1	and/or	nunt infection by Emergency Department physician based on presence of ≥ 1 risk factors for shunt infection ¹	dinical judgment	¹ Risk Factors for Shunt Infection
	Exclusion	Criteria: alternative source for fever identified		Shunt
	Notify Neuros	urgery attending at first suspicion of shunt infection		surgery
	Noury Neuros	TRIAGE:		within
• Vi	ital signs a1hr then a2hr when more	stable: temperature, BP, HR, RR, O2 sat, neuro check		previous 6
	/eight, head circumference (for <12			months
	lace on continuous CR monitoring	,		Clinical signs
		immediately if bradycardia, hypertension or depressed LOC	is noted*	ofinfection
	Obtain	detailed history/initial exam: See Appendix A.		involving shunt
		*		hardware
		INITIAL MANAGEMENT:		including
Labs:				skin erosion,
		tonin, blood culture, UA, urine culture		cellulitis,
	hunt tap by NSG: send STAT CSF for o	ell count, glucose, protein, gram stain, aerobic culture and a	naerobic culture	incisional
Imaging:	- I I - I	han the state of the second of the second state of	and the second	drainage or
		hout contrast is preferred if imaging modality if confirmation		abdominal
	hunt Valves)	ted in chart, may confirm via skull x-ray; Appendix B: Radiog	raphic Appearance of	pseudocyst
0	,	t: prior to ordering MRI, please ensure a Neurosurgery provi	der is able to reprogram	 Clinical signs
0		ging. Make MRI aware that patient has a programmable shu		ofmeningiti
0				 No other
		abdominal symptoms: limited ultrasound of abdomen		obvious
	large or complex pseudocyst of t			source of
Antibiotics a				fever
		ter obtaining blood culture, UA/urine culture, and CSF cultur	e, if possible:	 Previous
0		divided q8hr (max 2 g/dose) <u>AND</u>		shunt
0		[‡] /about <3 mo old: 15 mg/kg q8hr or as determined by phar	macy based on estimated	infection
Ĭ		months old – 11 years old: 70 mg/kg/day div q6hr; \geq 12 yrs o		L
• N		th 0.45 or 0.9% NaCl depending on serum Na levels)	0 0 ··· / ··· 10	
	Menstrual Age) = gestational age + p			
		•	_ /	
	Pre-0	<u>Op:</u> Admit to PICU on Neurosurgery service		ney Injury (AKI) based on the
	OR case reque	est for externalization (Neurosurgery to obtain consent for O		wing criteria: a creatinine by 1.5-1.9 times
		R monitoring (close monitoring for bradycardia)	baseline within th	ne priorseven days, or
	Continue NPC			creatinine by ≥0.3 mg/dL from
		Post-Op: admit back to PICU	For those with un	ncmol/L) within 48 hours, or Iknown creatin in e, an eGFR <90
	EVD/external	zed shunt parameters per surgeon; follow post-op care belo	W ml/min/1.73m ²	
			\	
×	×	×	×	×
ntibiotics	Labs/Monitoring	Pain/Fever	FEN/GI	Other
			PEN/GI	Other
¥ I				V
¥	Labs:	If acute kidney injury ² : Avoid NSAIDs or discuss with	IVF:	
	 CSF studies: cell count and 	Nephrology for approval.	IVF: • Maintenance IVF	OT/PT: activity f
ectious	 CSF studies: cell count and culture to lab per 	Nephrology for approval. • Toradol N 0.5 mg/kg/dose q6hr (max 30 mg/dose)	IVF: • Maintenance IVF • NS 1:1 replacement	OT/PT: activity include OOB with
ectious ease (ID)	 CSF studies: cell count and culture to lab per Neurosurgery and/or ID 	 Nephrology for approval. Toradol N 0.5 mg/kg/dose q6hr (max 30 mg/dose) x6 doses 	 IVF: Maintenance IVF NS 1:1 replacement with CSF output 	OT/PT: activity include OOB wit EVD clamped for
ectious sease (ID) ntinue empiric	 CSF studies: cell count and culture to lab per Neurosurgery and/or ID If CSF culture positive, repeat 	 Nephrology for approval. Toradol IV 0.5 mg/kg/dose q6hr (max 30 mg/dose) x6 doses 6 hours after last toradol dose, start 	IVF: • Maintenance IVF • NS 1:1 replacement with CSF output Medications:	OT/PT: activity include OOB wi EVD clamped fo therapies if stab
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ectious tease (ID) ntinue empiric tibiotics ancomycin d Ceftazidime) 4 hours or per	 CSF studies: cell count and culture to lab per Neurosurgery and/or ID If CSF culture positive, repeat in 24-36 hours to document sterilization. If persistently febrile or clinica deterioration: repeat CSF 	 Nephrology for approval. Toradol IV 0.5 mg/kg/dose q6hr (max 30 mg/dose) x6 doses 6 hours after last toradol dose, start ibuprofen PO 10 mg/kg/dose q6hr PRN (max 40 mg/kg/day or 2,400 mg/day, whichever is less) Acetaminophen IV 15 mg/kg/dose q6hr ATC for 24 	IVF: Maintenance IVF NS 1:1 replacement with CSF output Medications: Ondansetron 0.1 mg/kg/dose q8hr (max 4 mg/dose) PRN nausea/	 OT/PT: activity include OOB will EVD clamped for therapies if stat and tolerating clamping SCD/compressit boots for DVT p
ectious sease (ID) ntinue empiric tibiotics ancomycin d Ceftazidime) 4 hours or per recs	 CSF studies: cell count and culture to lab per Neurosurgery and/or ID If CSF culture positive, repeat in 24-36 hours to document sterilization. If persistently febrile or clinica deterioration: repeat CSF culture is warranted. Consider 	 Nephrology for approval. Toradol IV 0.5 mg/kg/dose q6hr (max 30 mg/dose) x6 doses 6 hours after last toradol dose, start ibuprofen PO 10 mg/kg/dose q6hr PRN (max 40 mg/kg/day or 2,400 mg/day, whichever is less) Acetaminophen IV 15 mg/kg/dose q6hr ATC for 24 hours (max 1,000 mg/dose) 	IVF: Maintenance IVF NS 1:1 replacement with CSF output Medications: Ondansetron 0.1 mg/kg/dose q8hr (max 4 mg/dose) PRN nausea/ vomiting	 OT/PT: activity include OOB will EVD clamped for therapies if state and tolerating clamping SCD/compression boots for DVT p per hospital pol
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Important factors to consider include:

- Shunt Type:
 - o ventricular-atrial shunt
 - o ventricular-plural shunt
 - ventricular-peritoneal shunt
- Headache History:
 - o location
 - o quality
 - o duration
 - o **treatment**
- Vomiting History:
 - o timing
 - o any precipitating events
- Neurological symptoms:
 - o change in LOC
 - ↑ irritability
 - o weakness
 - o seizures
 - o up/downward gaze
 - ↑ lethargy

Abdominal symptoms:

- significant ↑ abdominal girth
- o pain
- o tenderness
- o mass
- General:
 - o **trauma**
 - o fontanels
 - head circumference
 - $\circ \downarrow$ breath sounds for pleural shunts





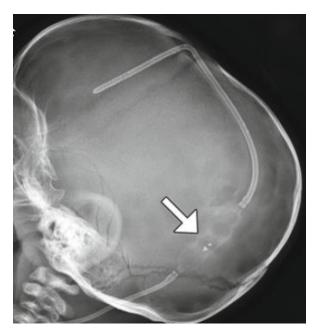
When evaluating the radiographic markings of any implanted device, it is important to recognize that the veracity of your interpretation depends on the quality of the radiographic images. For the best results, x-rays should be taken orthogonally to the plane of the shunt valve. The positioning of the valve relative to the skull base may also obscure the valve markings, as overlapping radiodensities along the skull base can blur valve markings. In more difficult cases, fluoroscopy or 3D CT reconstruction may be used to properly identify the radio-opaque markings on a shunt valve.

It is important to realize that an exhaustive list of all shunt valve radiographic markings is beyond the scope of this appendix. For additional information regarding common shunt valve markings found in North American neurosurgical patients, you may also reference the <u>ISPN's website</u> on the same topic.

Please see the next several pages for examples of radiographic images of nonprogrammable and programmable shunts. The sources of these images are:

- <u>http://www.kinderneurochirurgie-leipzig.de/therapeuticfocus/hydrocephalus/radiologic-identification-of-vp-shunt-valves-and-adjustment/</u>
- <u>https://www.ispn.guide/</u>
- https://www.medtronic.com/us-en/index.html
- <u>https://radiopaedia.org/</u>

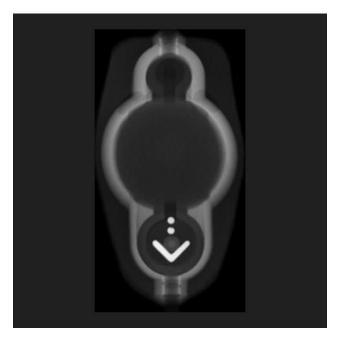
Non-Programmable Valve Examples:



Medtronic Delta Fixed Pressure Valve







Medtronic PS Medical Pressure Differential Valve (non-programmable)



Spitz-Holter Non-Programmable Valve





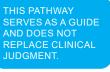
CLINICAL PATHWAY: Suspected Neurosurgical Shunt Infection Appendix B: Radiographic Appearance of Shunt Valves

Integra Omni Shunt Fixed Pressure Valve



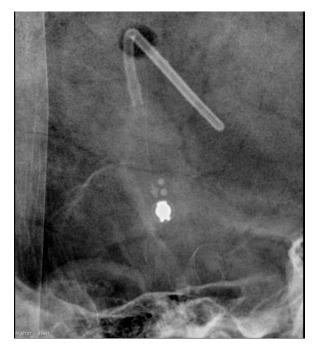
Integra DP Fixed Pressure Valve



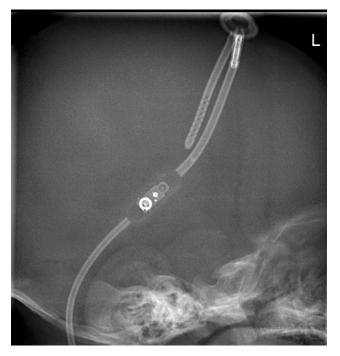




Programmable Valve Examples:



Strata Programmable Valve



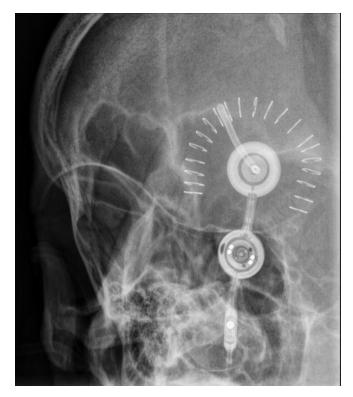
Codman Hakim Programmable Shunt Valve



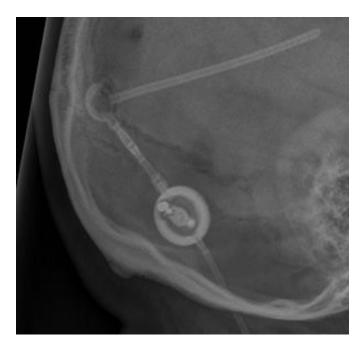


CLINICAL PATHWAY: Suspected Neurosurgical Shunt Infection Appendix B: Radiographic Appearance of Shunt Valves

THIS PATHWAY SERVES AS A GUIDE AND DOES NOT REPLACE CLINICAL JUDGMENT.



Unidentified Programmable Valve (likely Sophysa model)



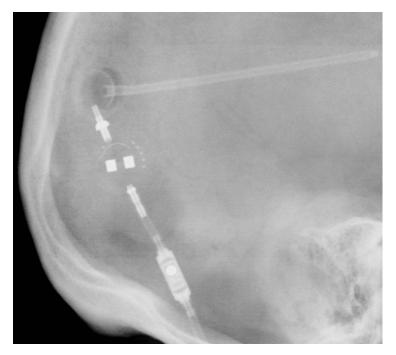
ProGrav Adjustable Valve

RETURN TO THE BEGINNING

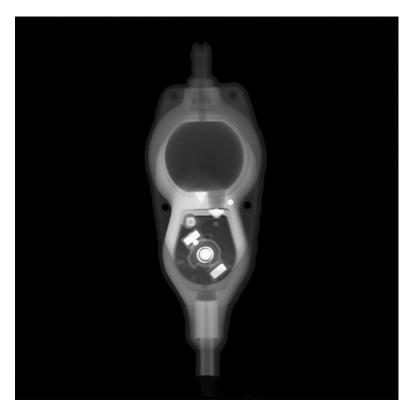


CLINICAL PATHWAY: Suspected Neurosurgical Shunt Infection Appendix B: Radiographic Appearance of Shunt Valves

THIS PATHWAY SERVES AS A GUIDE AND DOES NOT REPLACE CLINICAL JUDGMENT.



Sophysa Programmable Valve



Certas Programmable Valve

RETURN TO THE BEGINNING

CONTACTS: JONATHAN MARTIN, MD | PETRONELLA STOLTZ, APRN



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