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1. A 65 year old patient undergoes elective craniotomy for tumor resection. How long prior to elective craniotomy should systemic steroids (methylprednisolone) be administered to show a reduction in edema formation, a reduction in ICP, and an improved clinical outcome?

A. At least 6 hrs prior
B. At least 12 hrs prior
C. At least 24 hrs prior
D. At least 48 hrs prior

Go to Q 2
Steroids are not helpful acutely. The mainstay for acute intra-operative reduction of ICP remains osmotherapy in addition to appropriate positioning and CSF drainage.
Although the mechanism remains undefined steroids somehow improve the viscoelastic properties of the intracranial space followed by a reduction in edema. Unfortunately, this is not effective for acute events.
C. At least 24 hrs prior

Although clinical improvement occurs within 24 hours, a reduction in ICP may not occur for 48 to 72 hours after the initiation of therapy.

The efficacy of steroids in reducing cerebral edema associated with brain tumors (and only tumors) is well confirmed. Although the onset of this effect is relatively rapid, it is too slow for the management of acute intraoperative events. However, administration beginning 48 hours before an elective surgical procedure has the potential to reduce edema formation and improve the clinical condition by the time of craniotomy.

Ref: Miller's Anesthesia; Anesthesia for Neurologic Surgery. John C. Drummond, Piyush M. Patel and Brian P. Lemkuil. Chapter 70, 2158-2199. ed 8
2. A 72 year old male with history of coronary artery disease, hypertension, diabetes mellitus, recent stroke comes for a right carotid endarterectomy. He has undergone previous left carotid endarterectomy almost a year ago. The following are appropriate for monitoring adequacy of cerebral perfusion/oxygenation intra-operatively except:

A. Electroencephalogram
B. Awake patient
C. Transcranial Doppler
D. Arterial blood gases
E. Stump pressure monitoring

Go to Q 3
A. Electroencephalogram

EEG and SSEP are commonly used for intraoperative neurologic monitoring. The EEG may have limited specificity because it is affected by factors other than ischemia like volatile anesthetics, hypotension, hypothermia. Hence a stable physiologic and anesthetic milieu is mandatory during EEG monitoring and a MAC < 0.5 is usually preferred.
B. Awake patient

An awake patient, is widely considered to be the most sensitive method for detecting inadequate cerebral perfusion and function. Regional and local anesthesia allows continuous neurologic assessment of the awake patient. Awake monitoring reduces the need for shunting and avoids the expense associated with indirect monitors of cerebral perfusion. However, according to a meta-analysis, looking at 9 randomized control trials and 4600 patients undergoing carotid endarterectomy, no statistically significant difference in the incidence of stroke within 30 days of surgery between the local anesthesia group and the general anesthesia group was noted.

C. Transcranial Doppler

TCD allows continuous measurement of mean blood flow velocity and detection of microembolic events in the middle cerebral artery. TCD criteria can be used to diagnose cerebral ischemia during carotid cross clamping and hence the need for shunting. Moreover, most perioperative neurologic deficits are thought to be thromboembolic in origin and TCD can detect embolic events. However, probe positioning in the intraoperative period may be difficult.
D. Arterial blood gases

Arterial blood gases will not tell us about the adequacy of cerebral oxygenation particularly after clamping the carotid artery for surgical purposes. However, cerebral oximetry using near infra-red spectroscopy (NIRS), or indirectly with jugular bulb venous O2 monitoring could provide information on global cerebral oxygenation. Direct monitoring of cerebral oxygenation using an intra-parenchymal Licox monitor is not feasible in this type of surgery.
E. Stump pressure monitoring

This gives an estimate of the collateral circulation via Circle of Willis above the cross clamp and many centers use a cutoff of 45- 50 mmHg as indicative of the need for shunting. The advantages of monitoring carotid stump pressure are that it is inexpensive, relatively easy to obtain, and continuously available during carotid clamping.
3. A 72 year old male with history of coronary artery disease, hypertension, diabetes mellitus, recent stroke comes for a right carotid endarterectomy. He has undergone previous left carotid endarterectomy almost a year ago. Which of the following is a possible complication in this patient:

A. Decreased resting PaCO2  
B. Decreased sensitivity to narcotics  
C. Increased ventilatory responses to hypoxia  
D. Bilateral recurrent laryngeal nerve palsy

Go to Q 4
A. Decreased resting PaCO\textsubscript{2}

Patients who underwent bilateral carotid endarterectomy usually have an increase in the resting PaCO\textsubscript{2} as a physiologic consequence. This is due to the loss of the chemosensitive cells in the carotid bodies which respond to changes in pH, PaO\textsubscript{2} and PaCO\textsubscript{2}.
B. Decreased sensitivity to narcotics

Due to denervation of the peripheral chemoreceptors, the central chemoreceptors are the now primary sensors for maintaining ventilation. Patients have increased sensitivity to narcotics and serious respiratory depression may result from opioid administration for pain relief.

C. Increased ventilatory responses to hypoxia

Bilateral carotid endarterectomy is associated with loss of the normal ventilatory and arterial pressure responses to acute hypoxia.
Bilateral recurrent laryngeal nerve injury and resultant bilateral vocal cord paralysis can result in life-threatening upper airway obstruction and may need emergent reintubation.
4. A 45 year old male involved in a motor vehicle accident requires intensive care for the management of fronto-temporal contusions. His GCS is 8. The following are the principles of management in traumatic brain injury according to the brain trauma foundation guidelines EXCEPT:

A. Maintain a cerebral perfusion pressure between 50-70 mmHg
B. Prophylactic hyperventilation to a PaCO$_2$ of 25 mmHg.
C. Hyperosmolar therapy with mannitol for intracranial hypertension
D. ICP monitoring

Go to Q 5
A. Maintain a cerebral perfusion pressure between 50-70 mmHg

Guidelines from the brain trauma foundation recommend that CPP be kept between 50-70mmHg (class II and III evidence). The key principle is to ensure adequate oxygen delivery by maintaining cerebral blood flow. According to the retrospective cohort study by Griesdale et al, the proportion of time spent less than 50mmHg in head injured patients was associated with increased mortality.

B. Hyperventilation to a PaCO2 of 25mmHg

Ventilation should be adjusted to maintain PaO2> 60 mmHg. Monitoring PaCO2 is recommended as the ETCO2 may be unreliable. Hypercarbia should be avoided. Hyperventilation to provide hypocarbia can cause cerebral vasoconstriction leading to ischemia. Hence hyperventilation should be used only in instances of acutely elevated ICP and normocarbia restored as soon as possible.

Ref: J Neurotrauma. 2008 Mar;25(3):276-8
The standard agent is mannitol which is recommended when there are signs of progressive neurologic deterioration not attributable to extra cranial causes. In patients with hypotension, severe traumatic brain injury refractory to mannitol, 7.5% hypertonic saline has shown to improve cerebral and systemic hemodynamics.

Ref: J Neurotrauma. 2008 Mar;25(3):276-8
Both hypotension and raised intracranial pressure are the leading causes of death in head injury. There is class II and III evidence to support the role of ICP monitoring in TBI patients. ICP measurements can be used to predict worsening of intracranial pathology, calculate cerebral perfusion pressure and allow drainage of cerebrospinal fluid.

5. The following statements regarding osmotic agents to lower intracranial pressure are true EXCEPT:

A. They create an osmotic gradient forcing fluid into the intravascular compartment
B. Mannitol and hypertonic saline (HTS) can cause hypernatremia
C. In a situation of low blood pressure, mannitol is preferable.
D. Treatment goals for osmotic agents include serum osmolality 310-320 mOsm/L
A. They create an osmotic gradient forcing fluid into the intravascular compartment

Osmotic agents like mannitol and hypertonic saline when used for treatment of raised ICP act by increasing serum osmolality, resulting in the creation of an osmotic gradient between the intravascular space and extracellular space in the brain. This gradient allows fluid from the cerebral parenchyma to be drawn into the serum, resulting in a reduction in cerebral edema, subsequently reducing ICP. Mannitol also “recruits intracellular fluid to the extravascular space” and cause further intracellular dehydration.

Ref: Earnest Alexander et al; AACN Advanced Critical Care; Volume 22, Number 3, pp.177–182, 2011.
B. Mannitol and hypertonic saline (HTS) can cause hypernatremia

Mannitol is freely filtered by the glomerulus and does not undergo tubular reabsorption. Thus, it acts as an osmotic diuretic, increasing urinary losses of both sodium and electrolyte-free water. Lack of replacement of the fluid losses can lead to both volume depletion and hypernatremia. Mannitol can also cause hyponatremia, metabolic acidosis (by dilution), and hyperkalemia.

Hypertonic saline administration has been shown to cause natriuresis Secondary to increased renal perfusion pressure and associated diuresis. Despite this natriuretic response, serum sodium increases after the administration of hypertonic saline. Prolonged hypernatremia may result in hypokalemia because of sodium and potassium exchange at the distal tubule of the kidney.
C. In a situation of low blood pressure, mannitol is preferable.

Mannitol can lead to diuresis and volume depletion aggravating hypovolemia. Hypertonic saline may be the osmotic therapy of choice in hypovolemic or hypotensive patients because it remains in the intravascular space, thereby expanding intravascular volume and increasing mean arterial pressure.
Continuous infusions of 3% hypertonic saline may be titrated to treatment goals of serum sodium of 145 to 155 mEq/L. For osmotic agents (mannitol and hypertonic saline) a serum osmolality of 310 to 320 mOsm/L should not be exceeded. A 3% sodium chloride solution has an osmolality of 1027 mOsm/L and contains 513 mEq/L of sodium, compared with 0.9% sodium chloride, which has an osmolality of 308 mOsm/L and contains 154 mEq/L of sodium.