Spontaneous Intracranial Hemorrhage (ICH)

Supportive Care

- HOB 30 degrees
- Place on CR monitor
- Maintain euglycemia
- Maintain euvolemia, HGB >8g/dl
- Maintain normonatremia
- MAP goals: normotensive until source of bleed secured
- Active temperature management (see protocol)
- NPO
- Neuro checks Q1 hour

Seizure Medications

Seizure PPX:
- Keppra load 40mg/kg (max 2gm)
- Keppra maintenance 40mg/kg/day divided BID (max 2gm)

Seizure Tx:
- Ativan 0.1 mg/kg (max 2mg) x2
- Load Fosphenytoin 20mg/kg (max 1.5g)
- Start Fosphenytoin maintenance 5 mg/kg/d div BID (max 400mg/d)

Other Medications

DO NOT RECOMMEND THE USE OF DEXAMTHESONE (1)

Fever:
- Acetaminophen 15 mg/kg/dose Q4 hrs PRN T > 37.5 then see active temp management protocol

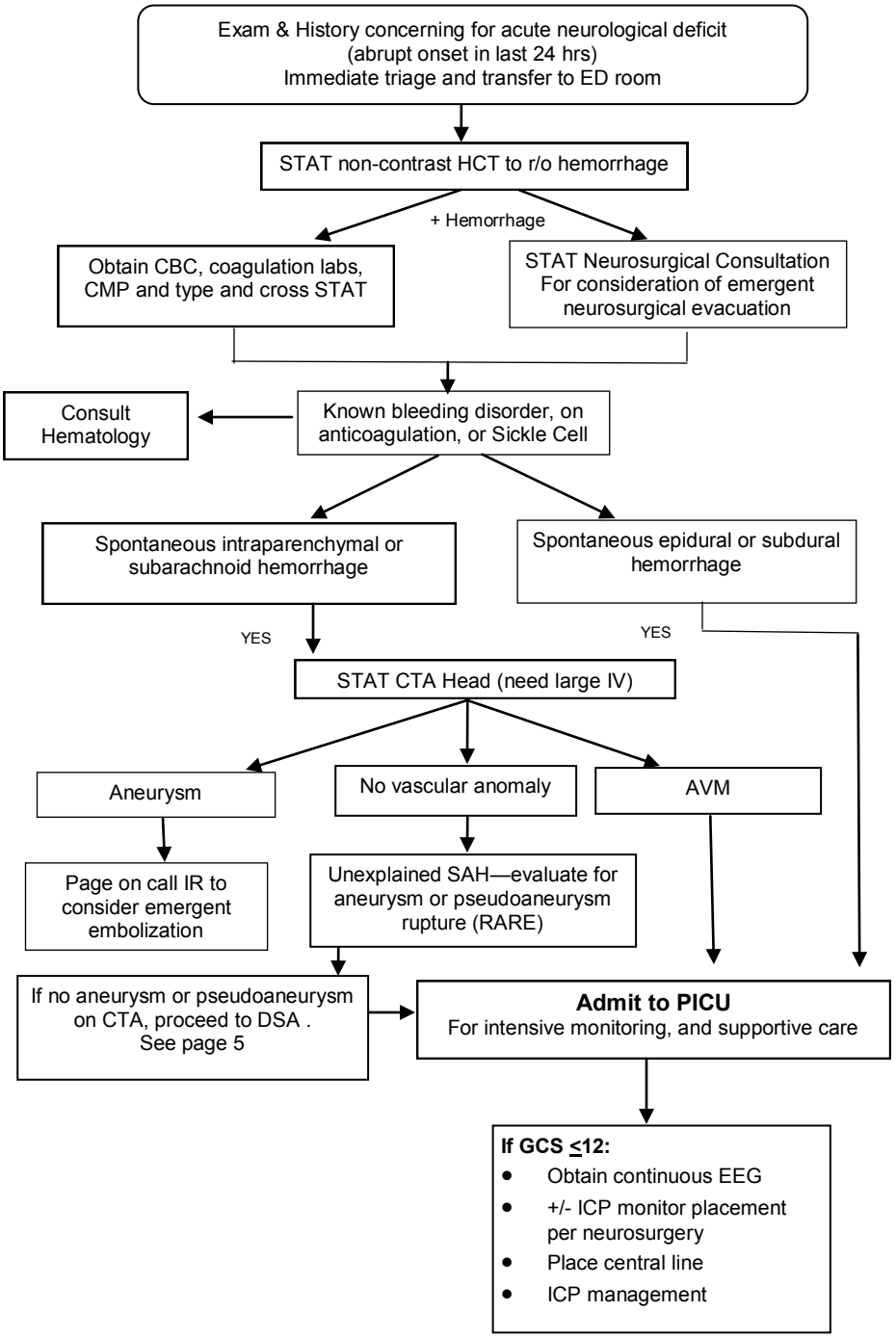
Increased ICP
- 3% NS bolus 5ml/kg (max 250 ml) then refer to ICP management protocol
- Mannitol 0.5g/kg

GI prophylaxis and bowel regimen
- Ranitidine 1 mg/kg/dose TID
- Miralax 17g daily once taking PO

Hemodynamics
- IVF (1st line) goal CVP 5-10 mmHg
  - if < 6 mos, use D5NS for maintenance IVF
  - if > 6 mos, use NS for maintenance IVF
- inotrope/vasopressors once intravascular volume restored and Hgb > 8

Nursing Care

- HOB 30 degrees
- Bed rest (Fall precautions)
- Specialty bed for Braden Q score <16
- Q1 hr neurochecks
- NPO, once cleared for PO, bed side assessment for swallow fxn
- Call MD for BP < goal
- Call MD for new or worsening deficits



Age	Neonate	1-2 yrs	3-4 yrs	5-6 yrs	7-8 yrs	9-10 yrs	11-12 yrs	13-14 yrs	> 14 yrs
MAP Goal 50%ile	45 mmHg	56 mmHg	63 mmHg	68 mmHg	71 mmHg	74 mmHg	76 mmHg	78 mmHg	82 mmHg

1. Poungrarin, N., et al. 1987). Effects of Dexamethasone in Primary Supratentorial Intracerebral Hemorrhage. The New England Journal of Medicine, 316, 1229-1233.

ICP Management	Other
Intraparenchymal devices (Bolt/Codman) • Continuous ICP monitoring • No ability to drain CSF • NOT MRI compatible Intraventricular devices (EVD) • Ability to drain CSF • Intermittent ICP monitoring if open to drain • MRI compatible Goals • ICP < 20mmHg • CPP Goal: 0-1yr >50mmHg, 1-12yrs >55, >12yrs >60	• Clear clinical seizure: start on seizure ppx x 3 months or until repair • Sequential Compression devices, can use unfractionated heparin 24 hours post surgery for DVT ppx • Please list heparin/lovenox as allergy so hematoma not exacerbated • For new focal deficit, change in LOC, or increase in TCD velocities—STAT HEAD CTA

Spontaneous Intracranial Hemorrhage (ICH) Flowsheet
Cerebral Vascular Malformation Page 3

Types

1. Arteriovenous malformations (most common)
2. Cavernous malformation
3. Developmental venous anomalies
4. Capillary telangiectasias—obtain family history and assess for telangiectasia to rule out HHT

AVM Management

- Complete Spetzler– Martin AVM Grading Scale (see below)
- Acute management does not usually involve surgical intervention
  - Rationale for delaying surgical treatment includes:
    * allowing for cerebral edema and hematoma to resolve
    * ability to appreciate the anatomy of the blood vessels more readily with absorption of hematoma
    * surgical risk is increased in the presence of cerebral edema, acute hemorrhage and increased ICP
    * NOTE: acute surgery may be considered for some grade I or II AVMs

- Permissive HTN if increased ICP. Avoid hypotension
- Start screening with TCDs on day 3. If concern for vasospasm, start Nimodipine PO/NG 1mg/kg (max 60mg) Q4H
- Screen for cutaneous telangiectasia and family history of AVMs, if present consider HHT testing and screening for AVMs in other organs.
- Risk for re-bleeding is highest in the first 72 hours

Acute imaging:
· Head CT on presentation. If ICH noted —> recommend CTA to assess for vascular abnormality.
· Head CT (non-contrast) day 2. Assess for expansion of hematoma, cerebral edema and hydrocephalus.
· MRI/MRA brain day 5 . Assess for hematoma expansion, cerebral ischemia and hydrocephalus.
· Consider diagnostic cerebral angiogram in the acute phase (e.g. within 1-2 weeks) to establish presence or absence of high risk features (e.g. proximal aneurysm, or deep draining vein)

Poor prognostic signs:

· Low GCS upon arrival	· Presence of associated aneurysm	· Posterior fossa location
· Presence of IVH	· Brainstem involvement	· Spetzler– Martin AVM score > 2

Access to multidisciplinary, integrated inpatient/outpatient rehabilitation program as early as possible

Long Term Management

Anticipate angiogram 3 months post rupture. Location will determine treatment options.
· Treatment options: Embolization with IR
Surgical excision (preferred if location permits)
Stereotactic radiosurgery (preferred for small AVMs and/or AVMs in non-resectable sites)

· Long term monitoring:
- If surgically resected, cerebral angiogram 1 year post resection
- If embolization or radiosurgery, CTA or MRA annually post-op until 18 years

Spetzler-Martin AVM Grading Scale

Size	**Points**
0-3 cm	1
3.1-6.0 cm	2
>6.0 cm	3
Location	
Noneloquent	0
Eloquent	1
Deep Venous Drainage	
No present	0
Present	1
TOTAL AVM Score	**1-5**

The Spetzler-Martin AVM Grading Scale is based on size, location and venous drainage of intracerebral AV malformation. The score is calculated by adding the points for each category. The lower the score, the better the outcome.

Jafar, J, MD and Rezai, A. MD. (1994). *Acute Surgical Management of Intracranial Arteriovenous Malformations.* Neurosurgery, 34: 8-13.
Srinivasan, V., et al. (2016). *Management of Intracerebral hemorrhage in pediatric neurosurgery.* Surgical Neurology International. 7 (Suppl 44): S1121–S1126.

No Vascular Anomaly

Causes:

- Hematological diseases such as coagulopathies or thrombocytopenia
  - Idiopathic thrombocytopenic purpura (ITP), acute lymphoblastic anemia (ALL), sickle cell anemia (SCA), hemophilia
- Cerebral tumors
- Moyamoya disease
- Septicemia, endocarditis/septic emboli
- Pharmacologic anticoagulation

Work Up:

- Send thrombophilia work up: Factor II, Factor IX, Factor XI, thrombin time, PT/PTT/INR & Fibrinogen
- Spontaneous ICH NOT anticoagulation related: send bleeding and clotting studies
- MRI brain with and without contrast to assess for vascular abnormality and/or neoplasm
- Consult hematology

Management:

- Determine need for correction of coagulation studies (platelets, vitamin K, FFP)
- Repeat head CT to monitor bleeding

Re-staring anticoagulation after ICH:

- The highest risk for hemorrhagic conversion is 3-5 days after bleed
- Determine risk vs. benefit when determining when to restart anticoagulation
- Determine prophylactic vs treatment dosing of anticoagulation
- Start with heparin infusion (easily reversible) targeting unfractionated heparin levels (tx: 0.35 - 0.7)
- Monitor for complications (ex: off anticoagulation for artificial valve, monitor daily ECHOs for vegetation)
- Obtain head CT 24 hours after restarting prophylactic or treatment dosing of anticoagulation to assess for hemorrhagic conversion or increased hemorrhage
- Transition to Lovenox once stable and the risk for bleeding has decreased

Murthy, S., Gupta, A., Merkler, E., Babak, N., Mandava, P., Iadecola, C., …Kamel, H. (2017). *Restarting anticoagulation therapy after intracranial hemorrhage: a systematic review and meta-analysis*. Available at https://doi.org/10.1161/STROKEAHA.116.016327 .

Aneurysm

Early Diagnosis:
· **Lumbar puncture:** If suspicion for SAH high (acute and rapid onset headache +/- nausea, vomiting, nuchal rigidity, photophobia, restlessness, agitation, confusion, decreased level of consciousness, seizures) and CT negative; best done at least 6, preferably 12, hours after onset of headache
· **Digital subtraction angiography: ASAP**, unless CTA sufficient for aneurysm detection and intervention planning

Management
Goal: early clipping or coiling within 24 hours

Prior to clipping or coiling:	After clipping or coiling:
MINIMIZE RISK OF REBLEEDING · Bed rest; minimize stimulation · Fever & pain control · Laxatives & stool softeners · Blood pressure <50-75%ile for age and height; short-acting V Ca^{++} channel blockers as needed (nicardipine) · Minimize CSF drainage (tamponade) Vasospasm ppx: Nimodipine PO/NG 1mg/kg (max 60mg) Q4H for up to 21 days Seizure ppx: Keppra 40mg/kg/day div BID x 7 days cEEG for 24 hours No antifibrinolytics (aminocaproic acid, tranexamic acid) unless anticipated delay to securing aneurysm, high risk of re-bleeding, and no contraindication)	· Avoid hypotension; IVF & pressors as needed · Avoid hyponatremia; hypertonic saline or fludrocortisone as needed · Avoid hypovolemia; IVF as needed · Avoid fever; antipyretics as needed · Avoid hyperglycemia & hypoglycemia · Avoid anemia; pRBCs as needed · Nimodipine PO/NG 1mg/kg Q4H f(max 60mg) or up to 21 days · TCDs daily days 3-14 (PRN BID) · cEEG for 24 hours unless GCS <12 then monitor days 4-9 · Close monitoring for complications

· If no aneurysm identified consider other causes of SAH: Occult head injury, illicit drugs, AVM, dural AV fistula, dural VST, rupture of intracranial dissection (pseudoaneurysm), bleeding disorder/coagulopathy, vasculitis, Moyamoya
· If aneurysm identified, consider evaluation for autosomal dominant polycystic kidney disease, coarctation of the aorta, Ehlers-Danlos syndrome (especially Type IV), fibromuscular dysplasia, pseudoxanthoma elasticum, Marfan's syndrome
· Screen later teenage and adult first degree relatives in families with two or more first degree relatives with cerebral aneurysms

Complications:

Vasospasm (onset day 3-5, peak day 5-10)
Screening: TCDs daily days 3-14 (BID PRN) obtain mean flow velocity/time-averaged maximum velocity & Lindegaard ratio)
See calculations and goal values for adults on page 6; *using goal values for adults in children overestimates likelihood of vasospasm although adult values are often used in practice
-Diagnosis: MRA or CTA
-Diagnosis: DSA if non-invasive imaging equivocal
-Management: Avoid hypotension and hypovolemia; IVF & pressors as needed; goal BP >50-75%ile for age and height

Delayed cerebral ischemia (decreased level of consciousness, focal neurologic deficits, EEG abnormalities [alpha/delta ratio])
-Screening: day 4-9 for patients with GCS < 12
-Diagnosis: MRI with diffusion and perfusion/MRA; CTA
-Diagnosis: DSA if non-invasive imaging equivocal
-Management: Induce hypertension; goal BP >95%ile for age
-Management: Intra-arterial therapy (calcium channel blockers, vasodilators, angioplasty) if induced hypertension insufficient to reverse symptoms

Increased intracranial pressure
-Consider EVD

Acute hydrocephalus
-Consider EVD

Hyponatremia
-Consider SIADH or CSW
-Isotonic crystalloids
-Hypertonic saline or fludrocortisone (0.1-0.2mg BID adult dose)

Cardiac dysfunction
-EKG
-Echo

Heparin-induced thrombocytopenia (due to procedures)

Deep venous thrombosis

Hunt Hess Grading Scale (*mortality for adults)		
Grade	**Clinical Features**	**Mortality***
1	Asymptomatic, minimal headache, slight nuchal rigidity	2%
2	Moderate to severe headache, nuchal rigidity, no focal neurologic deficits other than CN palsy	5%
3	Drowsy, confused, mild neurologic deficits	10%
4	Stuporous, moderate to severe hemiparesis, possible early decerebrate posturing, vegetative disturbances	25%
5	Deep coma, decerebrate posturing, moribund appearance	70%

Mean Flow Velocity Calculation

- For each side of MCA use your highest peak systolic (PS) and the associated end diastolic (ed) for the following calculation
- V_{ed} + 1/3 (V_{PS}—V_{ed})
- Goal mean flow velocity < 200 - *see table*
- **IF** goal mean velocity > 200, then calculate Lindegaard ratio below.

Lindegaard Ratio Calculation

- For each side use mean flow velocity of MCA divided by MEAN velocity of the ipsilateral extracranial carotid artery
- GOAL < 3 - *see table*

Grading of Vasospasm Severity

Degree of MCA or ICA Vasospam	MFV (cm/s)	AND	LR
Mild (<25%)	120—149		3 - 6
Moderate (25-50%)	150 –199		3 - 6
Severe (>50%)	>200		> 6

Factors that can globally increase flow velocity measurements

- increased cardiac output
- Anemia
- Elevated pCO2
- Drugs with cerebral vasodilatory properties
- Elevated body temperature
- age

Mean flow velocity is approximately equivalent to TAMAX (time-averaged maximum velocity)