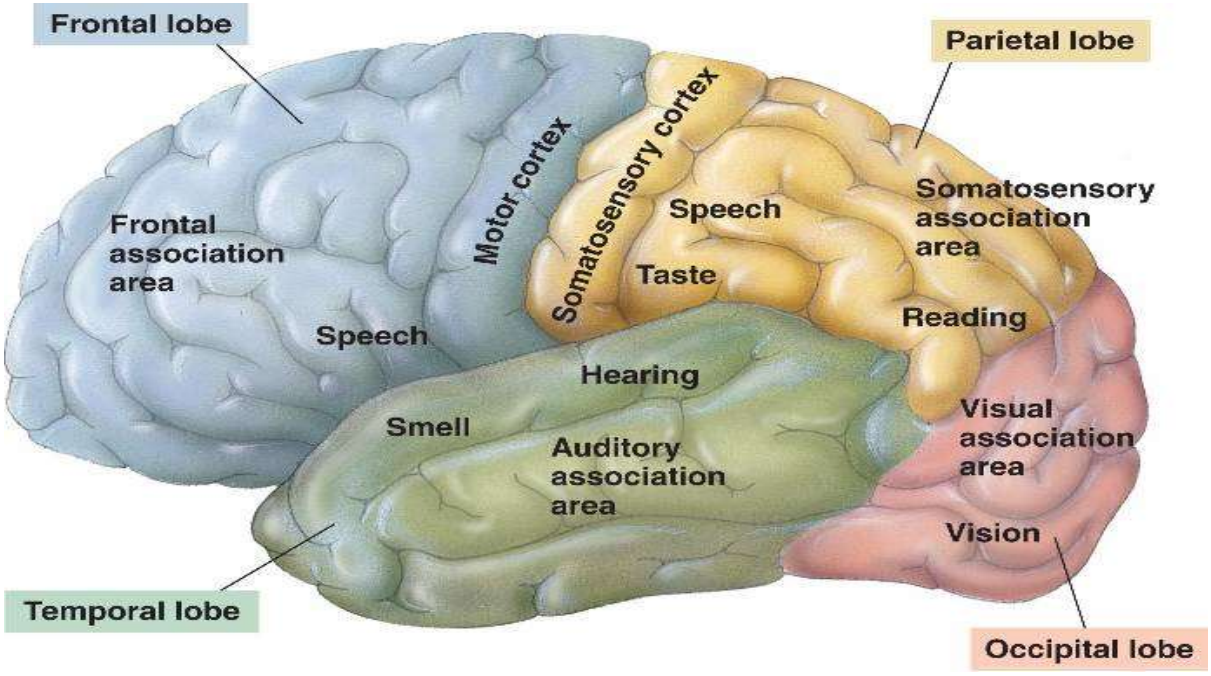
Brighton and Sussex University Hospitals NHS Trust

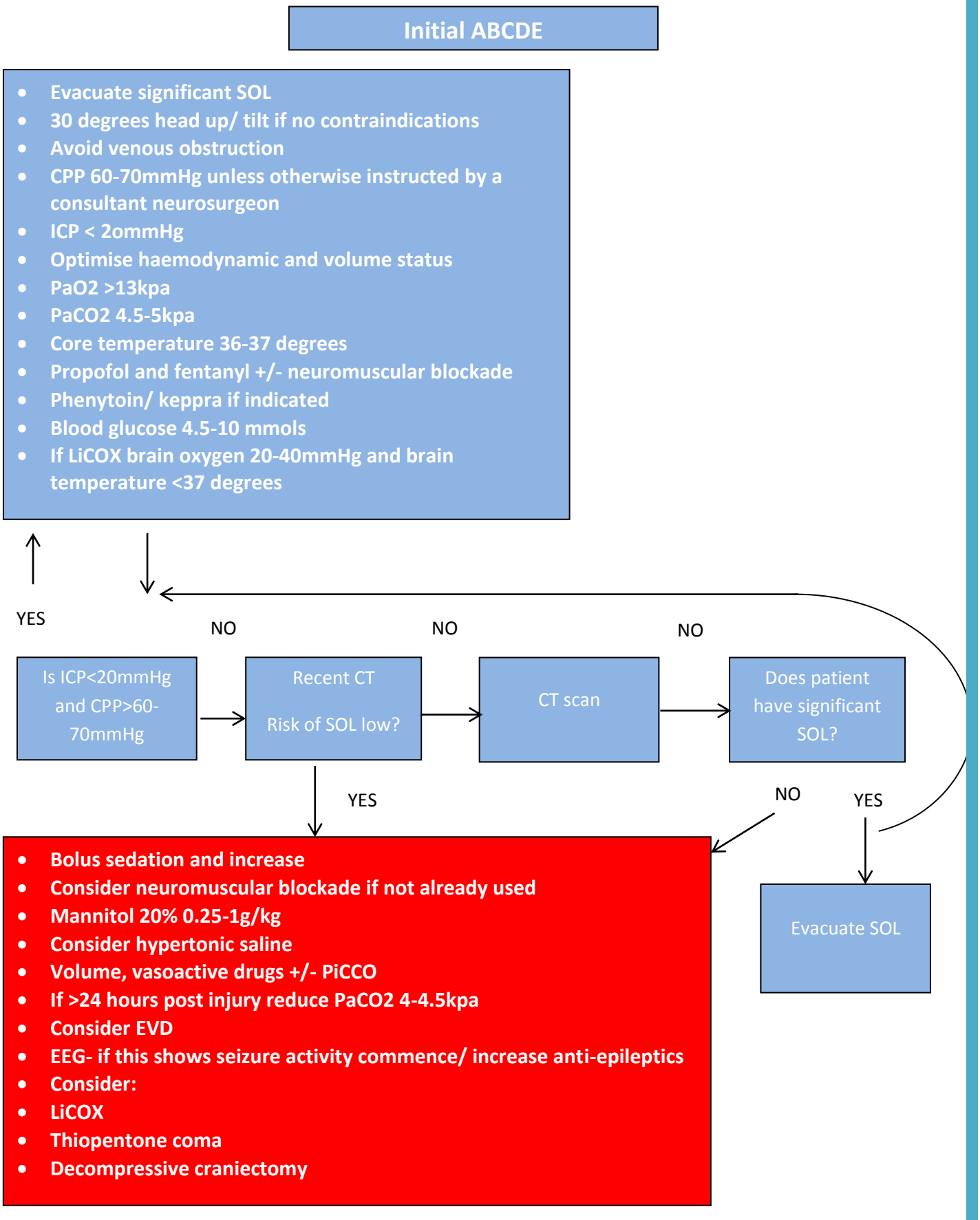
# NEURO-SURGICAL Handbook




## TO BE USED IN CONJUCTION WITH FULL TRUST GUIDELINES

Updated 2017

# Head injury algorithm



# Head Injury Parameters

**ICP** <20mmHg

**CPP** >60-70mmHg (if no ICP sensor MAP> 80 mmHg)

**CVP** 8-10mmHg

**BIS** 20-30%

**Core temp** 36-37 degrees℃ (For every 1 °c rise in body temperature there is a 13% increase in the metabolic rate)

**PaCO2 4.5 – 5 kpa**- (unless a LiCOX is in place).

Low PaC02 reduces blood flow (vasoconstriction) high PaC02 increases blood flow (vasodilation)

**Pa02** >13 kpa.

**HB** 8-10ml/l

**Blood glucose** 4.5-10mmol/l

**LiCOX** Pbt02 > 20-40mmHg and Brain Temp < 37 °c

Updated 2017

# Initial TBI management

## Essential monitoring and access:

Standard ICU monitoring plus:

- Wide bore oro-gastric tube or naso-gastric tube if no base of skull fracture or suspected base of skull fracture
- Temperature monitoring
- ICP monitoring if appropriate
- BIS monitoring to ensure adequate sedation

## Certain patients may need additional monitoring:

1. Cardiac output monitoring:
- To be inserted if no response to crystalloid and no response to 0.1mcg/kg/min of noradrenaline
- If acute or pre-existing cardiac disease
- Systemic sepsis
- Cardiac contusion
- Pulmonary oedema
2. Peripheral nerve stimulator if administering muscle relaxants
3. Consider EEG if suspecting seizures or during barbiturate coma

## Specific investigations above baseline:

- Troponin if chest trauma or >50yrs or if history indicates
- Triglyceride level as baseline (not lipid levels)
- CK
- Consider urine and serum osmolality and urine electrolytes if polyuric
- 9am Cortisol level in case of pituitary injury (must be off steroids)

Updated 2017

## Initial General Neurosurgical Management:

- Fully sedated and analgesia +/- paralysis if required
- SIMV (as per ARDS ventilation guidelines) for a minimum of first 48 hours
- Target $PaO_2$ > 13kPa
- Target $PaCO_2$ 4.5-5.0[5]

Aggressive hyperventilation should be avoided unless $PbtO_2$ is measured. Avoid $PaCO_2$ <4.0kPa except in critical situations when a $PaCO_2$ <4.0 kPa may be needed to "buy time" (e.g. prior to theatre or CT scan) but in these instances the patient must be on 100% $O_2$. The decision to reduce $PaCO_2$ to <4.0kPa must be made by a Consultant Neurosurgeon and Consultant Anaesthetist and ideally only with a LICOX in situ.

- Early evacuation of intracranial space occupying lesion (SOL).
- ICP < 20 mmHg
- CPP > 60 - 70mmHg[2]
- Unless otherwise specified by the Consultant Neurosurgeon or LICOX suggests a lower CPP. 50-60mmHg can be considered in certain situations in consultation with the Consultant Neurosurgeon.
- Target CPP should never be <50mmHg
- $PbtO_2$ 20-40mmHg
- Consider CSF drainage to manage intracranial hypertension
- Core temperature 36-37$^{o}$C. Treat pyrexia's vigorously
- Brain temperature < 37 $^{o}$C
- Optimal haemodynamic and volume status
- Tight seizure control
- Establish early enteral feeding within 24 hours if possible
- Blood sugar control 4.5-10mmols (minimum of daily blood sugars, 2-6hrly if high)
- Treat established or clinically significant infection vigorously

## Specific Management of severe TBI:

**ICP Monitoring**:

- ICP should be monitored in all salvageable patients with a severe TBI (GCS 3-8)
- When calculating CPP in TBI the MAP used in the equation (CPP=MAP-ICP) should be the mean cerebral arterial pressure estimated to exist at the level of the middle cranial fossa. **This can be achieved by levelling the transducer at the tragus.**

**Targets:**

- Initial management directed at maintaining:
    - ICP <22mmHg
    - CPP >60-70mmHg

**LiCOX:**

- If brain tissue oxygen monitoring (LiCOX) is in use then increase the CPP in stages and record PbtO2. Then set optimal CPP parameter to achieve PbtO2

# ICP- troubleshooting

- Check pupils
- Check PcO2 4.5-5kpa (may require regular blood gases in acute phase). Consider ventilation changes +/- RR or TV- re-check ABGs 20 minutes after ventilator change
- Mild hyperventilation 4-4.5kpa may be considered if > 24 hours post injury

(  Must be cleared with Neurosurgeons).

- 30 degree head elevation (reverse trendelenberg if c-spine not cleared)
- Body position- hips in alignment, head not hyperextended/ flexed ( patient may not tolerate side lying )
- Avoid excessive hip flexion> 90 degrees
- ET tube ties not too tight/ use an anchorfast device (can impede venous drainage). If wearing a hard collar ensure not too tight
- Check adequate sedation: BIS 20-30. Does the patient need to be paralysed?
- Avoid clustering of activities
- May respond to a bolus of sedation
- If ICP >20mmHg sustained for > 5 minutes inform neurosurgeons /N.I.C (Patient may need CT scan +/- osmotic therapy)
- If the patient is pyrexic treat with paracetamol. They may benefit from active cooling
- Observe effect of suctioning on patients ICP – patient may need suction. Pre- oxygenate prior.

Updated 2017

# CARE OF PATIENT WITH AN EVD

- Should be hung on dedicated drip stand
- Must be labelled with EVD stickers either side of 3 way tap closest to patients head.
  - **Stopcock levelled at EAM** ( external auditory meatus- see figure 1 equivalent of foraman of munro) must be re levelled to EAM if patient position changes

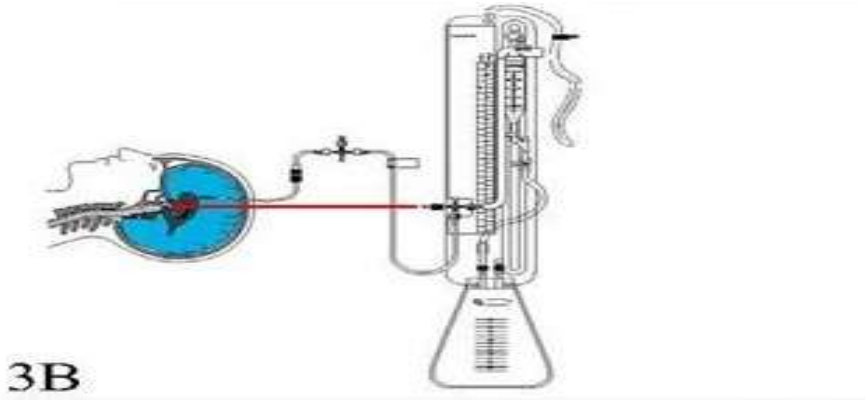


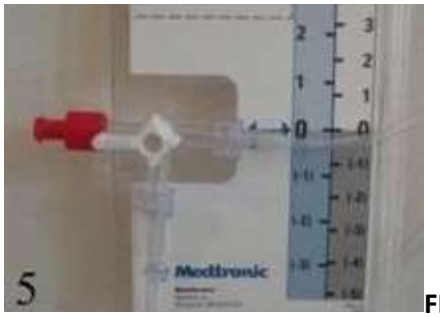

Figure 1

  - Level set as per neurosurgeon – normally between 5-20 cm/h20 – must be documented
  - If turning a patient/ sitting patient up / lying down ensure EVD turned off.( see figure 2). Re level with EAM then turn back on to patient
  - Drainage to be documented hourly- if no drainage, check that the drain is swinging.
  - If EVD stops draining and is not swinging contact **neurosurgeons** and inform NIC **immediately** (first check there are no obvious kinks or tap switched off) ⚠ increase frequency of neurological observations

# CARE OF PATIENT WITH AN EVD

- Inform N.I.C and Neuro staff if there is an increase of > 10mls an hour above patients base line or > 25ml in one hour.
- Maintain closed system at all times
- Do NOT place EVD horizontally on the bed when transporting the patient unless drip chamber is turned off and EVD is clamped.
- EVD site MUST be covered with a sterile dry occlusive dressing at all times – this should be checked hourly
- The EVD bag must be changed aseptically once it is over ¾ full.
- Observe for signs of infection- redness, swelling, pyrexia, raised CRP or WCC. This must be reported to N.I.C and medical team
- Make sure patient is reminded not to touch or pull at the EVD
- If CSF sampling is required **MUST** be done by the **Neuro-medical staff**
- If patient requires intra-thecal drugs (Vancomycin) this **MUST** be given by **Neuro-medical staff who will instruct when the drain can be re- opened.**
- If the EVD is challenged (i.e. raised or clamped prior to removal), neurological observations must be increased to hourly. **Any deficits reported to NIC and Neurosurgeons**.
- If patient is agitated or picky they must be constantly supervised to avoid accidental removal ( an emergency)

Updated 2017

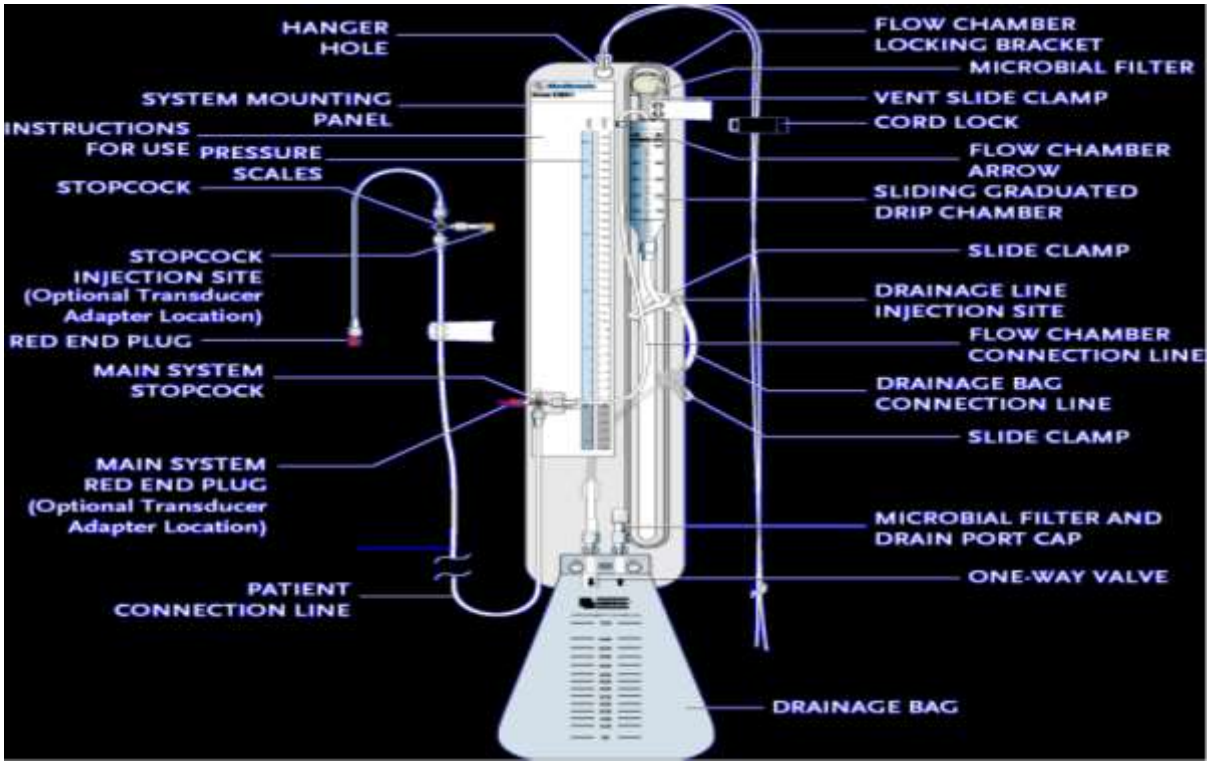



Open to drainage

**FIGURE 2**


**FIGURE 3**

Closed To Drainage




Updated 2017

# ANTI-CONVULSANTS

## First line treatment- phenytoin and /or levetiracetam

**Phenytoin**

**Loading dose** (for rapid therapeutic effect)**:** 20mg/kg **(max 2g)**

**Rate of infusion**: Not more than 50mg/min

**Contra Indications to Phenytoin**

- Sinus bradycardia
- SA block
- 2nd and 3rd degree A-V block
- Adams –Stokes syndrome
- Allergy to phenytoin
- Acute porphyria

If phenytoin contra-indicated or seizures not controlled consider using either:

**Levetiracetam** 250mg IV BD

**Carbamazepine** (oral or rectal only) or

**Sodium valproate** IV 400-800mg - max 10mg/kg

(With careful consideration as it may not provide protection against post traumatic seizures and has been associated with higher death rates)

**Intravenous Phenytoin administration:**

**IV (Neat)**

- Give a saline flush through the same cannula or central venous catheter (CVC) **before and after** the phenytoin injection (to avoid local venous irritation)
- Inject phenytoin dose **slowly** (50mg/min
- ) directly into **a large vein**, through a large gauge cannula or CVC

**IV (diluted)**

- Phenytoin injection can be diluted in 50-100 ml Nacl 0.9%- final concentration must not exceed 10mg/ml.
- Diluting phenytoin increases risk of precipitation. Use within one hour of dilution- check infusion remains clear of haziness and precipitation.
- **An in-line 0.2 micron filter should be used**. Continuously monitor ECG and BP during IV phenytoin administration

**Maintenance dose (i.v or oral)**

3-4mg/kg/24 hours (200-400mg in 24 hours).

Updated 2017

| Weight (kg) | IV loading dose 20 mg/kg. Undiluted run at 60ml/hour | IV Maintenance dose Bolus at 50mg/min | Enteral maintenance dose |
|---|---|---|---|
| Up to 56kg | 1000mg in 20mls | 50mg om, 50mg pm, 100mg nocte | 200mg od |
| 57 - 68kg | 1250mg in 25mls | 50mg om, 100mg pm, 100mg nocte | 250mg od |
| 69 – 81kg | 1500mg in 30mls | 100mg om, 100mg pm, 100mg nocte | 300mg od |
| 82 – 93kg | 1750mg in 35mls | 100mg om, 100mg pm, 150mg nocte | 350mg od |
| ≥94kg | 2000mg in 40mls | 100mg om, 150mg pm, 150mg nocte | 400mg od |

**Start maintenance dose 24 hours after loading dose.**

**Phenytoin monitoring**

**Therapeutic range: 10-20mg/L**

Check phenytoin level three days after starting to ensure no toxicity has occurred. Re-check levels seven days after starting to ensure therapeutic levels have been reached. If the patient is still having seizures aim for phenytoin levels of **15-20mg/l**.

Use the reported adjusted phenytoin level rather than the actual phenytoin level as this takes into account protein binding.

The sample sent should be a trough level (sent one hour before the dose is due). An albumin level should be requested at the same time as the phenytoin level due to it being highly protein bound.

**If level sub-therapeutic** i.e. **< 10mg/l**

If the therapeutic range has not been reached at day seven, use the following equation to calculate a suitable top up dose:

**Top-up phenytoin dose [mg] =**

**0.7 (L/kg) x weight (kg) x (required level [mg/L] – measured level [mg/L])**

Worked example:

Patients phenytoin level = 4.8mg/L Required level = 15mg/l

Patient = 85kg

Top-up dose mg/kg = (0.7L/kg x 85kg) x (15mg/L – 4.8mg/L)

= 59.5L x 10.2mg/L = 606.9mg

Round the calculated dose up to the nearest 25mg for ease of administration.

Omit the maintenance doses on the day of the top-up and recommence the following day. If this is the second time or more that a top up dose is being given, increase the daily maintenance dose by 25mg.

**If level toxic i.e. > 20mg/l**

If the phenytoin level is above the therapeutic range, withhold phenytoin. Take daily phenytoin levels. Once the blood level is < 20mg/l restart phenytoin at a lower dose. Consider the reason why the level is high (is there a drug interaction?)

NB- Due to the nonlinear kinetics of phenytoin, dose alterations should not be greater than 50mg at one time.

**Phenytoin suspension:**

Phenytoin is highly protein bound, therefore must be administered in the middle of a 4 hour enteral feed break.

**Keppra IV** injection is for intravenous use only and must be diluted prior to administration. Treatment should be initiated with a daily dose of 1000 mg/day, given as twice-daily dosing (500 mg BID). Additional dosing increments may be given.

In cases of renal impairment, relevant dose adjustment is needed

| CRCL (ml/min) | Dosage | Frequency |
|---|---|---|
| **> 80 ml/min** | 500-1500 mg | q12h |
| **50 - 80** | 500-1000 mg | q12h |
| **30 - 50** | 250-750 mg | q12h |
| **<30** | 250-550 mg | q12h |

# Neuromuscular blockade

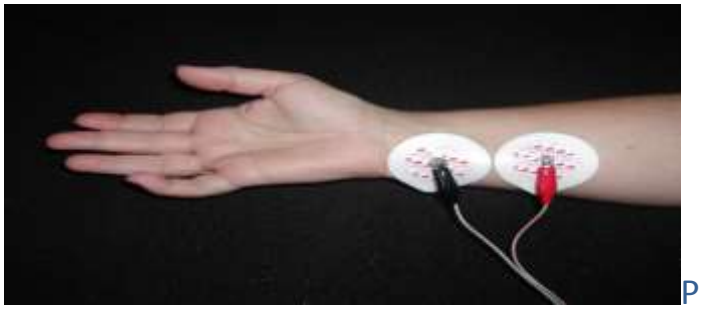
## Should be considered if ICP remains high or is LABILE despite full sedation

- A BIS monitor must be in place to ensure patients have adequate sedation and analgesia prior to administration of neuromuscular blockade BIS -20-30%
- Using Cisatracurium 150mg/30mls (5mg/ml or 5000micrograms/ml) administer an initial bolus dose of 150micrograms/kg (calculate using patients ideal body weight if they are obese) followed by a continuous infusion of 180micrograms/kg/hour titrated to achieve 1-2 twitches using the train of four test.
- A peripheral nerve stimulator must be used when administering neuromuscular blockade. ( see picture A)
- Prior to commencing the neuromuscular blockade the supra-maximal stimulation: SMS (which is a baseline response for the particular patient) should be identified using a peripheral nerve stimulator.
- The SMS (mA) should be recorded on the patients' observation chart/CIS. If you are not able to identify the SMS e.g the patient is already receiving a neuromuscular blockade then an SMS of 50mA for a normal adult or 60mA for an obese adult can be used.

**Neuromuscular blockade**

- The peripheral nerve stimulator (PNS) delivers 4 pulses over 2 seconds (train of four). The use of a PNS minimises the complications of

prolonged paralysis by monitoring the degree of neuromuscular blockade. You are looking for thumb twitching.


PICTURE A

## Cisatracurium chart

| | |
|---|---|
| 0 twitches | Reduce infusion by 20% increments until 1-2 twitches achieved. |
| 1 – 2 twitches | Maintain present infusion rate |
| 3 twitches | Reload with 50% of loading dose; increase infusion rate by 50% |
| 4 twitches | Reload with 100% of loading dose; increase infusion rate by 100% |

## BIS= BISPECTRAL INDEX

**SR- SUPRESSION RATIO**

**THE LOWER THE BIS THE LOWER THE BRAIN ACTIVITY**

**100= AWAKE**

**40= DEEP HYPNOTIC STATE**

**20= BURST SUPRESSION**

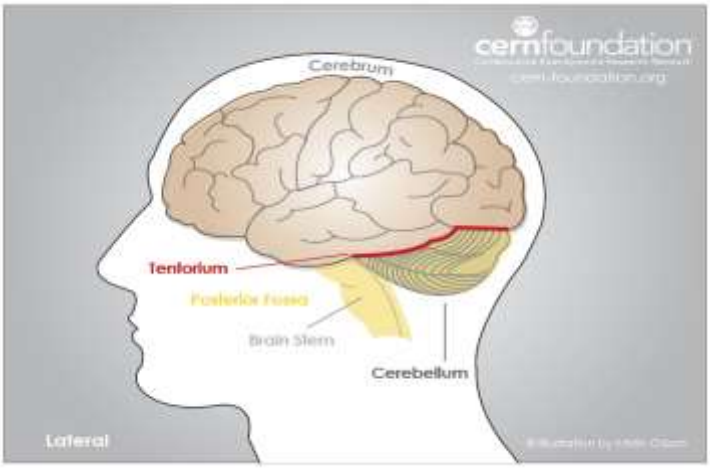
**0= ISOELECTRIC LINE**

# Post- operative care of craniotomy

- Head of bed elevation 30 degrees for venous drainage unless otherwise directed.
- Check notes for post op plan re mobilising, drains, etc.
- Potential cranial nerve dysfunction- visual deficits , homonymous hemianopia
- Head bandage for 24 hours – monitor for CSF leakage or blood
- Drains – normally closed suction for 24-48 hours. Observe for over drainage or CSF
- Blood pressure must be maintained within strict parameters set by neurosurgeons. Hypertension can cause bleeding into the tumour bed and hypotension can lead to hypo perfusion , ischemia and infarct
- Normo-thermia should be maintained-post operatively – I 1°C Increase in temperature causes a 13% increase in metabolic rate
- Monitor u and e s -risk of hypo- hyper-natraemia- osmos if urine output high, or given mannitol
- Monitor blood sugars- stress response / dexamethasone aim < 10mmol/l
- If any deterioration inform N.I.C and Neurosurgeons immediately

Updated 2017

# Post-operative care infra-tentorial craniotomy (post fossa)




- Post-operative complications for post fossa approach can be severe due to disturbance in the cerebellum and brain stem.

- Monitor for Cardiovascular / respiratory complications due to compression of medulla particularly with swelling Cardiac arrhythmias are not unusual after post fossa surgery or if blood has entered the CSF- Ensure electrolytes within range
  - Increased nausea and vomiting ( can be projectile and without warning!) Cyclizine generally works best for these patients but will need regular anti - emetics
  - ⚠ **NBM**- Swallowing and gag reflex impaired .Will need SALT input as HIGH risk of aspiration.
  - Dysphagia and dysarthria are common
  - Nystagmus and vertigo and Ataxia are common
  - Observe vital signs

- Avoid positioning on operative site if a large tumour has been removed to avoid shifting of cranial contents secondary to gravity
- If any deterioration inform N.I.C and Neurosurgeons immediately

# Post-Operative Guidance For Patients following Pituitary Surgery

- Neuro Observations as guided by Neurosurgeons
- At Least daily Urea and Electrolytes and paired osmolality's
- Strict hourly Monitoring of fluid balance
- If urine output> 200ml for 3 consecutive hours send U & E's and paired osmolality's as high risk of developing Diabetes insipidus (DI)
- If patient has lumber drain post-surgery follow guidance documented in notes by neurosurgeons regarding care (set level and the need to keep on)
- Observe patient for potential CSF Leak-It may be obvious leak from nose or patient may develop a salty taste in mouth or a dripping feeling in the throat. If present liaise with Neurosurgeons immediately
- Give steroids as prescribed
- Patients should be seen by endocrine team.
- Avoid Hot Drinks for at least 6 hours post-surgery then proceed to warm drinks if required for up to 12 hours post operatively

# CARE OF A PATIENT WITH A SAH

## Untreated aneurysms:

- Ensure Bed rest
- Adequate analgesia/ anti emetics. consider different types of anti- emetic. Nausea and pain will increase BP causing risk of re- bleed.
- Seek early blood pressure /Map goals from neurosurgeons ( will need an arterial line)
- Avoid swings in blood pressure
- Nimodipine 60mg p/o 4 Hourly. monitor for hypotension ( can be changed to 2 hourly if BP is compromised).Inform neurosurgeons if BP is affected. Nimodipine is given for 21 days post ictus.
- 3 litres fluid in- patient must not have a negative fluid balance
- Hourly neurological and CVS observations- **check for pronator drift with every set of observations-** early sign of deterioration
- Optimise U&E S Particularly Na + k+ Mg.
- Early dietician referral is required – food diary should be commenced- nutrition normally poor- consider NG feeding
- Any Neurological deterioration must be reported to the neuro medical team as patient will be at risk of re-bleed , hydrocephalus ( often within first 3 days) , or vasospasm /DCI
- **If increased urine outputs >200mls for 3 consecutive hours consider sending Paired osmolarities**

# Treated (clipped or coiled) aneurysms

- Ensure bed rest (Do not sit out unless advised directly by Neurosurgical consultant
- If neurological deterioration consider Delayed cerebral ischemia (DCI) or vasospasm ( Greatest risk period is between day 4-10 but can appear anytime within 21 days). Contact N.I.C/ neurosurgical team immediately
- Patient may need CT scan or CT perfusion- if evidence of vasospasm /DCI, MAP will usually be augmented to 90-100 (Sometimes up to 120 mmhg) with fluids +/_ vasopressors (Noradrenaline) and increased according to neurological function
- IV Nimodipine (Nimotop)may be administered via CVC through a dedicated line ( supplied with bottle) must run with 40 mls /hr. of normal saline .**Must be a neurosurgical decision**
- May require intra- arterial nimodipine ( done in angio suite)
- Increase neurological assessment to a minimum of hourly
- Observe for pronator drift
- 3 litres fluid in- strict neutral to positive fluid balance
- Observe electrolytes Na+ k+ and Mg – replace as required
- **If increased urine outputs >200mls for 3 consecutive hours consider sending Paired osmolarities**

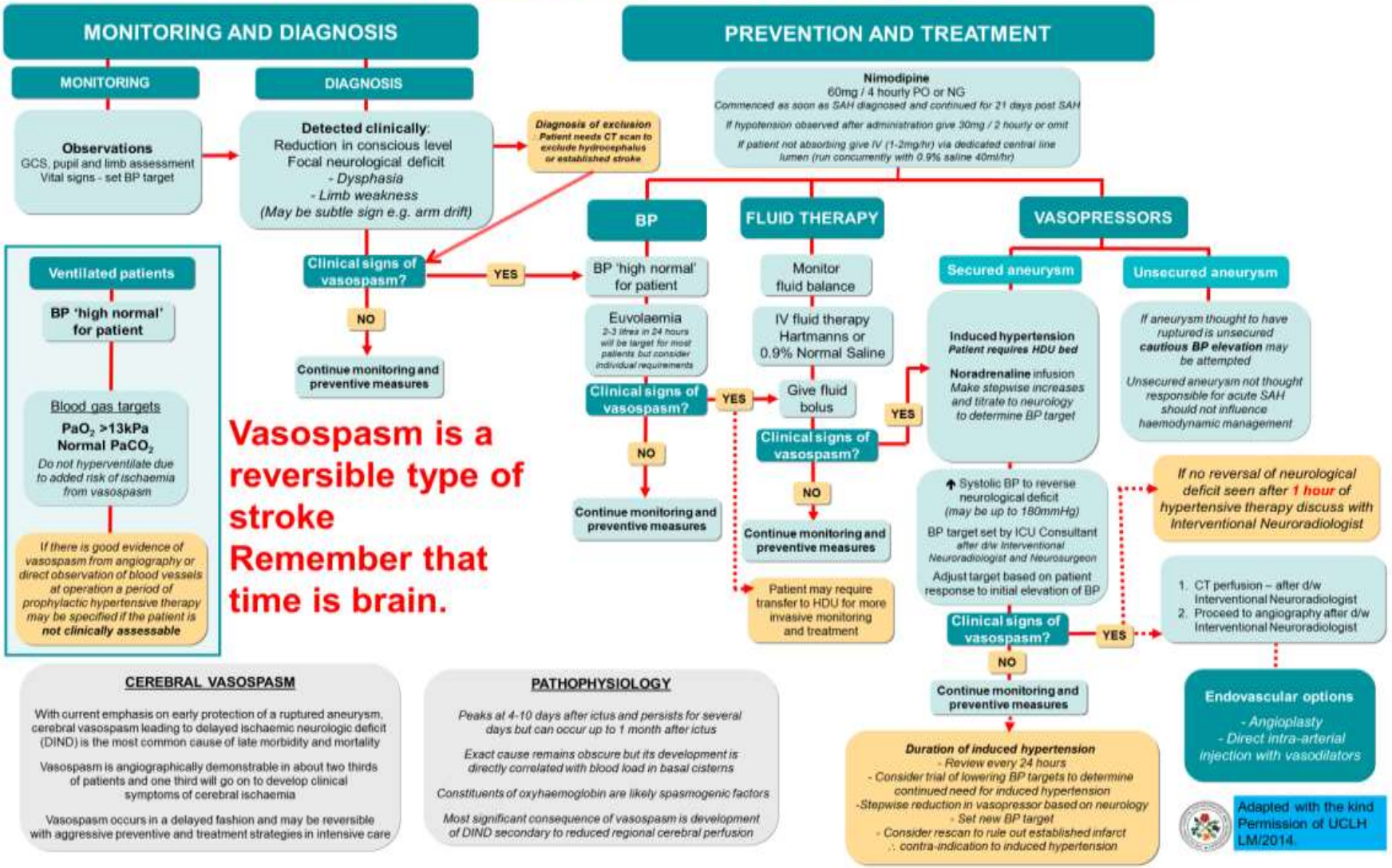
# CARE OF A PATIENT POST ANGIO +/-COILING

- Full neurological observations every 15 mins for 1 hour, half hourly for 2 hours ,then hourly-including pronator drift
- Check angioseal ( normally R groin)/ pedal pulses- observe for oozing/ haematoma/ absent pulses as above- any abnormal findings contact N.I.C
- Check notes to see if requires aspirin
- Leg straight for 4 hours
- Determine Map/ systolic parameters from neurosurgeons/ neuro-radiologist
- If patients drops GCS post coiling may be from thrombus, vasospasm or hydrocephalus- requires urgent CT scan- inform N.I.C and neurosurgeons
- If vasospasm prepare to commence patient on noradrenaline to increase MAP
- Continue Nimodipine 60 mg 4 hourly- if drops Blood pressure , 30 mg 2 hourly can be given
- IV Nimodipine (Nimotop)may be administered via cvc through a dedicated line ( supplied with bottle) must run with 40 mls /hr of normal saline .**MUST BE A NEUROSURGICAL DECISION**
- 3 litres fluid in- strict neutral to positive fluid balance
- Observe electrolytes – replace as required- be mindful of Na disorders- consider di /csw/ siadh

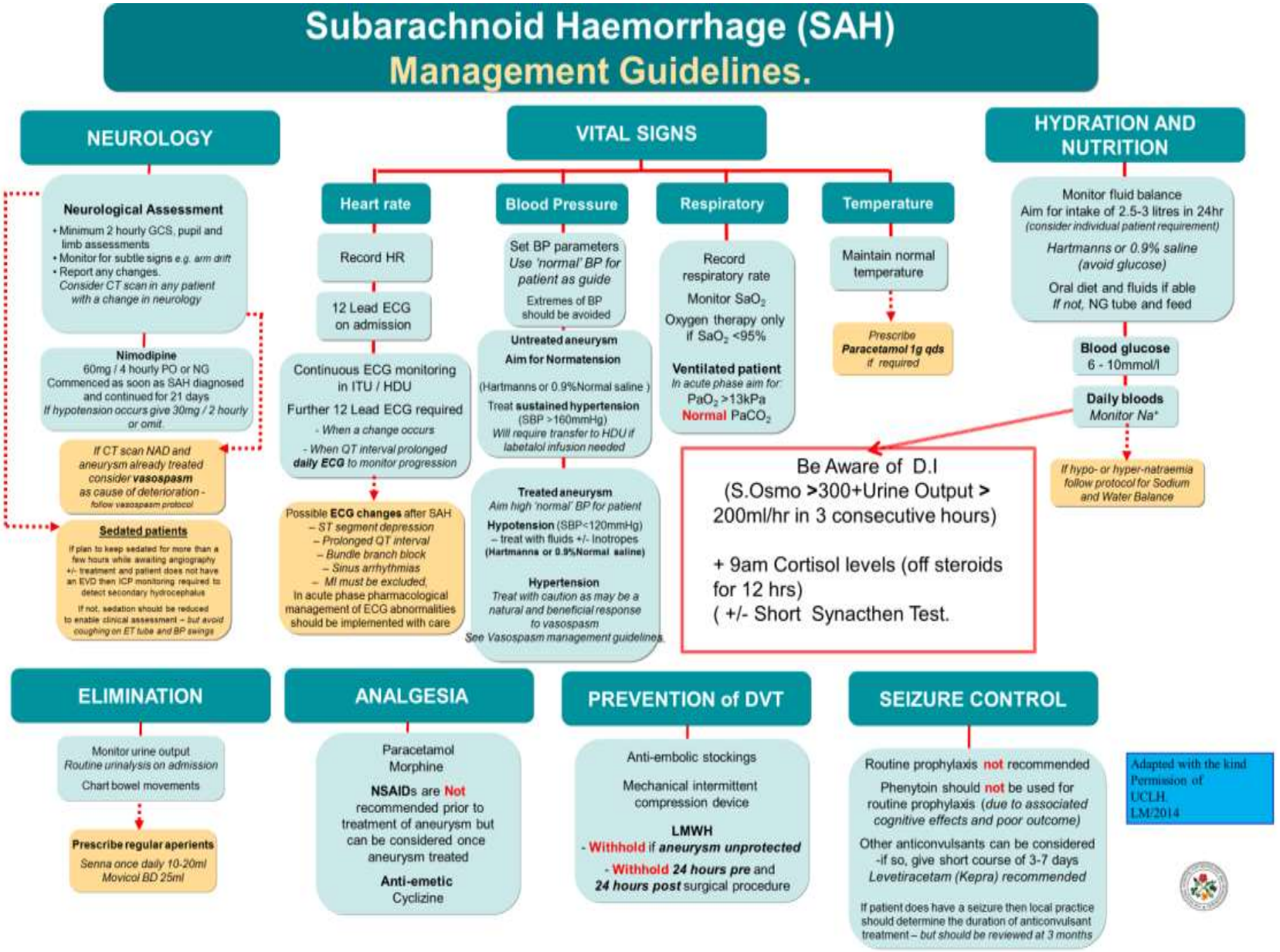
Updated 2017

Updated 2017

# Subarachnoid Haemorrhage (SAH)
# Management of Cerebral Vasospasm



Updated 2017



# Sedation and drugs

**Propofol 2%** 2-4mg/kg/hr – maximum 400mg/hr.
A bolus of 10-20mg (1-2mL of propofol 1%, or 0.5-1mL of propofol 2%) can be given for episodes of high ICP.
Calculating mg/kg/hr: (2% propofol) 20 x rate ÷ weight.

**Not for use in children.** Propofol is contraindicated for children aged 16 years and below, it should only be given in the very short term (<24 hours). Particular caution needed when administering to patients aged 17-18 years.

**Caution! Can cause propofol infusion syndrome (monitor for signs of metabolic acidosis/ cardiac arrhythmia/ hyperkalaemia/ rhabdomyolisis)**

**Monitor triglyceride levels.** Send baseline CK & triglyceride level post TBI and send daily levels if the patient is receiving >4mg/kg/hr or on propofol >48 hours

**Thiopental** 4 -8mg/kg/hr (following initial 250mg IV bolus over 5 mins)

For infusions reconstitute 3x 500mg vials with 60mls $H_2O$ for injection = 25mg/ml

**Caution! Can cause CVS instability – replace K+ with extreme caution (only if ECG changes are evident) as can lead to hyperkalaemia if thiopental infusion is ceased.**

# Sedation and drugs

**Fentanyl** 1-6micrograms/kg/hr -maximum 600micrograms/ hour (12ml/hour of fentanyl 50mcg/ml.

Prior to increasing dose, consider using a test bolus 0f 25mcg (with caution) to see the impact on ICP. If no impact on ICP then consider appropriateness of increasing the dose.

**Remifentanil** Commence infusion at 0.1mcg/kg/min. (Estimate patients' ideal body weight in kgs and calculate). Remifentanil rate limits: HIGH DOSE LIMIT = 0.5mcg/kg/min.

FOR INFUSIONS: Reconstitute 3mg with 60mls normal saline.

Calculating mcg/kg/min: 50 x rate ÷ weight

**Caution! Never bolus remifentanil- treat as an inotrope.**

**Midazolam** 1-15mg/hour (higher doses may be given with agreement of intensivists but must be documented in the medical notes)

Reconstite to 50mls with normal saline. Can be drawn up as single 1mg/ml (50mg), double 2mg/ml (100mg) or quad 4mg/ml (200mg) strength.

Calculating mg/hour: rate x mg/ml.

# Sedation and drugs

**Cisatracurium - Neuromuscular blockade**

Using NEAT cisatracurium 150mg/ 30mls (5mg/ml or 5000micrograms/ml). Administer an initial bolus of 150micrograms/kg. (Calculate using patients ideal body weight if they are obese) followed by a continuous infusion of 180micrograms/kg/hour titrated to achieve 1-2 twitches using the train of four test.

Calculating mcg/kg/hour: 5000 x rate ÷ weight

**Nimodipine** IV (Nimotop) initially 1mg/hour (5mls/hour). After 2 hours, increase to 2mg/hour (10mls/hour). For those with unstable blood pressure or weighing <70kg the rate should be 500mcg/hour (2.5mls/hour)

**Caution! It must be administered via a CVC line with the administration set supplied in the box with the vial. A co-infusion of either Nacl 0.9% or hartmanns 40mls/hour must run alongside.**

# Sedation and drugs

**Mannitol 20% (20g in 100mls)**

1.25-5mls/kg (0.25-1g/kg) over 15-30mins. Can be repeated 6 hourly if serum osmolarity remains <320mOsm/L.

Stored in the warmer to prevent crystallisation

Must be administered via a buretrol administration set with a 15 micron in-line filter. Can be administered peripherally via a large bore cannula however, administration via CVC is preferable

**Caution! Check serum osmos <320mOsm/L and Na+ < 155**

**Hypertonic saline 5%**

Sodium Chloride 5% polyfuser 1-2mls/kg over 15-20mins. Can be administered every 4-6 hours if serum osmolarity remains <320mOsm/L.

Consider administration if intracranial hypertension persists following 2x doses of mannitol. Consider inserting a LiCOX probe.

**Must be administered via CVC line**. Hyponatraemia should be excluded prior to administration (hypertonic saline administration in hyponatraemia bears the risk of central pontine myelinolysis)

**Caution! Check serum osmos <320mOsm/L and Na+ <155**