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Anesthetic management of awake craniotomy in the University Hospital of Lausanne

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Abstract

Background: Awake craniotomy (AC) may be required when neurological injury is affecting eloquent areas of the brain. Several anesthetic approaches have been proposed such as the asleep-awake-asleep (AAA) technique, the conscious sedation and recently the awake-awake-awake technique. Our institution follows a conscious sedation protocol since 2008 with the use of dexmedetomidine as the main anesthetic agent. The aim of this study is to review the anesthetic management of AC in our institution following our current protocol.

Methods: Retrospective single center analysis of all anesthetic data of patient who underwent an awake craniotomy since the beginning of this technique in the CHUV. Data concerning preoperative, intraoperative management and postoperative data were recorded, as well as complications and their management.

Results: Combination of dexmedetomidine and remifentanyl was the most used regimen for AC in our institution. The most frequent complications were respiratory and hemodynamic problems. Intraoperative hypotension (19.3%) was followed by hypoxemia (19.2%), hypertension (12.9%), bradycardia (6.4%), nausea (3.2%) seizure (3.2%) as encountered complications.

Conclusion: Our retrospective single institution study demonstrates the reliability of a dexmedetomidine based conscious sedation protocol with a few intra-operative complications and without major occurrence. For a majority of patient analgesia was insufficient with DEX only, remifentanyl was introduced. Prospective randomized trials are needed to determine which approach and anesthetic regimen are the most effective for the management of awake craniotomy.

Keywords: *awake craniotomy, conscious sedation, asleep-awake-asleep, dexmedetomidine.*

Background

Indications for neurosurgery depend on clinical symptoms, type of pathology or type of location of the injury. Traditionally, brain surgery mandates an immobile and asleep patient. General anesthesia (GA) for craniotomy allows a good airway and cerebral hemodynamics control. Eloquent cortex assessment is unachievable during GA (3). The combination of neuroleptics and opioids were introduced in the 1960's and called "Neuroleptanesthesia". It represented an important change in anesthetic approach for awake craniotomy (7). It provided a state of indifference, immobility and anesthesia along with hemodynamic and respiratory stability. Drawbacks of this anesthetic regimen were extrapyramidal and anticholinergic symptom, dysphoria and hypotension at large dose (1). in 1988, The first study regarding awake craniotomy was published by Archer et al. (8) in which they described a review of 354 patients undergoing awake craniotomy for epileptic foci using a combination of fentanyl and droperidol.

Awake brain surgery began at the turn of the 20th century mainly for the treatment of intractable epilepsy (1). More recently, indications for this procedure have spread to other conditions such as oncological neurosurgery and arteriovenous malformations located in specific areas. Typically, awake craniotomy (AC) is required when neurological lesions are located in eloquent areas (motor and speech areas) of the brain. It involves an awake and cooperative patient throughout the functional testing and brain mapping. This procedure represents a unique anesthetic setting, in which the neuroanesthesiologist is required to provide changing state of sedation, analgesia and adequate patient comfort (2) depending on the timing of the surgery. Anesthesiologist's ultimate challenge for this procedure is to provide adequate overall patients safety, including patent airway, optimal hemodynamic stability and at the same time the guarantee of a fully cooperative patient during the functional testing.

It is generally accepted that awake craniotomy represents the standard procedure in terms of reduced risks of postoperative neurological deficit, maximal removal of lesions regarding eloquent area of the brain and shortened hospital stay facing general anesthesia (4–6).

Different anesthetic approaches for awake craniotomies had been proposed since then, the AAA technique (*asleep-awake-asleep technique*) and conscious sedation technique. The AAA technique consists of deep sedation or general anesthesia before and after functional testing and brain mapping. The anaesthetic infusion is discontinued in order to have an awake patient within 15 minutes for functional testing. The patient is awoken and generally extubated for the functional testing and tumor resection, followed by further airway management (mostly with LMA or tracheal intubation) for the surgical field closure.

This technique provides an adequate analgesia, patient comfort and an optimal airway control but airway device manipulation before surgical field closure can be hazardous, as the patient's head remain fixed in a Mayfield frame.

The conscious sedation technique involves patient sedation and spontaneous breathing without airway device. In this protocol the anesthesiologist has to provide adequate monitoring and drug supply along with psychological support during the surgical procedures. This methods necessitates usually no airways manipulation (7). Other authors also successfully showed the feasibility of a protocol without any sedation (*awake-awake-awake* protocol) together with therapeutic communication centered approach (9,10). Despite all these different approaches no consensus concerning anesthesia for awake craniotomy exists at the moment. Today most used anesthetic regimen is the propofol-remifentanyl regimen but dexmedetomidine (DEX) is growing in popularity during the last decade.

The conscious sedation protocol was introduced in our institution as a standardized protocol 5 years ago along with the off-label use of dexmedetomidine, a highly selective central acting α2 agonist. Its affinity is 8 times higher than the same class drug clonidine. It acts on the inhibition of the norepinephrine release in the presynaptic pathways. Unlike γ-aminobutyric-acid (GABA) sedatives, the dexmedetomidine provides an anesthetic state unique of its kind, an easy arousal natural sleep-like sedation, analgesia and anxiolysis without cognitive impairment nor respiratory depression. Thus, a drug of interest for the sedation of non-intubated patient, also because its anesthetics-sparing characteristics (11,12). The drug was first approved for humans in the USA by the Federal Drug Administration in 1999 under the trade name Precedex® (Hospira, Inc. Lake Forest, IL). In Switzerland, the Swiss agency for therapeutic products (Swissmedic) approved and placed the dexmedetomidine on the market in 2012 under the trade name Dexdor® (Orion Pharma AG 6300 Zug) with short term sedation of intubated ICU patient as cost-saving indication versus midazolam (13,14). The first usage of dexmedetomidine for awake neurosurgery was published in a case report by Bekker et al. in 2001 (15). The anesthetic approach included an asleep-awake-asleep technique with a combination with sevoflurane, propofol and fentanyl. The author report oversedation difficulties (even at low DEX infusion rate) in crucial parts of the surgery.

Hemodynamic effects of DEX follow a biphasic response on the blood pressure. Low plasmatic concentration significantly lowers the BP without significant effect on heart rate. While at higher concentration gradual increase in blood pressure and SVR is observed, cause for that may be the peripheral α_2 mediated vasoconstriction (16), decrease in heart rate may be also observed. Dexmedetomidine does not have a significant effect on ventilation, it increases initially the $PaCO_2$ and respiratory rate without respiratory depression even at deep level of sedation.

The aim of this study is first to review all awake craniotomies since the beginning of this technique in our institution, the adherence to our protocol and the perioperative occurrences.

Methods

After consent by our local ethic committee (CER-VD), anesthetic data of patients who went through an awake craniotomy in the Lausanne University hospital from March 2010 to September 2015 were collected. All patients who underwent this procedure were retrospectively included and there were no exclusion criteria.

Pre-operative data including patient's fitness and chronic condition prior the surgery, age, sex, weight, ASA score, the side of the neurosurgical lesion as well as surgical indications was recorded. Intra-operative data included duration of the surgery, intraoperative anesthetics analysis and intraoperative complications. Adherence to the existing "awake craniotomy protocol" (see annexe 1) was analyzed, in which dexmedetomidine is used as main sedative for the procedure, bolus dose and maintenance. Dosage (bolus and maintenance) was also analyzed and compared to our institution current anesthetic protocol. Intraoperative complications were also recorded including: hypertensive state defined by a rise in usual blood pressure of ≥30% or the use of anti-hypertensive medication. Hypotension defined by a drop in usual blood pressure of ≥30% or intraoperative use of Ephedrine (Ephedrine®). Hypoxemia and oxygen desaturation were defined by a fall in arterial oxygen saturation of 90% and 80% respectively. Bradycardia episodes was defined by the use of atropine until a normal heart rate was reached. Other intraoperative complication included nausea, seizure was reported. Post-operative care included complication listed above and pain medication were also recorded.

JMP (© SAS Institute Inc.) was used for the statistical analysis. Continuous variables are characterized in mean, ± standard deviation and range. Whereas categorical variables are represented in number and percentage. If necessary, a Chi-square test was performed.

Anesthetic protocol

The patients elected for this procedure are first selected by the neurosurgeon and then the anesthetic technique is confirmed by the neuroanaesthesiologist. In case of severe anxiety and fear, the indication to this procedure may be reconsidered.

Comfortable positioning to reduce postural pain is essential while the awake patient is lying steady throughout the procedure. Warming blanket (Bair Hugger®) is also indicated. Basic anesthetic monitoring includes electrocardiogram, pulse oximetry, thermometer, urine bottle and an oxygen mask with an end-tidal carbon dioxide monitoring. In the operating room, arterial cannulation (Abbocath®) for invasive blood pressure monitoring is recommended. 1 to 2 peripheral venous lines are connected and the dexmedetomidine infusion started with a bolus dose of 1.0µg/kg to perfuse in 15 minutes and a maintenance dose of 0.2 to 0.7 µg/kg/h. The figure 1 represents an example of the

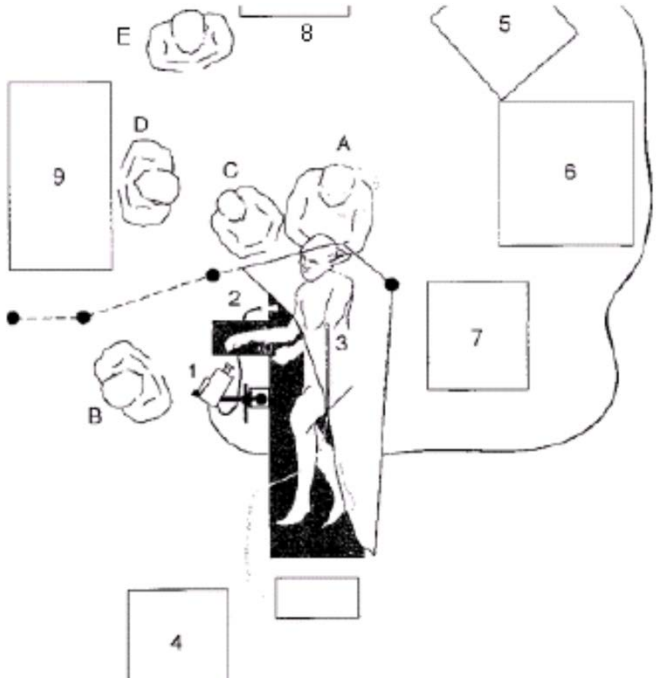

Fig 1. Operating theatre organization. (A) Neurosurgeon, (B) Anesthesiologist (C) Assistant Neurosurgeon, (D) Scrub nurse, (E) Neurophysiologist, (1+2) Camera and microphone, (4) Anesthetic machine, (5) Screen, (6) Neuronavigation device, (7) Electroencephalogram… Reproduced from our current protocol.

theatre setup. This anesthesia protocol is planned with dexmedetomidine as single anesthetic agent, and if deemed necessary by the in-charge anesthesiologist, a short-acting opioid such as Remifentanyl may be associated. This ladder is used for particular cases and should always be titrated along surgical and patient own requirements. As the dexmedetomidine infusion is started, the anesthesiologist performs a scalp block with locally injected Bupivacaine 0.5% + 5µg Adrenaline or Ropivacaine 0.5%. The supraorbital (V1), supratrochlear (V1), greater and lesser occipital (C2), zygomatico-temporal (V2) and auriculotemporal (V3) are blocked with 20ml of total solution. The points site of the Mayfield frame is also infiltrated bilaterally and primarily on the surgical side. Patient also received intravenous antibiotic prophylaxis with Cefazolin (Kefzol®). The patient is then draped with a good access to the head with correct positioning of surgical drape sheets either for an optimal intraoperative communication or the airway management if an intubation proves to be necessary.

Although this procedure is a conscious sedation a standard security equipment must be close at hand for the anesthesiologist especially a laryngeal mask airway fitted to the patient's morphology and thiopental in case of seizures.

Results

This study includes 31 patients who went through an awake craniotomy essentially for brain tumor (low and high grade gliomas) and brain metastasis surgery. The mean surgery duration was 116±26.5 minutes. A large part of patient suffered from neurological disorder mainly seizure and hemiparesis when specified. Almost a third (28%) of patient had hypertension. The table 1 summarizes the demographic data and the patient fitness of our sample.

Table 1. Demographic data and patient fitness (n=31)

Parameters/Condition	**Values Mean±SD (range) / number (%)**
Age	52.7 ±15 (20-77)
Sex (female)	12 (38.7)
Weight (kg)	75.6 ±12.1 (53-102)
ASA score	
1	1 (3.2)
2	23 (74.2)
3	7 (22.6)
Localisation of the lesion	
Right	10 (32.2)
Left	18 (58)
NS (not specified)	3 (9.6)
Neurological disorder (not specified)	20 (64.5)
Hypertension	9 (28.8)
Arrhythmia	2 (6.4)
Obesity	2 (6.4)
Smoking	8 (26)
COPD	1 (3.2)

COPD: chronic obstructive pulmonary disease

All patients received dexmedetomidine as main sedative for the procedure but an extensive proportion of the patient received remifentanyl and fentanyl, respectively 83.9% and 9.6%. Although our protocol recommends a dexmedetomidine only regimen with the use of Remifentanyl on a case by case basis, dexmedetomidine with remifentanyl was the most frequently used anesthesia regimen. Only 3 procedures were performed with dexmedetomidine only. Hypnotic medications such as propofol and midazolam were employed in 19.3% and 6.4% respectively. The table 2 summarizes the intraoperative anesthetics. The average loading dose and maintenance infusion minimum belongs to the proposed protocol. The average maintenance infusion maximum slightly above our protocol. Dexmedetomidine mean loading dose and maintenance infusion of our 31 patients is recapitulated in table 3.

Table 2. Intraoperative anesthetics	
Medication	**Number of patient (%)**
Dexmedetomidine	31 (100)
Dex only	3 (9.6)
Dex + Remifentanyl	26 (83.9)
Dex + Fentanyl	3 (9.6)
Propofol	6 (19.3)
Midazolam	2 (6.4)

The most encountered complications were of respiratory and hemodynamic nature, hypoxemia and oxygen desaturation happened 3 times each. Hypotension was observed in 19.3% of our sample and required the administration of sympathomimetic. Ephedrine was used 4 times, Noradrenaline and Phenylephrine 1 time each. Hypertensive episodes were encountered four times and they all occurred in first third of the procedure. One patient presented a hypertensive crisis and needed a vasoactive treatment with Dihydralazine (Nepresol®). Two patients showed episodes of bradycardia at 40 bpm, necessitating Atropine administration. No episode of tachycardia was encountered. Seizure was encountered once and required a Thiopental treatment. Nausea was present in one case and necessitated administration of Ondansetron (Zofran®).

Table 3. Dexedetomidine infusion	
Parameters	**Dose Mean±SD (range)**
Loading dose (µg/kg)	0.97 ±0.1 (0.5-1.06)
Maintenance infusion (µg/kg/h)	
Minimum	0.43 ±0.14 (0.16-0.75)
Maximum	0.78 ±0.19 (0.42-1.26)

Table 4. Summary of Intraoperative Complications	
Perioperative Complications	**Our series N=31 (%)**
Hypertension	4 (12.9)
Hypotension	6 (19.3)
Hypoxemia (<90%)	3 (9.6)
Oxygen desaturation (<80%)	3 (9.6)
Bradycardia	2 (6.4)
Seizure	1 (3.2)
Nausea	1 (3.2)
GA conversion	0

GA: General anesthesia

In the postoperative period the most encountered problem was pain. 9 patients received morphine. Three patients were hypotensive. Two patients suffered from nausea, one patient experienced a shivering episode and one patient was agitated. Only 83 percent of the data concerning the postoperative period were available.

Discussion

Awake craniotomy remains todays gold standard procedure for tumor resection regarding the eloquent cortex (5,6). However, many anesthetic protocols have been proposed being the asleep-awake-asleep technique, the conscious sedation technique and recently the awake-awake-awake technique without any sedation (17). Our retrospective single institution study demonstrates the reliability of a conscious sedation protocol with a few intra-operative complications without major occurrence. The size of our series is comparable to the others studies in the literature (11,18–20).

Dexmedetomidine was used as sole agent in our institution, but 28 patients (90.3%) required additional opioids and 7 patients required hypnotics medications as well (Propofol and Midazolam). (The use of dexmedetomidine represents a new drug our institution). Analgesia was insufficient for a majority of patient with a DEX only regimen. Goettel et al. (21) published a prospective multicentric randomized controlled trial in which dexmedetomidine and a propofol and remifentanyl regimen were compared for AC. The authors state that DEX only was not sufficient for all stage of awake craniotomy especially the initial stage of the procedure since positioning of the Mayfield head frame along with skin incision, craniotomy, periosteal and dura mater detachment are the painful parts of the procedure (2,22). During this stage, a careful surveillance to the patient's own requirements because a majority of them may need supplementary analgesia and sedation. Goettel et al. administered a fentanyl bolus to all patient on this purpose. Sokhal et al (18) reported that 12 of 22 patients needed a combination with titrated dose of fentanyl in a DEX based protocol comparable to ours. Hansen et al. reported that two-thirds of their patients requested additional Remifentanyl in awake-awake-awake without any sedation approach. This highlight the anesthetics sparing properties of the DEX and the fact that it might be insufficient during critical stages of AC. Three patients were comfortable with DEX only. We demonstrated the feasibility of conscious sedation approach with a DEX only regimen in a minority of our patients. No authors supported the usefulness of a DEX only regimen for awake craniotomy.

The maintenance dose was used up to 0.7 µg/kg/h according to recommendation of the manufacturer. This dose was similar to those reported in the literature. As a new drug, there are only a few studies concerning a "maximum dose" and if a higher dose (>0.7 µg/kg/h) is more effective and safe as the approved dose (≤0.7 µg/kg/h). Authors reported a safe maximum dose for short term sedation (<24h) of 1.4 µg/kg/h in critically ill patients with a careful monitoring in a ICU context (14).

Hypertension was observed in four patients (12.9%) and all occurred in the first third of the procedure. Dilmen et al. reported a blood pressure significantly higher in a dexmedetomidine based conscious sedation group versus a AAA group during skin incision and the Mayfield frame fixation

(20). It is also stressed in the dexmedetomidine package insert that this drug might cause transient hypertension due to its initial vasoconstrictive effect during the loading dose (23).

A drop in blood pressure (19.6%) and bradycardia (6.4%) was the most encountered hemodynamics adverse effect in our series. Hypotension occurrences were comparable to those described in the literature (11). In Goettel et al. series reported a significantly lower heart rate in the DEX group (21). It is also believed that the DEX was not initially approved Europe for these dose dependent effects (12).

Respiratory complications are the most feared complication during awake craniotomy because the airway remain unsecured during the procedure. Additionally, this procedure makes the access to the patient's airway far more delicate as the patients head is fixed the Mayfield head frame. Respiratory depression and obstructive apnea carry a substantial risk of hypercarbia and its consequence on the cerebral blood flow. Respiratory complications required an anticipation effort for the anesthesiologist even if these occurrences were transitory. In case of obstructed airway, a jaw-thrust maneuver should be sufficient but an airway equipment must be close at hand for the anesthesiologist. Alike Manninen et al. (remifentanil/fentanyl-propofol CS approach) (19) we observed a higher incidence of airway complications in the first patients going through this approach. The incidence improved also over time. We believe that our anesthesiologist team became more used to this unique anesthetic setting and delicate intraoperative drug titration. Dexmedetomidine appear to have a better profile facing propofol-remifentanyl regimen concerning respiratory occurrences (21). Our results regarding airway complications were comparable despite high variability in the literature. (18,20)

One patient experienced an episode of nausea. Nausea occurrence in awake craniotomy is also a great concern since it can be followed by vomiting episode with an unsecured airway and increased ICP due to Valsalva maneuver. These episodes of nausea are more likely to happen during the initial surgical stage due to *dura mater* and meningeal arteries traction (7) which may also necessitate an opioid coverage. A single episode was easily controlled with ondansetron in our series. If not sufficient authors reported that low dose of propofol may be used on this purpose (3,6). There is no consensus concerning prophylaxis and premedication for AC. Some authors did a systematic anti-emetic prophylaxis on all patient without any occurrence of nausea or vomiting (18). In case of PONV history and motion sickness an anti-emetic prophylaxis might be discussed (4). We recommend premedication on a case by case basis.

Seizure occurrence are reported in up to 17 % in the literature (9). Seizure are more likely to occur during the cortical mapping when the cortex is electrically stimulated. Convulsions may also happen following local anesthetic intoxication. This carries a considerable risk respiratory desaturation and restlessness (3). We reported only one seizure occurrence successfully treated with a thiopental

bolus. The seizure occurrence was lower in our series than the incidence reported in the literature. Almost a two-third of the patients were told to maintain their anti-convulsant prior the morning of the surgery. A majority of authors seem to prefer the propofol for the treatment of symptomatic seizure (3,9,19,21). Goettel et al. reported a higher incidence of seizure in their DEX group versus their propofol-remifentanyl group without significance. It is considered that Dexmedetomidine does not suppress the epileptogenic activity and should then be continued during cortical mapping. More study concerning the epileptogenic threshold of the dexmedetomidine are needed (12).

Some limitations concerning our study should be considered. The retrospective design was imposed and some data were not available or missing (e.g. In the postoperative time). The little size of our sample also limits the results of our study despite some comparable protocol and occurrences incidence. Patient outcome and satisfaction were not reviewed in our series and should be assessed in the upcoming time for a better understanding of the patients own experience of AC with our current protocol. Furthermore, as this protocol was quite innovative when introduced in our institution, we can only estimate that a number of additional sedatives where used in the operating room by physicians not at ease with this protocol. The fact that less additional sedatives where used when an experimented neuro-anesthesiologist was in charge, while no additional patient discomfort was reported seems to be a promising explanation. This theory seems corroborated by recent findings in our institution where the current management of the awake craniotomy is accomplished in more than 90% of the cases with dexmedetomidine alone, with additional morphine in the post-operative period.

Conclusion

Conscious sedation with dexmedetomidine is the preferred anesthetic approach of choice at our institution. Our retrospective single institution study demonstrates the reliability and the safety of a conscious sedation protocol with a few intra-operative complications without major occurrence. The Dexmedetomidine provides an adequate reversible sedation, anxiolysis without respiratory depression and does not interfere with the cortical mapping. The dexmedetomidine was successfully introduced in our institution as sole agent in the management of awake craniotomy since its approval in Switzerland. Despite the feasibility of a few DEX only regimen, a majority of patients may require additional analgesia which emphasize the anesthetic sparing properties of this drug. Dexmedetomidine and remifentanyl was the most used regimen at our institution. Prospective randomized trials are needed to determine which approach and anesthetic regimen are the most effective for the management of awake craniotomy.

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1 Annexe

Craniotomie vigile avec Dexmedetomidine (Dexdor©) pour Dr Roy Daniel

La chirurgie intracrânienne n'est pas douloureuse, mais des gestes liés à l'anesthésie (laryngoscopie) ou à la chirurgie (mise en place du cadre de Mayfield, incision de la peau, décollement du périoste et ouverture de la dure-mère) provoquent une réponse sympathique.
La technique de craniotomie vigile peut être rendue nécessaire pour des interventions liées à des tumeurs ou malformations artério-veineuse par exemple, situées dans une région sensible (aire de Broca,….) qui nécessitent une surveillance clinique et neuropsychologique en direct et lors de la chirurgie. Ainsi, l'exérèse chirurgicale pourra être maximale en minimisant les séquelles post-opératoires.
Pour le Dr Roy Daniel, cette procédure se fait en anesthésie locale (bloc du scalp fait par le médecin anesthésiste) sous perfusion « sédative » de dexmédétomidine (Dexdor©).

1. **Procédure :**
    a. Installation en salle d'opération selon figure 1.
    b. Equipement standard de sécurité en anesthésie
    c. Lunettes à oxygène avec monitorage de l'$EtCO_2$
    d. 1 venflon, puis perfusion dexmedetomidine (voir plus bas)
    e. Pendant durée bolus, bloc du scalp bilatéral selon figures 2 fait par anesthésiste
    f. Complément équipement avec deuxième venflon et cathéter artériel radial (abbocath)
    g. Anesthésie locale avant Mayfield par anesthésiste
    h. En réserve pour cas particulier, rémifentanyl bolus (1-2 µg/kg)

Perfusion de Dexdor© (dexmédétomidine)

Préparation: 1 ampoule 2mL = 200µg ad 20 mL NaCl = 10µg/mL

Bolus 1.0 µg/kg à administrer en 15minutes suivi d'une perfusion de 0.2-0.7 (-1) µg/kg/h.

Début avec 0.6 µg/kg/h. Réglage selon besoin du patient.

Bloc du scalp selon schéma avec à choix :

Bupivacaine 0.5% + 5ug Adrénaline /ml (1 :200'000) ou Ropivacaine 0.5% (Total de 20ml)

Bloc bilatéral car cadre de Mayfield. Le bloc est d'abord effectué du côté à opérer.

Si patient en deuxième position, bloc en salle d'accueil.

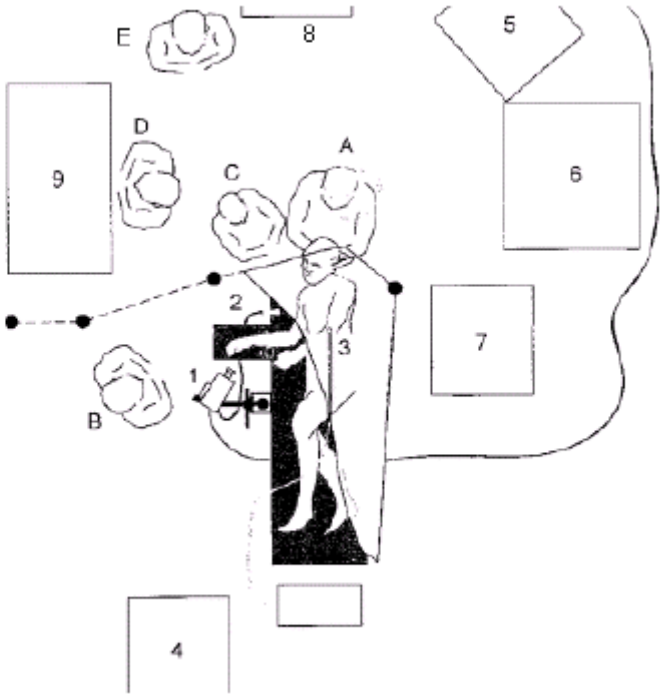
Voici le lien pour le Téléjournal démontrant une crâniotomie vigile faite au CHUV selon ce protocole. N'hésitez pas à le partager avec vos patients :

http://www.rts.ch/video/info/journal-19h30/3729976-le-grand-format-pour-extraire-une-tumeur-le-chuv-a-pratique-avec-succes-une-operation-a-cerveau-ouvert-avec-une-patiente-restee-eveillee-durant-toute-l-intervention.html

Nota Bene :

- Ces patients doivent être « sélectionnés » par le chirurgien et la validation de la technique adaptée au patient par l'anesthésiste est obligatoire.
- Pas de prémédication par principe. Si le patient est perçu comme très anxieux, réflexion quant au bon choix du patient pour la technique de crâniotomie vigile.
- Afin de gérer au mieux les potentiels problèmes per-opératoire, un accès aisé à la tête est essentiel. S'assurer que la mise en place des champs opératoire n'entrave pas cet accès à la tête.
- Pendant l'intervention chirurgicale, une évaluation neuro-psychologique doit être fait par les neuro-psychologues (ou les anesthésistes !). Pour cette raison, l'accès au visage du patient avec un contact visuel est important.
- Ne pas hésiter à demander aux neuro-psychologues de laisser la place aux anesthésistes en cas de besoin.
- Avoir à portée de main un masque laryngé adapté à la morphologie du patient ainsi que du Thiopenthal en cas de crise d'épilepsie
- Bouteille d'urine en place si possible

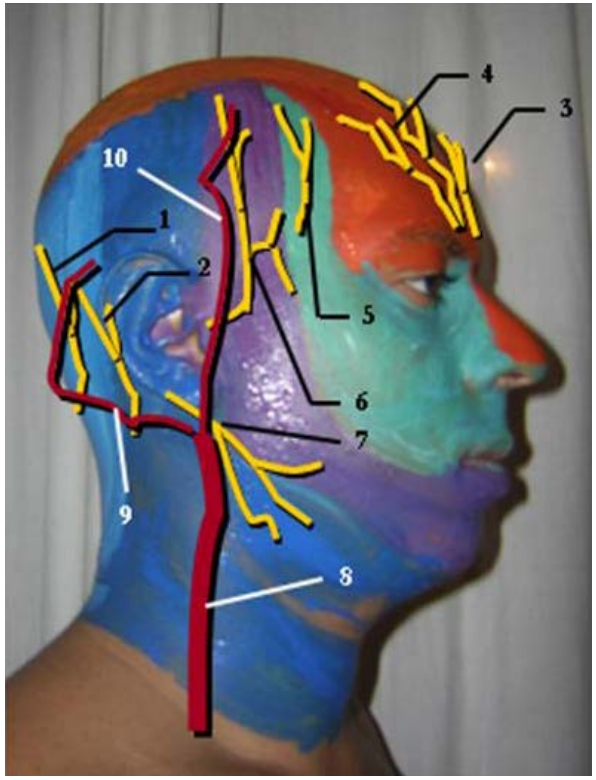
Exemple de positionnement en salle d'opération pour crâniotomie vigile (figure 1).

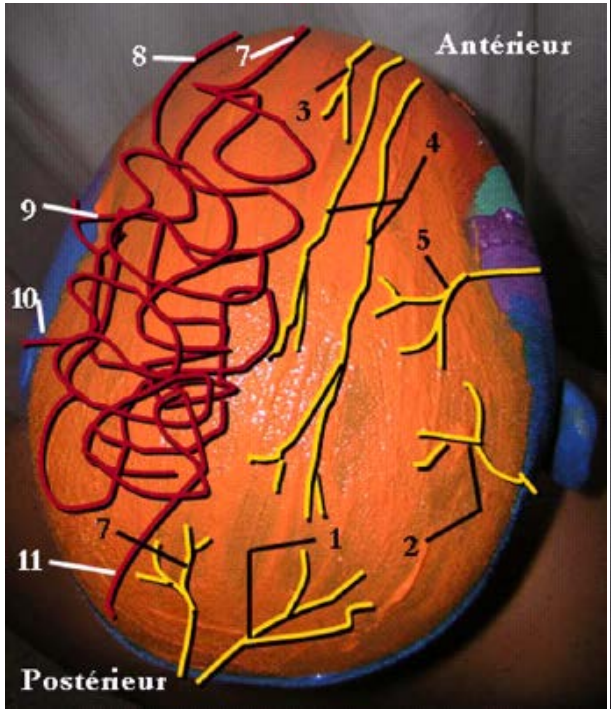


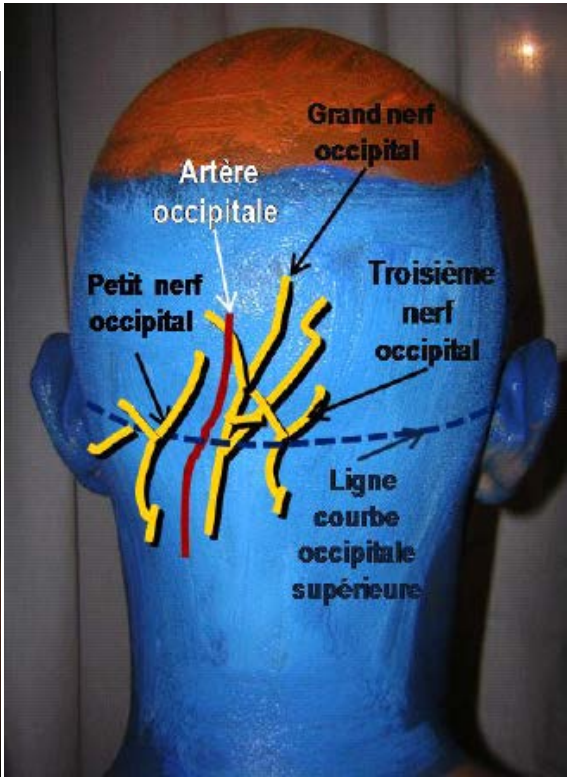
A. Neurochirurgien
B. Anesthésiste
C. Neurochirurgien
D. Instrumentiste
E. Neurophysiologue

1. + 2. . Caméra vidéo, neuropsychologue
4. Machine d'anesthésie
5. +.6. + 7. + 8. : écran, microscope, EEG, ….

Bloc du scalp pour neurochirurgie (Figures 2)







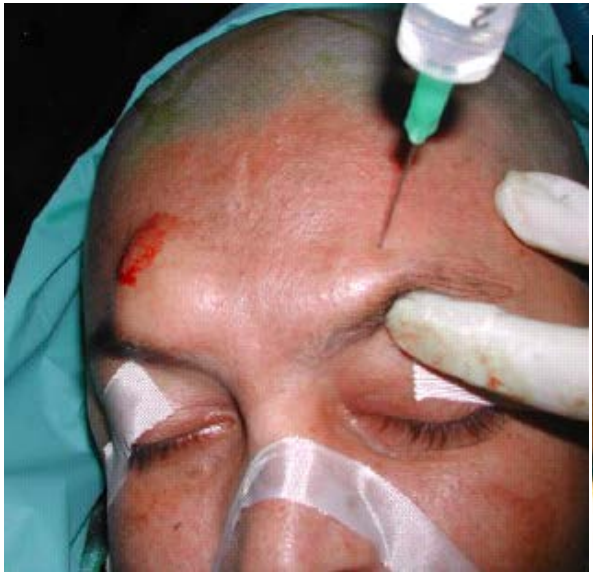
1. **Nerf d'Arnold**
2. **Nerf petit occipital**
3. **Nerf supratrochléaire**
4. **Nerf supraorbitaire**
5. Nerf zygomatique (V2)
6. **Nerf auriculotemporal**
7. Branche post. N. gd auricul.
8. Artère carotide, int (9), ext (10)

7. Artère sus-trochléaire
8. Artère sus-orbitaire
9. Artère temporale superficielle
10. Artère auriculaire postérieure
11. Artère occipitale

Bloc des nerfs Grand, Petit et troisième occipital

Illustrations photos des trois blocs nécessaires

1. **Désinfection chirurgicale des points de ponctions**

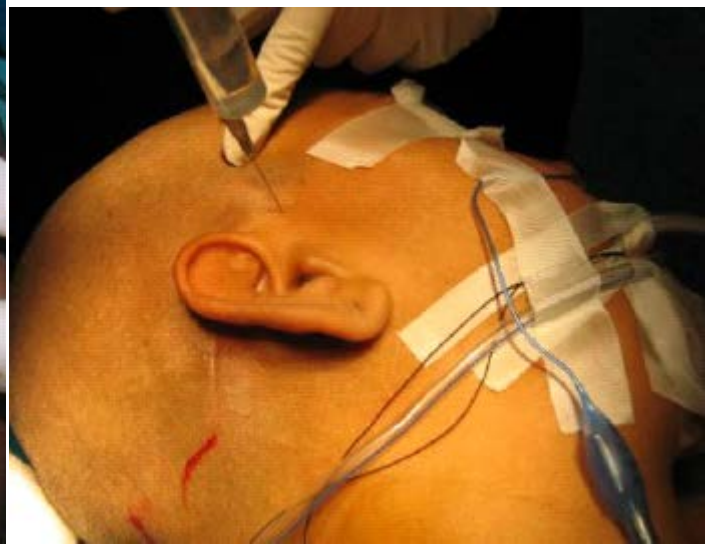


A. Bloc des N. supratrochléaire et supra-orbitaire

1.5 cm au-dessus trou sus-orbitaire, aiguille 22G

Perpendiculaire à peau + long arcade sourcilière

1.5-2 ml sol. anesthésique

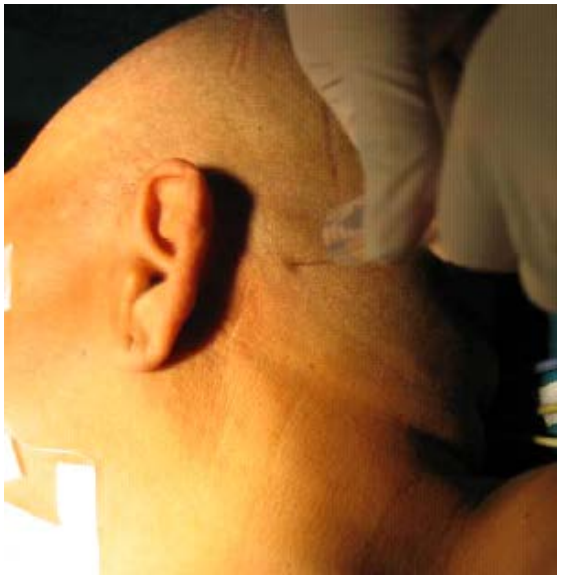


B. Bloc du N. auriculotemporal

1.5 cm en avant et 1cm au-dessus du tragus

injection en éventail

2-3 ml sol. anesthésique



C. Bloc du Grand N. auriculaire + Petit + grand + 3ème occipital

1.5-2 cm derrière oreille, même niveau que B

Ligne mastoïde-occiput. Milieu = a. occipitale

2.5-4 ml de chaque côté artère = infiltration