Brain Surgery While Awake

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Advantages of AC

• Decrease in complications related to general anesthesia, e.g. intubation,
• decrease in the dose of anesthetics, rapid recovery, likely decreased hospital stay
• Possibility of cortical mapping,
  – decreases morbidity
  – enhances degree of resection
  – helps to locate the least eloquent and safest entry for resection.
• Continuous neurological assessment during the resection provides an “on line” feedback
Definition of “eloquent” brain

- areas of brain that, if removed or stimulated, will result in loss of
  - sensory processing
  - linguistic ability
  - weakness/paralysis
  - visual changes
- Sensory area of anterior parietal lobe
- Motor cortex
- Language-related areas
- visual cortex
- hypothalamus and thalamus
- internal capsule
- brainstem

Significance of Tumor Location

- Adjusting for other known prognostic factors, patients with tumors in areas presumed to be eloquent had worse overall and progression-free survival
- Confirmation of tumor overlapping functional areas during intraoperative mapping was strongly associated with shorter survival (OS, HR 9.6, 95% CI 3.6-25.9).
- In contrast, when mapping revealed that tumor spared true eloquent areas, patients had significantly longer survival, nearly comparable to patients with tumors that clearly involved only noneloquent areas, as demonstrated by preoperative imaging (OS, HR 2.9, 95% CI 1.0-8.5).
Should all eloquent cases be done awake?

Surgery in Eloquent Cortex

- Current advances improve our understanding of anatomic and functional characteristics of surgical area to prevent neurological morbidity
- Emerging imaging technologies
- Advancing intraoperative techniques widen extent of resection
- Mapping of motor and language pathways has become well-established for the safe resection of intrinsic tumors.

Operative Techniques in Eloquent Cortex

- Craniotomy under general anesthesia
  - Image-guidance integration functional MRI data, DTI
  - Intraoperative SSEP, phase reversal and cortical stimulation
- Advantages
  - Pt immobile during Sx
  - Easier management of anesthetics
  - Improved ventilation/oxygenation
  - Easier to teach when pt is asleep
- Disadvantages
  - Operating blindly potentially causing damage
  - Brain shift over convexity may render image-guidance inaccurate / unreliable
  - “Fear” to resect “too much” and cause harm
  - Potentially less aggressive resections
Operative Techniques in Eloquent Cortex

- **Craniotomy under general anesthesia**
  - image-guidance integration functional MRI data, DTI
  - intraoperative SSEP, phase reversal and cortical stimulation

Operative Techniques in Eloquent Cortex

- **Awake Craniotomy**
  - image-guidance integration functional MRI data, DTI
  - intraoperative SSEP, phase reversal and cortical stimulation
  - **Advantages**
    - Direct and most accurate feedback from the patient
    - Brain shift can be compensated for by ongoing “live” monitoring
    - Possibly improved extent of resection
    - Possibly improved outcome and survival
  - **Disadvantages**
    - NOT for EVERYBODY: Pts move, cough, scream...
    - Brain can fungate through craniotomy
    - Respiratory problems
    - Even the most stoic pts can’t stay calm for longer than 2 hours
    - Not suitable for lesions extending to skull base or involving larger vessels
    - Seizures

Imaging of Eloquent Cortex

- f-MRI (sensitivity 81%, specificity 53%)
- DTI
- Magnetoencephalography
- Still relatively imprecise
- Brain shift

Imaging of Eloquent Cortex

Does extent of resection matter?

- The greatest risk of tumor recurrence is within 2 cm of the contrast enhancing rim on neuroimaging
- Growing body of evidence to suggest the extent of resection may correlate with PFS and even outcome

Cortical Mapping Strategies

- Identification of language and motor areas
- Causes depolarization of a very focal area of cortex → evokes certain responses
- Local excitation of neurons
- Orthodromic and antidromic propagation
- Accuracy approaches 3-5 mm with modern bipolar stimulators
Cortical Mapping Strategies

- “Positive” vs “negative” sites
- More tailored approaches
- Smaller exposures
- Time efficient
- < 2 h

Negative / Positive mapping

- Negative mapping of eloquent areas provides a safe margin for surgical resection with a low incidence of neurological deficits.
- However, identification of eloquent areas not only failed to eliminate but rather increased the risk of postoperative deficits, likely indicating close proximity of functional cortex to tumor.

Language Localization Challenges

- Variability of language areas
- Study of temporal lobe resections with subdural grids showed the distance from temporal pole to the area of language function ranged from 3 to 9 cm
- Use of intraoperative cortical and subcortical stimulation is essential for safety and improvement in extent of resection
Language Localization Challenges

- if the distance of the resection margin from the nearest language site is greater than 1 cm, significantly fewer permanent language deficits occur


Anesthesia Considerations

- Experienced anesthesia team / CRNA
- Midazolam for premedication
- Monitoring: a-line axillary temperature probe
- Sedation with propofol (up to 100 g/kg/min) and remifentanil (0.05 g/kg/min and higher)
- Propofol/remifentanil boluses for Foley and head pinning.
- 1% lidocaine gel to lubricate Foley
- Scalp ring block with 1% lidocaine with epinephrine/05% marcaine.
- Intravenous methohexital (10 mg/mL), and ice cold saline available for seizure control.
- Optional dexmedetomidine (up to 1 g/kg/min) and remifentanil
  - (0.05 g/kg/min and higher) after mapping

Taylor MD, Bernstein M. Awake craniotomy with brain mapping as the routine surgical approach to treating patients with supratentorial intraaxial tumors: a prospective trial of 230 cases. J Neurosurg 1995;83:55–51.

Local anesthesia

- Ring block
- Along the incision
- Mixture of 1% Lidocaine with epinephrine and 0.25% Marcaine
AC technique

- Sedated + Local
- Awake + Local
- Sedated + wearing off local

Technique

- Lateral
- supine

Technique

- Minimal shaving
- Craniotomy cranietomy exposing tumor and up to 1.5 cm around it
- Grids placed to locate sensory-motor cortex while pt asleep
- Dural opening
- Cortical mapping is started at a low stimulus (1.5 mA) and increased to a maximum of 10 mA,
- 10 to 15 stimulated points per patient, positive sites marked with sterile number tags
- afterdischarge potentials via grid recording,
- number counting, spontaneous speech, naming, motor activity continuously throughout resection phase
Technique

2 entries

Anterior

Medial
We can make picture look pretty, but what’s the evidence?

What is the Evidence?

- Numerous studies
- Various issues
  - Outcomes
  - Techniques
  - Ethical concerns
  - Comparison to crani under general anesthesia...

AC vs surgery under general anesthesia in eloquent and non-eloquent areas

- prospectively compared 2 groups who underwent surgery for supratentorial lesions: (AC group, n = 214) and (GA group, n = 361, including 72 patients with lesions in eloquent areas).
- 2 groups were comparable in terms of sex, age, pathology, size of lesions, quality of resection, duration of surgery, and neurological outcome, and different in tumor location and preoperative neurological deficits (higher in the AC group).
- However, specific data analysis of patients with lesions in eloquent areas revealed a significantly better neurological outcome and quality of resection (P < .001) in the AC group than the subgroup of GA patients with lesions in eloquent areas, they were discharged home sooner.

CONCLUSION:
- AC with brain mapping is safe and allows maximal removal of lesions close to functional areas with low neurological complication rates. It provides an excellent alternative to craniotomy under GA.

AC for tumors near eloquent cortex:

- 309 Patients with tumors near and/or within eloquent cortex
- Craniotomy was tailored to encompass tumor plus adjacent areas presumed to contain eloquent cortex.
- Intraoperative cortical stimulation for language, motor, and/or sensory function was performed in all patients to safely maximize surgical resection.

RESULTS:

- A gross total resection (90% or >95%) was obtained in 64%, and a resection of 85% or more was obtained in 77% of the procedures.
- Eloquent areas identified in 65% of cases, and in that group, worsened neurological deficits were observed in 21% of patients, whereas only 9% with negative mapping sustained such deficits (P < 0.03).
- Overall, intraoperative neurological deficits occurred in 64 patients (21%); of these, 25 (39%) experienced worsened neurological outcome at 1 month, whereas only 27 of 245 patients (11%) without intraoperative changes had such outcomes (P < 0.002).
- At 1 month, 83% overall showed improved or stable neurological status, whereas 17% had new or worse deficits; however, at 3 months, 7% of patients had a persistent neurological deficit.
- Extent of resection less than 95% also predicted worsening of neurological status (P < 0.025).

AC in Elderly Patients

- 334 young (45.4 ± 13.2 years, mean ± SD)
- 90 elderly (71.7 ± 5.1 years) patients
- Significantly more younger patients had a better preoperative Karnofsky Performance Scale score (>70) than elderly patients (P = 0.0012).
- Elder patients harbored significantly more high-grade gliomas (HGG) and brain metastases, and fewer low-grade gliomas (P = 0.0001).
- No significantly higher rate of mortality, or complications were observed in the elderly group.
- Age was associated with increased length of stay (4.9 ± 6.3 vs. 6.6 ± 7.5 days, P = 0.01).
- Maximal extent of tumor resection in patients with HGG was associated with prolonged survival in the elderly patients.

CONCLUSIONS:

- Awake-craniotherapy is a well-tolerated and safe procedure, even in elderly patients. Gross total tumor resection in elderly patients with HGG was associated with prolonged survival. The data suggest that favorable prognostic factors for patients with malignant brain tumors are also valid in elderly patients.

Psychological Sequelae of Awake Craniotomy

- 16 patients undergoing an awake surgery were surveyed with a self-developed questionnaire, the Posttraumatic Stress Disorder Inventory for Awake Surgery Patients, which adopts the core components of the Diagnostic and Statistical Manual of Mental Disorders (Fourth Edition) posttraumatic stress disorder (PTSD) criteria.
- The mean time between surgery and data collection was 97.3 ± 93.2 weeks.

RESULTS:

- 44% stated they had experienced either repetitive distressing recollections or dreams related to the awake surgery.
- 18.8% stated persistent avoidance of stimuli associated with the awake surgery.
- Symptoms of increased arousal occurred in 62.5%.
- 2 patients presented with postoperative psychological sequelae resembling PTSD symptoms.
- Younger age and female sex were risk factors for symptoms of increased arousal.
- Possible long-term effects of an awake surgery should be considered and discussed with the patient when planning this type of surgery.
Complications

- General surgical complications
  - Bleeding
  - Infection
  - Wound healing problems
  - Cosmetic issues
  - Pain and numbness in incisional area

- Location-specific complications
  - Speech and understanding problems
  - Motor deficit
  - Visual

- Seizures

Possible pitfalls

- Excessive IV sedation
  - use nasal trumpet,
  - laryngeal mask
  - even intubation to secure airway

- If become restless and uncooperative
  - mapping has to be stopped and further resection continued under sedation.

- Proper selection
- Detailed preoperative counseling are essential

Prospective study of awake craniotomy used routinely and nonselectively for supratentorial tumors.

- 610 patients underwent awake craniotomy for supratentorial tumor resection.
- Intraoperative brain mapping used in 511 cases (83.8%).
- Mapping identified eloquent cortex in 115 patients (22.5%) and no eloquent cortex in 396 patients (77.5%).
- Neurological deficits occurred in 89 patients (14.6%).
- Deficits more common in patients with preoperative neurological deficits or in whom mapping successfully identified eloquent tissue.
- Twenty-five (4.9%) of the 511 patients suffered intraoperative seizures, and two of these individuals required intubation and general anesthesia.
- Four (0.7%) of the 610 patients developed wound complications.
- Postoperative hematomas in seven patients (1.1%), four of whom urgently required a repeated craniotomy to allow evacuation of the clot.
- Two patients (0.3%) required readmission to the hospital soon after being discharged. There were three deaths (0.5%).

Intraoperative seizures during awake craniotomy

- 477 with complete records identified.
- 60 (12.6%) experienced intraoperative seizures.
- The AC procedure failed in 11 patients (2.3%) due to seizures.
- Patients with intraoperative seizures were significantly younger (45 ± 14 years vs 52 ± 16 years, P = .003).
- Higher incidence of frontal lobe involvement (86% vs 57%, P < .0001).
- Higher prevalence of a history of seizures (P = .008).
- Short-term motor deterioration developed postoperatively in a higher percentage of patients with intraoperative seizures (20% vs 10.1%, P = .02).
- Longer admission (4.0 ± 3.0 days vs 3.0 ± 3.0 days, P = .045)

Conclusions

- Awake craniotomy appears
  - Safe and well tolerated in various age groups
  - Neurodeficits are predictable
  - Probably associated with more aggressive resection, possibly longer PFS and better outcome
- It is unlikely that a prospective, randomized study will ever be conducted, retrospective, matched studies or prospective observational trials may be more practical

Thanks!