Awake neurosurgery: an update

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ABSTRACT

Intraoperative brain mapping has the goal of aiding with maximal surgical resection of brain tumors while minimizing functional sequelae. Retrospective randomized studies on large populations have shown that this technique can optimize the surgical approach while reducing postoperative morbidity. During direct electrical stimulation of the language areas adjacent to the tumor, the patient should be collaborative and be able to speak to participate in language testing. Different anesthesiological protocols have been proposed to allow intraoperative brain mapping, which range from local anesthesia to conscious sedation or general anesthesia, with or without airway instrumentation. The most common intraoperative complications are seizure, respiratory depression, and patients' stress and discomfort. Since awake craniotomy carries both benefits and potential risks, the following factors are crucial in the management of patients: 1) careful selection of the patients and 2) communication between the anesthesiological and surgical teams. To date, there remains no consensus about the optimal anesthesiological regimen to use. Only prospective, multicentre randomized studies focused on evaluating the role of different anesthesiological techniques on intraoperative monitoring, postoperative deficits, and intraoperative complications can answer the question of which anesthesiological approach should be chosen when intraoperative brain mapping is requested.

Key words: Brain mapping - Brain neoplasms - Anesthesia.

«We all know there is no "little man' sitting in the pineal gland where the seventeenth century philosopher, Rene Descartes, seemed to visualize him. Consciousness is not something to locate in space. But the neuronal activity that accompanies it is. Sensation and movement and speech and perception are not located in special areas of the cerebral cortex. But there are cortical areas that can be delimited with increasing exactness for each of these functions. These cortical areas are parts of special mechanisms. In each of them one may identify the neuron transactions without which the corresponding mental phenomena are impossible. The action of each mechanism depends upon the cortical area, together with its connections to underlying thalamus and other parts of the higher brain stem. Interference with brain-stem action results in unconsciousness. Cortical removals deprive a man only of one or more of his functional capacities».

The above statement by Wilder Penfield, a pioneer [1] in intraoperative direct electrical cortical stimulation for epilepsy surgery, implies that surgical resection of supratentorial tumors carries the risk of depriving a man of functional capacities while leaving him aware of his own deficits. Consistent with this idea, the current neurosurgical approaches for the treatment of cerebral tumors, while playing a major role in improving patient survival with a more extensive tumor resection, also carries the potential of producing cognitive and functional loss and decreasing a patient's quality of life. Thus understanding the localization of important functional areas such as those for language and movement in the human brain is crucial in the surgical decision making processes. By combining preoperative functional imaging and tractography with direct electrical stimulation of cerebral structures during intraoperative tumor resection, both cortical and subcortical pathways within and near the intrinsic cerebral tumors can be identified and preserved in order to avoid permanent morbidity.[3, 4] Moreover, functional imaging and electrical stimulation of the brain[5] have given insights about the location of specific neurological functions, their integration and connections, anatomical and functional interindividual variability, and brain plasticity,[6] memory and awareness.[2, 7] Currently, no prospective randomized studies have been done to examine the role of intraoperative brain mapping in decreasing postoperative deficits and improving both patient survival and quality of life as compared to standard neurosurgery. However, previous retrospective studies on intraoperative brain mapping carried out in large populations revealed the possibilities of increasing the margins and quality of tumor resection within the speech areas, decreasing the risk of sequelae, and thus improving survival.[3, 4] These results are now generally accepted as self-evident in practice and thus do not require testing in randomized studies.

Awake craniotomy

Originally developed to allow accurate localization of epileptic foci in the dominant hemisphere with minimum risk of postoperative language disturbances, intraoperative brain mapping has been widely applied for tumor resection near the language as well as the motor areas. Wilder Penfield described the technique with these words:[1, 7] «*my special province has been the surgical treatment of epilepsy, removing abnormal areas of the brain, areas in which the unbridled electrical discharges arise that produce epileptic seizures. There are many brain areas that can be removed with little or no detectable functional loss. During such surgical procedures, the skull is opened and the brain exposed under local anesthesia, while the patient lies on the operating table fully conscious. Only thus is the cause of the attack to be found, and the surgeon's hand guided. The patient talks and answers the surgeon's questions while he maps out the various functional areas by applying a gentle electrical stimulus here and there on the cortex. The pattern of fissures and convolutions […] is never twice the same. The electrode is needed for orientation*».

The most common anesthesiological approach has been local anesthesia, as described above.[2] This approach meets the need to maintain patients in an awake and cooperative state in order to decrease false negative results during stimulation of language areas. Later, anesthesia is usually provided using a combination of local anesthesia (local infiltration and regional blockade) and intravenous (i.v.) medications to provide sedation, anxiolysis, and supplemental analgesia during long procedures.[8] Inadequate analgesia during craniotomy and prolonged sedation interfering with brain mapping can be major drawbacks of this technique. The need to minimize interference with other intraoperative neurophysiological monitoring methods such as electrocorticography (electrodes over the cortex) and electromyography has limited the repertoire of drugs available for sedation. Traditionally, neuroleptoanalgesia using a combination of opioid (often fentanyl) and droperidol has been used.[9] Since the 1990s, the use of propofol sedation during these procedures has become increasingly popular, and it is usually coupled with an opioid drug such as fentanyl or, more recently, remifentanil.[10-13] In particular, propofol and remifentanil are short acting, titratable, and rapidly cleared i.v. anesthetics that have allowed for the development of asleep-awake-asleep anesthesia. In these cases, general anesthesia is maintained during patients' positioning, preparation, and the actual craniotomy procedures, but this is followed by rapid emergence from anesthesia for intraoperative brain mapping. After the tumor is resected, the patients then return to sleep during closure. With this technique, there is less stress and discomfort for the patients, and the procedure takes less time. However, this asleep-awake-asleep technique is still not widely accepted because it requires either airway instrumentation or some kind of airway control during spontaneous ventilation. Thus, the combination of propofol and an opioid, though more time consuming to administer than local anesthesia, may be preferable for long procedures and challenging intraoperative brain mappings. Currently, awake surgery is challenging for the anesthetist who is called upon not only to balance good analgesia and sedation, but also to not interfere with the intraoperative monitoring while ensuring airway and hemodynamic control. Newer drugs such as dexmedetomidine, which have not been made available worldwide, have been used and dexmedetomidine in particular has been reported to give higher level of sedation without producing respiratory depression compared to opioids.[5, 14]

Complications

As far as intraoperative complications are concerned, the incidence of intraoperative seizures during either awake or asleep craniotomies is highly variable in the literature with an average of 9.5%, but a range of 0% to 24%.[15] This high variability could be due to different seizure definitions, retrospective data collections, different durations and characteristics of brain mapping, and different tumor and patient characteristics. Most of the seizing can be resolved by irrigation of the surgical field with cold saline or administration of propofol, but occasionally, reintubations are necessary in awake patients. Prophylaxis with phenytoin or other antiepileptic drugs in the preoperative period should be used to decrease the occurrence of major intraoperative complications.[8] As mentioned above, respiratory depression represents the other common complication reported during awake craniotomy with i.v. analgesia and sedation, and many different airway instrumentations have been proposed ranging from laryngeal mask airway to nasal trumpets.[10, 11] Moreover, increased arterial pressure and tachycardia have been reported during painful phases and emergence from anesthesia, and it seemed reasonable to consider the use of short acting vasodilators as prophylactic adjuncts at the time of head fixation or rapid emergence. Prospective randomized studies comparing different anesthesiological approaches are also lacking in the literature. Therefore, very few conclusions about the best anesthesiological approach can be easily drawn from the available data.[10, 11]

Patient selection

Since awake craniotomy carries both benefits and potential risks, two main factors must be considered in the management of patients: 1) careful selection of the patients and 2) communication between the anesthesiological and surgical teams. For example, patients who are scheduled to be tested with intraoperative stimulation of only the motor function can be maintained with secured airways under general anesthesia with low dosages of anesthetics that do not induce paralysis so that observations of movements and electromyography (asleep craniotomy) can be performed. On the other hand, patients with tumors located in the temporal lobe of the non-dominant hemisphere without any involvement of language functions might be asked to be awake in order to perform intraoperative visual-spatial tasks.[5] Above all, patients have to be compliant, have a good language capacity, and be aware of the potential benefits and risks associated with the procedure.

Conclusions

In conclusion, different anesthesiological protocols can be used in neurosurgery cases involving intraoperative brain mapping. Numerous techniques have been described from local anesthesia to conscious sedation or general anesthesia, with or without airway instrumentation. There is currently no consensus about the optimal regimen to use: each institution chooses its own techniques to suit the needs of the surgeon, and their individual expertise and preferences while considering different patients' characteristics and procedure durations. Can the postoperative outcomes and extension of resection be validly compared between different groups undergoing different anesthesiological managements? Only prospective, multicentre randomized studies directed at evaluating the role of different anesthesiological techniques on intraoperative monitoring, postoperative deficits, and intraoperative complications can answer the question of which anesthesiological approach should be chosen when intraoperative brain mapping is requested.

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