All About Shunts

Mirna Giordano, MD

Disclosure

• I have no financial relationship or interest with any company producing health care products or services related to the content of this didactic session
• No discussion/reference of any commercial products or services will take place
• I do not intend to discuss an unapproved/investigative use of commercial products or devices
Workshop Objectives

- Review the CNS anatomy and the physiology of CSF production and flow
- Hydrocephalus - etiology, prevalence and treatment options
- Discuss how to confidently work up VPS patients for potential infection or malfunction
- Discuss common and rare signs and symptoms of increased ICP, HPI and Exam details
- Discuss cases that illustrate key learning points for the children with VPS
- Update on currently ongoing clinical research

All About Shunts

- 9:45-10:05  Mirna Giordano, MD
- 10:05-10:50  Hannah Goldstein, MD
- 10:50-11:10  Small group discussion I
- 11:10-11:20  Break
- 11:20-12:00  Tamara Simon, MD
- 12:00-12:20  Small group discussion II
- 12:20-12:30  Q&A
- 12:30-12:45  Evaluation and Feedback
Why this workshop?

- To share our **Story** of Co-management
- To **Promise** excellence in patient care
- To **Challenge** and **Inspire** others to share their stories to create good **Ripples**
- To create a new **Language** to power with, not over

**Part 1**

- Review CSF/Hydrocephalus History
- Review CSF composition and function
- Review CSF production and dynamics
Egyptians

• 1700 B.C.
• First written documentation of fluid within the human head

Our Father (460-375 B.C.)
CSF History

- **Hippocrates**
  - “water surrounding the brain”
  - Hydrocephalus - "too much water in the head"
  - Performed punctures - unclear what was punctured exactly

- **Herophilus**
  - first one to describe the choroid plexus "chorioid mennix", given similar vascularity to fetal choroid
Galen (130-200) of Pergamon

- “Excremental fluid in ventricles of brain”
- Hydrocephalus - extra axial accumulation
- Soul was contained in ventricles and helped purification of the waste into the pineal gland
- CSF - sacred role - alchemy of **vital spirit/blood** becoming **animal spirit/CSF**
- This belief lasted for over 1500 years
• Trephination with twisted bark – Greeks
• South America - Andean and pre-Incan cultures
• Mexico, Guatemala and the Yucatan Peninsula (950 -1400)
Dark Middle Ages

- Abul Qasim Al Zahrawi (Abulcasis) – diagnosis and treatment of hydrocephalus
- No NEW details – **Status Quo** – 1200 years
LA CHIRURGIE
D'AREGAIN

100 Images

ÉDITÉES AVEC PRÉCISION

1840

F. PÉRIGOIS

DR. AREGAIN

IMPRIMERIE DE M. JAN

1840
Vesalius (1514-1564)

• *Vesalius* “the water had **not** collected between the skull and brain’s outer membrane, but within the ventricles of the brain”

• Agreed with Galen that CSF was “**Spiritus Animalis**”

CSF/Hydrocephalus History

• **Swedenborg** (1688-1772) - mining engineer looking for a source of a soul, “spirituous lymph” or “highly gifted juice”

• **Cotugno** 1774 - “water in the labyrinth”, got fluid from the ventricles with percutaneous aspiration
CSF/Hydrocephalus History

• **Thomas Willis** (1621-1675) suggests choroid plexus produces CSF, first to disagree with the idea of ventricles holding the vapor during the life, that condensed after death

• Found out that clearly brain liquid is “altered in meningitis”

CSF/Hydrocephalus History

• **Pacchioni**, 1701 - described **arachnoid granulations**, but believed they produce CSF

• **Morgagni**, 1761- described HC with myelomeningocele

• **Monro** – Foramina of paired system
CSF / Hydrocephalus History

- **Magenide** 1783-1855, Medial cerebellar foramen, CSF flow
- **Mestrezat** 1883-1928, described accurate CSF chemical composition
- **Luschka** 1859, followed with foramina
- Harvey **Cushing** 1869-1939, proved that CSF made in choroid plexus

CSF

- Extensively analyzed, yet roles still unfolding
- **Buoyancy** - Ultra filtrate of blood that cushions the brain, but not only
- **Clears Waste** - Facilitates removal of metabolites
- **Medium/ Niche** - Creates proper environment for neurological processes
Choroid plexus

- Highly vascularized secretory epithelium
- Forms soon after anterior neural tube closure
- Consists of tufts of capillaries, endothelial cells covered with ependymal cells and bulbous microvilli
CP-CSF

- Choroid plexus - CSF (eCSF, fCSF, aCSF) now claims much more active role in the development, homeostasis and repair of the CNS.
- CP viewed as a nursery for neuronal and astrocytic progenitor cells - so hides potential for ischemic and traumatic brain injury novel therapies.

### Composition of CSF

<table>
<thead>
<tr>
<th>Substance</th>
<th>Plasma (mg/dl)</th>
<th>CSF (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>145.0</td>
<td>150.0</td>
</tr>
<tr>
<td>K⁺</td>
<td>4.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>5.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>1.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>108.0</td>
<td>130.0</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>27.4</td>
<td>21.0</td>
</tr>
<tr>
<td>Lactate</td>
<td>7.9</td>
<td>2.6</td>
</tr>
<tr>
<td>PO₄³⁻</td>
<td>1.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Protein</td>
<td>7000.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Glucose</td>
<td>95.0</td>
<td>60.0</td>
</tr>
</tbody>
</table>

(protein and glucose expressed as mg/100 ml)
CSF

• Human embryonic CSF (eCSF) – in astonishingly huge spaces has a crucial niche - bathing role
• CSF contacts every single neural stem cell
• Gives cues, instructions, information on the neural cell proliferation, differentiation and maturation

CSF

• Sleep/Wake - orexin/hypocretin, melatonin
• Appetite - leptin, insulin
• Brain injury/Repair - augurin, IGF 1,2
• Sonic hedgehog (Shh) signaling - stimulates choroid plexus pericytes to grow
• Retinoic acid - key long range signaling
• Wnt signaling - regulates early neurogenesis
CSF Flow

• Arterial pulsations in the choroid plexus

• Hydrostatic pressure gradient

• Ciliary movement of ependymal cells lining ventricles
Hydrocephalus

What is it?
• Abnormal collection of CSF within the brain

What causes it?
• Blockage of flow
• Overproduction
• Inadequate reabsorption
Hydrocephalus: a common problem

- Incidence: 0.7 to 1.0 per 1,000 live births in the US
  - This number only reflects children born with hydrocephalus
- Prevalence: 0.8-1.5% of the population
- Incidence higher in developing world
  - Nutritional causes
  - Higher incidence of infant meningitis
- The most common problem encountered by pediatric neurosurgeons
- Will be seen by EVERY pediatrician

Hydrocephalus: Etiology

- Obstruction (blockage of flow)
  - Intraventricular hemorrhage causing clotting of the ventricles
  - Tumors
  - Aqueductal stenosis and other structural malformations
- Overproduction
  - Choroid plexus papilloma
- Impaired reabsorption
  - Scarring at the arachnoid granulations
    - Hemorrhage
    - Infection
    - Trauma
  - Repaired myelomeningocele
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Hydrocephalus: etiology

- Congenital (38%)
- Congenital with myelomeningocele 29%
- Perinatal hemorrhages 11%
- Trauma/SAH 4.7%
- Brain tumor 11%
- Previous infections 7.6%
Hydrocephalus: Treatment Options

• Treat the underlying cause (if possible)
• Temporizing measures
  – External ventricular drains
  – Subgaleal shunts
• Shunts (V-P, V-A, V-other)
• Endoscopic third ventriculostomy +/- choroid plexus cauterization

ETV: Endoscopic Third Ventriculostomy
ETV: Endoscopic Third Ventriculostomy

Shunts

- 1952, CHOP - Nulsen and Spitz with John Holter, father of a child with MMC – developed ventriculo jugular shunt with spring and ball valve made of silicone
- Today, dozens of options for shunts, with programmable and non-programmable valves
- VPS, VAS, V-other-S, Spinal- peritoneal shunts
- Placement with endoscope, stereotactic guidance
Ventriculo-peritoneal Shunts (VPS)

- Device that diverts CSF from the ventricles to the abdominal cavity
- Pressure or flow regulated one-way valve
  - May be programmable
VPS: a solution, but also a problem

- VPS break, get clogged, and get infected
- 50% of patients will require a shunt revision
  - Many more than once
  - Higher rate for children <6 months
  - Higher rate for certain etiologies
  - Greatest risk of infection within the first 3 months of placement
- Shunt failure/revision is associated with negative developmental outcomes
VPS: solutions to the problem?

- Research to try to understand risk factors in VPS malfunction and infection
- How to prevent?
- How to best treat?
- Solutions:
  -- avoid placing them (ETV, choroid plexus cauterization)
  -- construct a better shunt
  -- better understand CSF complications

VPS Malfunctions

- Extreme clinical vigilance
- Blocked shunt is potentially life threatening
- Of utmost importance for pediatricians to understand key principles when assessing these patients
- Obstruction, breakage, migration or infection
  -- the most common culprits
VPS patient

- Clinical presentation of shunt malfunction/infection – highly variable
- Proximal malfunction most common in <2yrs age, or within 2 years of shunt placement
- Distal obstruction or break more common in long standing shunts
- Evaluation may be a challenge, so pediatricians heavily rely on neuroimaging and NSG

Shunt malfunction?!? The initial evaluation

- HPI
- Exam
- Shunt investigation
- Image
- Shunt tap
- Surgical exploration
- Shunt Revision/Removal
Shunt Malfunction: HPI

- History of the present illness
  - Signs/symptoms depend on age
  - Duration of symptoms (acute/subacute/chronic)
  - Sick contacts

- **Neuro Baseline**

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Signs and symptoms

- Bulging anterior fontanelle
- Rapid increase in HC
- Sunsetting
- Irritability
- Lethargy
- Headaches
- Vomiting
- Worsening vision
- Decreased school performance
- Behavioral changes
- Papilledema
- CN III, VI, VI palsies
- Cushing’s triad: hypertension, bradycardia, irregular respirations
Shunt History

- Indication for Shunt: hydrocephalus (etiology, age, pathology, treatment, imaging)
- Type of Shunt
- Dates of insertions and revisions
- Hx of malfunction
- Hx of infection
- Symptoms with prior malfunctions (mom knows best)

Shunt malfunction: Physical Exam

- Vital signs (Cushing’s triad?)
- Mental status; level of arousal/lethargy/irritability
- Cranial nerves (Upgaze palsy, CN 6 palsy, Papilledema)
- Coordination/gait; reflexes
- Other illness (gastroenteritis, URIs, otitis, appendicitis)
- Abdominal tenderness/distention
- Skin
- Valve inspection
- Shunt tract exam: fluid collections, erythema or discontinuation or protrusions
- **Neuro baseline**
Shunt malfunction: Imaging

- Shunt series
- Cranial imaging
  - Head ultrasound
  - Non-contrast head CT
  - MRI (T2 volumetric)
    - Expediency
    - Comparison is key
- Tc99 Shuntograms
- Further abdominal imaging

Shunt Series

- AP and lateral plain X-rays of the entire length of VPS (skull, chest and abdomen)
- Demonstrate: catheter fracture, catheter disconnection, calcification, or distal tip migration
- Poor sensitivity 4-26%
- High specificity 92-98% for shunt malfunction
- Important to know shunt revision history
Shunt breaks
Broken shunt?

No – old retained catheter

YES!
Cranial Imaging: What to look for

- Alterations in ventricle size – comparison is key!
- Cortical sulci effacement
- Loss of the basal cistern
- Periventricular edema
- Slit like ventricles
- Subdural hematomas or hygromas
- Proximal catheter migrations
- “Stiff” ventricles/scarring of ventricular walls
- **Comparison is key**

Head CT

- Sensitivity 53-92%
- Specificity 76-93% for detecting shunt malfunction
- Experienced parent = Head CT; study in which parents had 89% sensitivity and 62% specificity for shunt malfunction
Radiation exposure

- Ionizing radiation
- Shuntogram > CT > Shunt series
- 2-3 CT scans per year of life
- 40% > 5 CT scans
- 15% > 15 CT scans
- Cumulative effective dose difficult to predict: age, scanner settings and acquisition software
- Risk for cancer 1:97 standard, 1:130 low dose

Rapid Brain MRI

- Radiation sparing
- Long, loud experience with at times need for sedation because of motion artifacts
- Rapid or ultra fast sequence protocols, single volumetric sequence (<10 min)
- Sensitivity 51-59% and specificity of 89-93% and accuracy 82-84% of confirmed VPS malfunction
- Risk for programmable shunts, nearly 27% had shunt valves accidentally reset by MRI – must be checked
- <1% needs sedation
Which scans represent shunt malfunctions?

ALL OF THEM!
Shunt tap

• Always by NSG
• CSF inspection (cell count, glucose and protein)
• Cultures and sensitivities
• Risk of precipitating malfxn or seeding infxn
• Decision to revise or remove – if highly suspicious for infection

Shunt malfunction: Call to neurosurgery

• Basic HPI
• Shunt history
• Other explanations for current presentation?
• Neuro exam
• Acuity
Pediatric Hospital Medicine meeting
All About Shunts

Update on clinical and translational CSF shunt research

July 21, 2017  Tamara D. Simon, MD, MSPH
Division of General Pediatrics and Hospital Medicine
Department of Pediatrics

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Objectives

- Outline current research efforts underway to:
  - understand risk factors for CSF shunt infections
  - prevent CSF shunt infections
  - treat CSF shunt infections

The new problem

- CSF shunts have complications
  - They fail
  - They get infected
The new problem


Possible solutions

- Avoid placing a CSF shunt
- Construct a better CSF shunt
- Better understand CSF shunt complications
Possible solutions

- Avoid placing a shunt
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2012 MacArthur Fellow: Ben Warf

ETV with choroid plexus cauterization

Increasing number of cases of ETV with choroid plexus cauterization in the Hydrocephalus Clinical Research Network

Possible solutions

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  - Apply known best practices
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  - Investigate treatment approaches
  - Think creatively about new paradigms
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Solutions for Patient Safety (SPS)

- Ohio Children’s Hospital Solutions for Patient Safety (OCHSPS)
- Eight children’s hospitals
  - Agreed to not compete on safety
  - Collaborated on defining public reporting
- National expansion
  - CMS funded Hospital Engagement Network
  - Currently >80 hospitals
SPS Surgical Site Infection (SSI) Prevention

- Focus on neurosurgical shunts as one of three high-risk procedures
- Based on National Healthcare Safety Network definitions
  - ICD-9 code vs manual review
  - Superficial SSI (30 days)
  - Deep incisional SSI (Δ 365 to 90 days on 1/1/13)
  - Organ space SSI (Δ 365 to 90 days on 1/1/13)
  - Meningitis (365 days)
- Monthly reporting
  - SSI rate for three procedures
  - Process adherence for bundle
SPS Surgical Site Infection (SSI) Prevention

- **Standard SSI Prevention Bundle**
  - Previously recommended only, hospitals implemented what they want/can
  - As of 7/1/14 some required and some recommended
- **Required**
  - Preoperative bath
  - No razor for hair removal
  - Antibiotic timing (pre-incision)
- **Recommended**
  - Skin prep
  - Antibiotic redosing
Change in duration of deep incisional/organ space SSI surveillance

Bundle components become required
Data coordinating center in SLC
14 clinical sites each with HCRN Investigator(s) and Research Coordinator

HCRN consensus definition

- Shunt infection defined as:
  - Positive bacterial culture or gram stain of:
    - CSF
    - Wound swab
    - Pseudocyst fluid or
  - Shunt erosion (visible hardware) or
  - Abdominal pseudocyst
  - Positive bacterial blood culture in those with a ventriculoatrial shunt
- 6 month follow-up

Hydrocephalus Clinical Research Network (HCRN) quality improvement effort to reduce infections

Original protocol:
Intrathecal antibiotics

Mean monthly shunt infection rate before and after protocol implementation.

Mean monthly shunt infection rate before and after protocol implementation.

Hydrocephalus Clinical Research Network (HCRN) quality improvement effort to reduce infections

Original protocol: Intrathecal antibiotics

Updated protocol: Antibiotic impregnated catheter

No change in infection rates

Possible solutions

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Hydrocephalus Clinical Research Network (HCRN) quality improvement effort to reduce infections

Original protocol: Intrathecal antibiotics

Updated protocol: Antibiotic impregnated catheter

No change in infection rates


Antibiotic impregnated catheters vs. intrathecal antibiotics (vs. neither)

- Efficacy, complications, antimicrobial resistance, and costs
  - PHIS+
  - 2007 to 2012
  - 6 children’s hospitals inpatient data
  - R-01 resubmission

Hydrocephalus Clinical Research Network (HCRN) quality improvement effort to reduce infections

Antibiotic impregnated catheter

Antibiotic impregnated catheters

- Efficacy in infection prevention compared to prophylactic IV antibiotics alone
  - Pedsnet
  - All shunt surgeries from 1/1/09 on
  - 8 participating hospitals
  - Pilot project
  - R-01 submission
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Infection treatment

- Surgical treatment: two surgeries
  - Full removal and external ventricular drain placement, followed by new shunt placement or
  - Externalization, followed by reinternalization or new shunt placement
- Medical treatment: prolonged inpatient antibiotics (usually 10-14 days)
  - Organism recovered in CSF
  - Usually *Staphylococcus epidermidis* or *Staphylococcus aureus*
- Reinfection rates of 20-26%

Risk factors for reinfection

- Developed an extensive dataset from a single center
  - 118 children with infection
  - 1/1/97-6/28/10
  - 31 reinfections

- Developed similar dataset from HCRN registry
  - 233 children with infection
  - 4/1/08-12/31/12
  - 38 reinfections
### Patient factors for reinfection

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Single center Hazard ratio (95% confidence intervals)</th>
<th>Multi-center Hazard ratio (95% confidence intervals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial shunt: complex</td>
<td>7.7 (1.2, 28.1)</td>
<td>1.9 (0.6, 6.3)*</td>
</tr>
<tr>
<td>Initial shunt: atrial</td>
<td>4.0 (1.3, 10.0)</td>
<td>1.9 (0.6, 6.3)*</td>
</tr>
<tr>
<td>Any complication after first infection</td>
<td>3.1 (1.2, 7.0)</td>
<td>Not tested</td>
</tr>
<tr>
<td>Intermittent negative CSF cultures</td>
<td>3.2 (1.3, 7.0)</td>
<td>Not tested</td>
</tr>
<tr>
<td>Surgical approach other than removal</td>
<td>Not tested</td>
<td>3.2 (0.8, 11.7)</td>
</tr>
<tr>
<td>Overall IV antibiotic duration</td>
<td>Not tested</td>
<td>Not significant</td>
</tr>
<tr>
<td>No rifampin use</td>
<td>Not tested</td>
<td>7.9 (1.1, 173.1)</td>
</tr>
</tbody>
</table>

### IDSA guidelines in 2004

<table>
<thead>
<tr>
<th>Organism/CSF findings</th>
<th>Recommended duration of antibiotic treatment</th>
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</thead>
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<tr>
<td>Coagulase negative Staphylococcus, normal CSF:</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>3 days of negative cultures</td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>10 days of negative cultures</td>
</tr>
<tr>
<td>Coagulase negative Staphylococcus, abnormal CSF:</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>7 days of negative cultures</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>10 days of negative cultures</td>
</tr>
<tr>
<td>Other gram-positive organisms</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>7 days of negative cultures</td>
</tr>
<tr>
<td>Gram negative bacilli</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>10 days of negative cultures</td>
</tr>
<tr>
<td>Yeast</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
<td>10 days of negative cultures</td>
</tr>
<tr>
<td>No Growth, normal CSF</td>
<td></td>
</tr>
<tr>
<td>No culture (+) after shunt removed</td>
<td></td>
</tr>
<tr>
<td>Culture (+) after shunt removed</td>
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Adapted from Tunkel, et al. Practice Guidelines for the management of bacterial meningitis. CID 2004;39:1267-84

Possible solutions

- Avoid placing a CSF shunt
- Construct a better CSF shunt
- Better understand CSF shunt complications
  - Apply known best practices
  - Investigate prevention approaches
  - Investigate treatment approaches
  - Think creatively about new paradigms
New Paradigm?

- Chronic or recurrent nature of CSF shunt infection
- Critical role of revision surgeries
- Minimal contribution of patient or treatment factors

- Role of microbial environment in infection
New Paradigm?

- Chronic or recurrent nature of CSF shunt infection
- Critical role of revision surgeries
- Minimal contribution of patient or treatment factors
- Role of microbial environment in infection
  - Common pathogens are *S. epidermidis* and *S. aureus*

- Biofilm producers
Detour: biofilm production

- Complex, adherent assemblages of numerous microbes
- Responsible for many persistent and chronic infections and in medical device infections


Detour: biofilm production

- Complex, adherent assemblages of numerous microbes on the shunt catheter surface
- Responsible for many persistent and chronic infections and in medical device infections including shunt infections

Visualization of S. aureus biofilm growth on explanted catheters. Catheters were removed 10 days post-infection and visualized with scanning electron microscopy. While some biofilm disruption occurred following catheter removal and processing, a large portion of the catheter surface is covered with bacteria (A; 200 magnification). Higher magnification of this area shows bacteria adhering to the catheter surface (white arrows) as well as white blood cells (*) (B; 3,000 magnification).

Snowden lab: Mouse model of CNS catheter-associated infection

• Demonstrates persistent catheter associated infection with S. aureus and S. epidermidis.
• Allows investigation of bacterial and immunologic factors involved in pathogenesis of shunt infections, as well as neurologic outcomes, in adult and infant hosts.

Snowden et al, 2012, Infection and Immunity

Snowden lab: Clinical implications from mouse models

• Biofilm infections persist much longer and at higher levels than abscesses:
  • Highlights the need for device removal in most cases, as infection is likely to persist.
• Biofilm infections are less inflammatory than abscess or other non-biofilm infections:
  • We may need a lower threshold of diagnosis, in terms of inflammatory markers such as pleocytosis, fever, or elevated C-reactive protein, in order to diagnose biofilm infections.
Detour: biofilm production

• Complex, adherent assemblages of numerous microbes on the shunt catheter surface
• Responsible for many persistent and chronic infections and in medical device infections including shunt infections
• Biofilm-dwelling bacteria grown in vitro exist in a largely dormant antibiotic-resistant mode
• Biofilm persistence may necessitate removal of shunt and replacement in a different tract


New Paradigm?

• Chronic or recurrent nature of CSF shunt infection
• Critical role of revision surgeries
• Minimal contribution of patient or treatment factors
• Role of microbial environment in infection
  • Common pathogens are *S. epidermidis* and *S. aureus*
  • Biofilm producers
  • Biofilm is present in shunt infection
Detour: microbiota

- Conventional culture techniques
  - designed to detect free-floating clonal populations of individual microbial species during logarithmic growth phase
  - therefore may not detect organisms in infectious biofilms


Detour: microbiota

- High throughput sequencing is a culture-independent molecular approach to characterizing the microbiota
- Identified the bacterial and fungal DNA present in first CSF sample from 8 children with CSF shunt infection
Detour: microbiota

- CSF microbiota analyses for all eight infections identified
  - a variety of bacterial DNA, most of which did not grow in conventional culture
  - a variety of fungal DNA, none of which grew in conventional culture (not tested)
  - at least one bacterial taxon in conventional culture
New Paradigm?

- Chronic or recurrent nature of CSF shunt infection
- Critical role of revision surgeries
- Minimal contribution of patient or treatment factors
- Role of microbial environment in infection
  - Common pathogens are *S. epidermidis* and *S. aureus*
  - Biofilm producers
  - Biofilm is present in shunt infection
  - Microbiota is present in shunt infection

Does the microbial environment play a role before infection?
Stay tuned for more!

- Avoid placing a CSF shunt
- Construct a better CSF shunt
- Better understand CSF shunt complications
  - Apply known best practices
  - Investigate prevention approaches
  - Investigate treatment approaches
  - Think creatively about new paradigms
Thanks

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Thanks

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<td>Nicole Hamblett</td>
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[Sebastian Children’s Hospital, Research Foundation] [UW Medicine, School of Medicine]