

MANAGEMENT OF STROKE RELATED MALIGNANT BRAIN SWELLING

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CONDITION AND INCIDENCE

- Large volume ischemic strokes usually secondary to occlusion of the Internal Carotid Artery (ICA) and/or the Middle Cerebral Artery (MCA territory) can result in significant tissue edema and swelling (Malignant Cerebral Infarction/Swelling; MCI/MBS) and secondary herniation .
 - Subfalcine (lateral shift across midline)
 - Uncal (unilateral medial temporal lobe against brainstem)
 - Central (bilateral medial temporal lobes against brainstem)
 - Tonsillar (cerebellar tonsils against medulla)
- MCI/MBS incidence post ischemic stroke is <10%
- MCI/MBS mortality rate is 78%

NEUROLOGIC EXAM

- NIHSS >15
- Depending upon hemisphere dominance findings include
 - Hemiplegia
 - Aphasia (Dominant)
 - Neglect (Non-Dominant)
 - Visual field defect
 - Forced gaze deviation
- **FOR MANAGEMENT, DECISION MAKING, AND FAMILY/PATIENT COUNSELING UNDERSTANDING ELUCIDATING TRUE HANDEDNESS IS CRITICAL**
 - 90% incidence right handedness (Left brain dominant)
 - 10% incidence left handedness (11% of men and 9% of women)
 - Left handed are less lateralized for pure hemisphere dominance)
 - 1% incidence cross dominance (right and left hand preferred for different activities)
 - <1% ambidexterous (can equally use right and left hand for any activity)

IMAGING

- CT and MRI with stroke volume > 100+ cc or >50% of MCA territory
- Hyperacute period (<6-12 hours)
 - CT may be normal (ASPECT 10) or show early signs of ischemic brain
 - CTP may show large penumbra and/or core
 - MRI likely will show ischemic brain on DWI sequences
- Acute period (>6-12 hours)
 - CT more likely to show ischemic changes with ASPECT ≤ 7
 - CTP will likely show penumbra:core ≤ 1.8
 - MRI shows ischemic changes on DWI often >145 cc
- Ischemic tissue often shows evidence of intraparenchymal hemorrhage.

WHAT OFTEN PREDICTS MBI/MBS AND POOR OUTCOME?

- Younger age
- Higher (>18)NIHSS
- >50% low density or increased DWI signal in MCA territory
- Absent revascularization within 24h of ischemia onset
- Decreased LOC within 3h and no reaction to pain in first 24h
- Poor intracranial collateral circulation
- DWI volume >145 cc

MANAGEMENT SUMMARY

- Patients who present within 24 hours of stroke onset and who do not fall into the exclusion criteria for iv-TPA and/or Acute Stroke Intervention (ASI) will often undergo iv-TPA and/or endovascular thrombectomy/lysis.
- Patient admitted to ICU at Primary/Comprehensive Stroke Center
- Intubation and mechanical ventilation as indicated
- Blood pressure control
- Fluid management
- Decompressive craniectomy as indicated

INITIAL MEDICAL ICU MANAGEMENT

- Airway control with intubation if patient is unable to protect airway
 - Permits oxygenation and PaCO₂ control and may reduce aspiration
 - May require sedation and loss of reliable neurologic examination
- Blood Pressure Regulation to maximize CBF to penumbral tissue and minimizing risk of hemorrhagic conversion in ischemic tissue
 - SBP <220 mm Hg
 - DBP < 105 mm Hg
- Maintain serum glucose 140-180 mg/dL
- Isotonic fluids to reduce risk of increasing cerebral edema
 - Maintain serum Na >135.
- HOB 30 degrees
- Avoid anti-coagulation for 48h or longer if hemorrhage has occurred.
- SCD and low molecular weight heparin when safe for DVT prophylaxis
- NPO until cleared for dysphagia
- Q1H neurologic examination using accepted grading scales

MEDICAL MANAGEMENT IF MALIGNANT SWELLING DEVELOPS

- Pharmacologic paralysis to control RR and TV and eliminate muscle contraction and coughing which may raise ICP further
 - Hyperventilation
 - Goal PaCO₂ 30-35 mm Hg to vasoconstrict and reduce CBV, but not so low as to reduce CBF enough to worsen stroke
- Hypertonic saline, urea, and/or mannitol as temporizing measures to reduce edema by establishing an Osmotic gradient
 - 20% Mannitol 1-1.5g/kg bolus, then 0.5g/kg Q6H
 - Serum Osm <320 milliosmoles/kg
 - Hypertonic saline 14-23.4% at 50-30 cc boluses
 - Theoretical problem is Mannitol or Na entering dead tissue across disrupted BBB which would increase Osm and draw additional fluid into ischemic brain thus worsening edema and swelling
 - Theoretical problem is osmotic agents might preferentially dehydrate non-ischemic brain. This decrease in normal brain volume can further drive herniation of swollen brain towards healthy brain.

ADDITIONAL NON-SURGICAL OPTIONS

- Barbiturate induced coma to reduce electrical activity to isoelectric
 - Reduction in brain activity reduces CBF significantly thus reducing ICP
 - No randomized studies to show clear benefit
 - Risks include infection, cardiac injury
- ICP pressure monitoring
 - No proven benefit

DECOMPRESSIVE HEMICRANIECTOMY

- Removal of skull and opening of dura to permit swollen brain to expand out of skull rather than expand across compartments towards normal brain (herniation) thus damaging normal brain by compressing tissue, kinking arteries against fixed intracranial structures (dura, bone) and reducing blood flow to normal brain through ICP increase and concomitant CPP reduction.
- 12 cm diameter decompression recommended
- Margin of skull defect
 - Anterior to floor of anterior cranial fossa
 - Posterior to 4 cm behind EAC
 - Superior to 1 cm lateral to midline SSS
 - Inferior to floor of middle fossa

DECOMPRESSIVE HEMICRANIECTOMY OUTCOMES

- Best timing for surgery is unclear, but performance in large volume strokes prior (<24 hours from time of stroke) to signs of herniation may be beneficial.
- Randomized studies include DECIMAL, DESTINY, HAMLET, DESTINY II, HeADDFIRST revealed
 - mRS <6 at 12 months for DHC vs Medical group was 70% vs 31%
 - mRS ≤ 3 for DHC vs Medical group was 27% vs 14%
 - mRS 4-5 for DHC vs Medical group was 32% vs 10% and 11% vs 4%, respectively.
 - Mortality for both treatment arms in patients <60 and >60 years old and in various symptom onset times to surgery of 48h vs 96h were identical.
 - No clear benefit to surgery performed within 24 hrs of stroke
 - No benefit to surgery performed after 48 hours from time of stroke
 - Mortality at 12 months was lower in DHC group
 - DHC primary benefit is increased survival but this management yielded survivors with more severe disabilities.
- QUESTION: Is the increased chance of survival with DHC worth the increased risk of surviving with significant cognitive and physical deficits?
- ANSWER: There is no correct answer. DHC may best be reserved for patients under age 60 when performed within 48 hours of the ischemic event and only after carefully counseling the family about the benefit of having an increased chance of surviving with mRS ≤ 3 (compared to medical therapy alone) but the high risk of surviving with a severe disability.
- Other risks of DHC include:
 - Wound breakdown/necrosis secondary to scalp ischemia induced by large incision and surgical ligation of superficial temporal artery and occipital artery
 - Swollen brain herniation through defect and scalp breakdown
 - Seizures
 - Meningitis
 - Hydrocephalus
 - Brain hemorrhage as brain expands and fragile parenchymal vessels tear
 - Sinking flap syndrome