review EVD (cm H₂O) and LD setting (in mL/h of CSF drained)
- Review hourly CSF output to obtain baseline
- Review baseline ICP mm Hg, ICP trends, and available multimodal monitoring data
- Review baseline CSF color and consistency
- Review clamp trials data if available
- Review coagulopathy profile
- Review antibiotic plan if anticipating new EVD/LD insertion in the operating room
- Provide EVD and LD details during preoperative handoff between intensive care/ward providers and the anesthesia providers

**Transporting patients with EVD and LD**
- Confirm decision to travel with EVD or LD clamp vs. open
- If traveling with EVD clamp, ensure clamping at both proximal port on EVD and distal port on CSF collecting system
- Confirm HOB status during transport
- Confirm availability of dedicated intravenous pole for EVD/LD mount
- Confirm leveling EVD at external auditory meatus and LD at phlebostatic axis or at lumbar catheter insertion site
- Enable ICP monitoring during transport
- Confirm availability of medications needed to treat intracranial hypertension during transport

**Intraoperative management of indwelling drains**
- Prepare transducer cable
- Identify EVD/LD tubing by appropriate unique labeling
- Confirm HOB status during surgical procedure
- Confirm leveling of EVD at external auditory meatus and LD at phlebostatic axis
- Obtain ICP waveform and baseline ICP value
- Record q 1-h EVD/LD setting
- Record at least q 1-h ICP values (recorded with EVD closed to drain)
- Record at least q 1-h EVD/LD drain output (expressed in mL)
- Provide EVD and LD details during intraoperative handoffs between anesthesia providers

**Inform surgeon if any ≥ 1 of the following**
- Sudden decline in CSF drainage or no drainage from EVD or LD, or occlusion of EVD or LD
- If drain output is > 15-20 mL at any time or in any given hour
- Sudden change in CSF color
- Dampening or loss of ICP waveform
Educational Resources

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Society for Neuroscience in Anesthesiology and Critical Care

47th Annual Meeting
September 12-14, 2019
Arizona Grand Resort and Spa
Phoenix, Arizona

Save the Date!

EDUCATION CORNER

Article of the Month
The Role of Brain Vasculature in

SNACC NEWS

Call for Participants in the 2nd Annual SNACC Neuroscience Symposium - This year’s symposium entitled “Effects of Anesthetics on
Summary

• Common indications, contraindications and patient preparation for extra-ventricular drain (EVD) placement
• Pre-operative assessment & IHT of patients presenting for or with EVD
• Management of patients with EVD in the perioperative setting including monitoring and CSF drainage