Principles of anesthesia for craniotomy in awake patients
Principios de la anestesia para craneotomía en paciente vigil

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Resumen

La realización de una craneotomía con el paciente despierto se está utilizando cada vez más en diversas situaciones, como en neurocirugía funcional sobre la estimulación cerebral para tratar la enfermedad de Parkinson y la cirugía para tratar la epilepsia, así como los procedimientos neuroquirúrgicos destinadas a resección de tumores cerebrales en áreas elocuentes. Los principios anestésicos para realizar la craneotomía despierta tienen el objetivo de realización de una analgesia adecuada, sedación, la estabilidad hemodinámica sistémica y la permeabilidad de la vía aérea con el tipo de procedimiento neuroquirúrgico a realizar. El objetivo de este estudio es revisar los principios que rigen la conducta de la anestesia para la neurocirugía que es necesario para lograr la craneotomía con el paciente despierto.

Palabras clave: Anestesia equilibrada, conciencia en pre operatorias, craneotomía, procedimientos neuroquirúrgicos.

Abstract

Craniotomy in awake patients is becoming more widely used in a range of situations, such as functional neurology, brain stimulation for treatment of Parkinson disease, surgery for treating epilepsy, as well as in neurological procedures to resect brain tumors in eloquent area. The main anesthesia regimen for craniotomy in the awake patient is chosen to provide the appropriate analgesia, sedation, systemic hemodynamic stability and airway patency for the type of neurosurgical procedure being carried out. The objective of the present study was to conduct a review of the principles governing anesthesia for neurosurgeries involving craniotomy in awake patients.

Key words: Intraoperative Awareness, Balanced Anesthesia, Neurosurgical Procedure, Craniotomy.

Introduction

The main anesthesia regimen for craniotomy in awake patients is chosen to provide the appropriate analgesia, sedation, systemic hemodynamic stability and airway patency for the type of neurosurgical procedure being carried out. The overall objective is to keep the patient awake, cooperative and comfortable[1]. Currently, craniotomy in awake patients is widely employed in the field of functional neurosurgery, brain stimulation for treating Parkinson´s disease and in surgery of the treatment of epilepsy, and is also used in neurosurgical procedures for resecting brain tumors in eloquent cortex[2].

Awake craniotomy is indicated for resection of supra-tentorial tumors in eloquent cortex, where it is beneficial to be able to monitor patient speech as well as motor and visual functions. The advantages over conventional tumor resection are: more accurate diagnosis of the lesion, reduction of the size of the lesion prior to adjuvant therapy, reduced neurological deficit post-operatively, shorter hospital stay and lower perioperative morbidity[1].

Some pre-requisites are fundamental for successful craniotomy in awake patients. The patient must be carefully selected and be cooperative, have good discourse ability, no restrictions to remaining stationary for long periods and also have normal airway exams[1].
The objective of the present study was to conduct a review of the principles governing the anesthesia for neurosurgeries involving craniotomy in awake patients.

Pre-anesthesia assessment

Awake craniotomy is a characteristically elective procedure. This allows thorough pre-anesthesia assessment that yields pertinent information on the medical history of the patient and their physical and mental condition. When present, neurological deficits and the pattern of convulsive seizures must also be identified[3].
Patients exhibiting confusion, impaired communication, extreme anxiety, that require surgical positioning in ventral decubitus, as well as situations involving highly painful procedures and inability of the patient to remain still, are all exclusion criteria for the procedure [3,4]. Severe obesity (BMI > 40 kg/m^2), obstructive sleep apnea, symptomatic gastroesophageal reflux, altered mental state, dysphasia, large vascular tumors and major involvement of the dura mater are also cited in the literature as criteria for exclusion for the procedure[4].
During pre-anesthesia assessment, procedures for fasting must be followed and the airways rigorously assessed[5]. Pre-anesthesia medications are not recommended because they may blunt the senses. In order to avoid distortions on electrocorticography, drugs such as benzodiazepines must not be prescribed[3].
Anticonvulsants and antiparkinsonian drugs must be maintained up until a few hours prior to the procedure[6]. However, it is important to emphasize that the maintenance of monoamine oxidase inhibitors remains controversial in the literature[7]. Patients submitted to deep brain stimulation for the treatment of Parkinson´s Disease, when their medications are withdrawn pre-operatively, may present greater rigidity during infusion of opioids[5].
The psychological preparation of the patient should be carried out through clarifications given during the pre-anesthesia visit. All of the details of the surgery should be explained and the need for patient collaboration during the procedure should be emphasized. Patients should be made aware of the possibility of nausea, vomits and convulsive seizures during the intra-operative and post-operative periods, among other potential complications[3].

Monitoring

Anesthesia monitoring is essential during awake craniotomy for early detection of physiological changes and prevention of future complications. Such monitoring includes electrocardiogram, pulse oximetry, invasive arterial pressure and capnography. Additional monitoring can be performed using the BIS (Bispectral index score)[1].

Patient positioning

After anesthesia induction, due care must be taken over the positioning of the patient to prevent potential nervous-vascular, muscle-ligament or ischemic lesions caused by compression or traction. Patient position should be comfortable, avoiding pressure on vulnerable tissues. The surgical team must be able to see and hear the patient and the patient must be able to see and hear the team[5].

Airway management

Safely maintaining the airway is one of the major concerns involved in this type of procedure. This special care is due to the possibility of over-sedation of the patient which, along with certain positions and potential co-morbidities, can cause airway obstruction, respiratory depression and even bronchoaspiration. The mandible elevation maneuver and manual ventilatory support may be necessary[1]. The devices used for maintaining the airway include a Guedel cannula, nasopharyngeal cannula and, when general anesthesia is used, a laryngeal mask and orotracheal tube[5].
Removal of the airway devices during the procedure must be done with care as this can lead to coughing and the Valsalva maneuver, a situation that increases intracranial pressure and must therefore be avoided[5].
Reinsertion of these devices after concluding verbal communication can be challenging. Surgical positioning of the patient and the presence of a stereotactic fixation system are factors hampering reinsertion of the supraglottic devices and direct laryngoscopy. Thus, in the event that positioning of this supraglottic device proves ineffective or direct laryngoscopy is hindered, orotracheal intubation can be performed using flexible fiberoptic bronchoscopy[2].

Anesthesia technique

The anesthesia techniques available in awake craniotomy are: local anesthesia with or without conscious sedation and anesthesia using the “asleep - awake - asleep” technique with or without airway instrumentation[2]. In the latter approach, the patient remains anesthetized during the craniotomy and is awakened when collaboration is required. The choice of anesthesia technique depends on the surgical procedure to be performed.
Infusion of propofol at slightly higher doses than those used for sedation are the basis of anesthesia for the “asleep - awake - asleep” technique. Continuous propofol infusion appears to be safe, even when the airway is not protected by endotracheal intubation or laryngeal mask insertion. Advantages of propofol use include: fast switch in level of sedation or anesthesia, lowering of brain metabolic rate and reduction in cerebral blood flow. Its neuroprotective effect is attributed to its antioxidant activity[8]. Propofol interacts with gamma-aminobutyric acid (GABA), leading to excitation of the central nervous system which results in movements simulating tonic-clonic seizures known as non-epileptic myoclonus[5]. In addition, the drug has anticonvulsant activity and its use is associated with lower intracranial pressure relative to inhalatory agents[8].
Volatile anesthetics should be avoided since at high doses these may cause vasodilation, increasing intracranial pressure[5]. These drugs may also cause distortion of the electroencephalographic trace, constituting a dose-dependent phenomenon. The use of short-acting non-depolarizing neuromuscular blockers should only be indicated if intubation is part of the technique. It should be pointed out that many patients are in use of anticonvulsant medication, and therefore higher doses may be needed[5].
Remifentanil provides good sedation potential for the awake craniotomy procedure since it allows change of the patient´s sedation state together with low potential for post-operative agitation and low incidence of convulsions[5]. Bilgin et al.[9] assessed the hemodynamic parameters of patients submitted to

stereotactic brain biopsy and compared the effects of three opioids: alfentanil, fentanyl and remifentanil. All three drugs showed similar hemodynamic and ventilatory responses but fentanyl bolus resulted in greater hemodynamic instability than remifentanil or alfentanil infusion.

There is a growing body of evidence on the potential of dexmedetomidine in the process of conscious sedation of patients submitted to awake craniotomy. This drug is a highly specific aplha-2 agonist and exhibits ansiolytic, analgesic and sedative potential, preserving ventilatory autonomy. Properties of the drug include sympatholytic and antinociceptive activity, which provides greater hemodynamic stability during critical periods of neurosurgical stimulation[10]. Also, during brain mapping of epileptic patients, dexmedetomidine ensures sufficient sedation at a dose of 0.1-0.2 mg/kg/min without the need for inserting a supraglottic device[11].

Sarang and Dinsmore[1], in a retrospective study assessing the records of patients submitted to awake craniotomy for tumor resection, subdivided the sample into three groups according to anesthesia technique employed. Patients in group 1 were sedated with fentanyl, midazolam or droperidol in combination with local infiltration using bupivacaine 0.25% and lidocaine 0.5% and kept on spontaneous ventilation. Patients in groups 2 and 3 were submitted to the "asleep-awake-asleep" technique and placed on ventilation with laryngeal mask. Group 2 was anesthetized with infusion of propofol and fentanyl, and infiltration using bupivacaine 0.25% and lidocaine 0.5%, whereas group 3 was anesthetized using propofol, remifentanil and infiltration with bupivacaine 0.5%. The authors concluded that patients from group 3 had more favorable outcomes, fewer complications, absence of hypercapnia and no need for additional analgesia during the post-operative period[1].

The group with the most favorable outcome was monitored using the BIS (bispectral index score) and used laryngeal mask and controlled ventilation until tumor exposure. The venous infusion rates of propofol and remifentanil were adjusted according to patient hemodynamic response and BIS. Remifentanil infusion was 0.05 to 2 μg. kg $^{-1}$.min^{-1} in anesthetized patients and 0.005 to 0.01 μg. kg $^{-1}$.min^{-1} in awake patients. Upon tumor exposure, remifentanil infusion was reduced, the patient commenced spontaneous ventilation, the laryngeal mask was then removed and propofol infusion discontinued. After tumor resection, the patient was anesthetized and laryngeal mask reinserted[1].

In the same study[1], the authors noted the following anesthesia complications associated with the procedures in the three groups studied: pain, nausea and/or vomits, excessive sedation, decline in oxygen saturation (< 90%), hypercapnia, hypoventilation (rr < 8 bpm), airway obstruction, hemodynamic changes such as systolic arterial pressure < 80 mmHg or > 170 mmHg, bradycardia (< 40 bpm) or tachycardia (> 110 bpm) and neurologic complications such as brain edema, convulsions or development of new neurologic deficit. In group 2, 34% of patients presented hypercapnia, 24% reported pain during the procedure and 11% had arterial hypertension. Arterial hypertension was the main complication of patients in group 3 (4% of patients) while airway obstruction was the leading complication found in patients from group 1 (3% of patients)[1].

Costello and Cormack[12], based on their years of experience, reported the main obstacles to achieving successful outcomes during anesthesia for awake craniotomy. According to the authors, professionals should be alert to controlling the following issues: pain, airway obstruction, nausea, vomits and convulsions. Intra-operative pain occurred mainly during head fixation, dissection of the temporal muscle, traction of the dura close to the territory of the meningeal artery and of the intracerebral blood vessels. Airway obstructions occurred when the need for analgesia exceeded the sedation doses. Episodes of nausea and vomiting associated with inadequate analgesia and with hypovolemia and during surgical manipulation of the dura mater, temporal lobe and amygdala were also observed. Convulsions were also observed, particularly due to cortical stimulation or as a result of low level of anticonvulsants or toxicity of the local anesthesia. The authors also highlighted the role of successful local anesthesia in preventing these outcomes[12].

Local anesthesia

Observing the different surgical timepoints is paramount for assessing intraoperative pain. Two timepoints are associated with highest pain potential: head fixation with pins for proper positioning, and during dissection of the temporal muscle due to traction on the dura mater and blood vessels. Current techniques recommend the use of infiltrative anesthesia of the scalp with local anesthetic and continuous sedation with short-acting drugs such as remifentanil[5].

In a prospective, randomized, controlled study, Geze et al.[4] compared the effects of local infiltration of the scalp with that of infiltration of the sensitive branches of the trigeminal nerve on the hemodynamics and stress responses in patients submitted to general anesthesia for craniotomy. The study compared local infiltration into the scalp during skull-pin placement (5 ml of 0.5% bupivacaine) in combination with infiltration of the line of surgical incision of the skin (20 ml bupivacaine at 0.5%) versus block of the sensitive branches of the trigeminal nerve (2-5 ml bupivacaine at 0.5% at each site). The authors concluded that the selective block of the trigeminal nerve was more effective in controlling hemodynamic responses and preventing stress hormone increases[4].

The technique for selectively blocking the sensitive branches of the trigeminal nerve is based on infiltration of six nerves: aurículotemporal, zygomatic, supraorbital, supratrochlear, greater occipital and lesser occipital. The literature recommends associating the block of the sensitive nerves of the trigeminal with infiltration of the site of the fixation pins, as well as the area of skin incision[2]. This approach provides satisfactory and safe local anesthesia, using the block with local anesthetic solutions at sufficient concentrations and volumes. The safest options, taking into account their cardiotoxicity and neurotoxicity, are ropivacaine and levobupivacaine. The use of solutions with adrenalin is preferable to extend the duration of the block, minimize acute increases in plasma levels and avoid toxicity by the local anesthetic[12].

Psychological aspects

Regarding the psychological component of the procedure, a study of patient perceptions during the awake state[13] revealed that the procedure was tolerable when patients are given explanatory information about it. Around 20%

of patients were cooperative, although could not recall being awake, 20% remembered experiencing slight discomfort, 30% were anxious, and 15% reported feeling scared[1].

Conclusions

The principles of anesthesia for awake craniotomy require a skilled anesthetist to perform hemodynamic and pharmacologic management. This procedure requires the use of advanced devices for controlling the airway and an anesthetist experienced in their use.
The medical team must be aware of the need for high quality local anesthesia to control intra-operative pain. The doctor-patient relationship during this procedure is of fundamental importance. The patient must be prepared for the procedure through the provision of information and dispelling of fears. It is vital that patients are cooperative and have preserved cognitive ability.
Ideally, an institutional protocol should be devised by a multi-disciplinary team defining the inclusion and exclusion criteria for this procedure. The anesthesia protocol should be designed with the aim of optimizing the anesthesia, reducing complication rates and increasing anesthesia quality.

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