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Post-craniotomy pain: Analgesia and scalp blocks

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INTRODUCTION

There is a historical and widespread belief that patients have minimal pain post-craniotomy.[1–4] However, studies show that post-craniotomy analgesia is frequently suboptimal, with pain often not assessed and, therefore, inadequate analgesia achieved in 30-60% of patients.[2–5] This is due to the common belief that craniotomy surgery is not painful, the reluctance of healthcare providers to use opioid analgesia secondary to concerns that any associated sedation may impede neurologic assessment, and concerns over respiratory depression and hypercarbia leading to raised intracranial pressure.[4] Moreover, altered neurological status after craniotomy can hinder appropriate pain assessment.[6] In fact, when assessed, patients often have significant acute post-craniotomy pain, with up to two-thirds of patients reporting moderate to severe pain and 10-25% reporting severe pain postoperatively.[2–5]

Besides patient discomfort, uncontrolled post-craniotomy pain can increase the risk of acute complications such as hypertension, agitation and vomiting, delayed recovery, increased length of hospital stay, increased mortality, and healthcare costs.[2,5,7] Some of these symptoms can be particularly deleterious in neurosurgical patients as they can mimic, obscure, and increase the risk of neurosurgical complications, like raised intracranial pressure and intracranial haemorrhage.[1–3]

PATHOPHYSIOLOGY

Post-craniotomy pain is often described as superficial and commonly presents as a generalised headache with pounding or pulsating qualities and is most significant in the first 48 hours post-surgery.[8] It is thought to arise from the dissection of the richly innervated scalp, pericranial muscles, surrounding soft tissues and dura mater. The brain tissue itself does not contribute significantly to postoperative pain. Suboccipital, retrosigmoid, and subtemporal operative approaches are associated with a greater frequency and severity of pain, likely related to the associated surgical dissection and reflection of major muscle tissues like the temporalis, splenium capitis and splenius cervicis muscles.[5,6,9]

CHRONIC POST-CRANIOTOMY PAIN

There is a 7-30% risk of chronic post-craniotomy headache, with 25% of these patients having severe pain.[2,4] Chronic post-craniotomy headache is debilitating and difficult to treat, can significantly impair quality of life and social functioning, and impede return to employment.[2,4] A consistent predictor for the development of *chronic* postsurgical pain is the severity and duration of *acute* postoperative pain.[4] Chronic headaches are common post-head injury, and patients having surgery for primary head injury are at higher risk for the development of chronic post-traumatic headaches.[6] Although there is limited data on the efficacy of interventions to prevent chronic post-craniotomy headache, evidence supports that severity and duration of acute postoperative headache may play a role in central sensitisation and that interventions aimed at reducing acute pain may be beneficial in reducing the risk of chronic post-craniotomy headache.[2,3]

Mitigating acute post-craniotomy pain may help diminish the possibility of chronic post-craniotomy pain, as demonstrated in studies showing that scalp infiltration with ropivacaine reduced the incidence of both persistent and neuropathic pain two months post-craniotomy.[7,10] Further studies on locoregional techniques and prevention of chronic post-craniotomy pain are still required. However, evidence from wider surgical populations suggests locoregional techniques may play an essential role in achieving effective analgesia, compared to conventional systemic treatments, in reducing the incidence of chronic postoperative pain.[2]

Risk factors for severe acute post-craniotomy pain

Patient factors that are independent predictors of more severe postoperative pain include younger age, female gender, level of preoperative pain, anxiety, and depression.[7] Specific to post-craniotomy pain, younger age and level of preoperative pain were associated with more significant postoperative pain; however, there is limited and conflicting evidence to demonstrate an association with gender and greater postoperative pain.[8] With regard to surgical risk factors, the amount of postoperative pain may be related to the extent of peri-cranial muscle dissection and reflection in the operative approach. Additionally, infratentorial procedures have been shown to have more pain than supratentorial approaches, with subtemporal and suboccipital routes yielding the highest incidence of postoperative pain.[8,11] Conversely, frontal craniotomy is associated with lower pain scores and opioid consumption.[5–7,9]

Risk factors for chronic post-craniotomy pain

Chronic pain following craniotomy is more common in patients with pre-existing pain, psychological vulnerability (e.g. catastrophising), anxiety, female gender, younger adults, worker's compensation-related claims, and opioid requirements. Severity and incidence are greater after infratentorial procedures compared to supratentorial procedures.[4,7]

POST-CRANIOTOMY ANALGESIA

The traditional approach to post-craniotomy analgesia via the use of low-dose opioids is often inadequate and can have side effects that are concerning in this patient population. Multimodal opioid-sparing approaches have proven beneficial in terms of better pain relief, less opioid administered, and subsequently fewer opioid-related side effects.[2,12] Opioid-sparing multimodal analgesia is increasingly important for enhanced recovery after surgery (ERAS) for craniotomy and is associated with benefits in postoperative analgesia, length of hospital stay and cost reduction in patients undergoing craniotomy.[13,14]

Pre-emptive analgesia is important to consider as it may ameliorate the mechanisms involved in developing both acute and chronic postoperative pain. Pre-emptive analgesia is particularly beneficial in neurosurgery, as the nature of the surgery may impede the patient's initial ability to report pain and thus achieve adequate postoperative analgesia. The need for accurate postoperative neurological assessment is often a factor credited with decisions to limit postoperative analgesic options.

The PROSPECT (Procedure Specific Postoperative Pain Management) Working Group of the European Society of Regional Anaesthesia and Pain Therapy (ESRA) recommend a multimodal analgesic regimen for craniotomy which consists of paracetamol, nonsteroidal anti-inflammatory drugs (NSAIDs), intravenous dexmedetomidine infusion and a regional analgesic technique, with opioids reserved as rescue analgesia.[5]

The following is a compendium of common analgesic modalities that are considered in targeting post-craniotomy pain.

Paracetamol

Paracetamol provides modest pain relief, is superior to placebo for reducing postoperative pain scores but not opioid consumption, and is recommended preoperatively and postoperatively.[5,12,15] However, paracetamol alone is ineffective as an adequate analgesic regimen.[2,4]

Nonsteroidal anti-inflammatory drugs (NSAIDs)

There is high-quality evidence that NSAIDs reduce pain up to 24 hours postoperatively.[2,5] They also reduce opioid requirements and postoperative nausea and vomiting.[2,5] NSAIDs are superior to placebo and paracetamol for analgesia and reducing opioid requirements. However, there has been a reluctance to include them in a craniotomy analgesic regimen due to a single-centre retrospective cohort study that identified an association between the development of postoperative haematoma and the use of aspirin or non-selective NSAIDs.[4] A systematic review and meta-analysis found that NSAIDs provided satisfactory analgesia and were not associated with clinically meaningful bleeding, with results being consistent across various types of NSAIDs and surgical procedures.[16]

Parecoxib has shown benefits in improving the level of sedation and analgesia, but no opioid-sparing effect.[17,18] Another study using rofecoxib (withdrawn from the market in 2004) demonstrated better analgesia, reduced opioid adverse effects, earlier mobilisation, reduced length of stay and reduced total hospitalisation costs.[19]

While postoperative administration of NSAIDs may still be considered controversial, there are reasonable studies showing no adverse effect of postoperative administration.[5,7,20,21] There are protocols at some centres that choose to administer them selectively, such as in uncomplicated cases with no coagulopathy or waiting 6-24 hours postoperatively. The PROSPECT guidelines recommend paracetamol and NSAIDs as basic analgesia after craniotomy.[5]

Opioids

Opioids form a mainstay in the management of moderate to severe pain in craniotomy despite concerns surrounding adverse effects of respiratory depression, sedation, hypercarbia, and raised intracranial pressure.[6] They are associated with increased rates of postoperative nausea and vomiting after craniotomy.[20] The PROSPECT guidelines have, therefore, recommended that opioids be reserved as rescue analgesia for severe pain in the postoperative period.[5]

Codeine

Codeine was historically and is still widely used. However, it has been shown to be inadequate in the management of post-craniotomy pain. It should be considered less effective or predictable than morphine and other opioids due to genetic variability in metabolism and has a risk of potential respiratory depression and sedation.[7]

Tramadol

Tramadol has less potential for respiratory depression and dependence compared to other opioids. However, it has a greater risk of nausea and vomiting and a rare incidence of seizures. Although it has been used successfully in craniotomies, its analgesic efficacy is inferior to morphine, and its side effects limit its use.[7,22] When added to a multimodal regime of paracetamol and other opioids rather than as a sole agent, tramadol may reduce pain scores, opioid requirements,[5] hospitalisation costs, and length of stay while also leading to earlier mobilisation.[22,23]

Alpha-2 agonists

Intraoperative dexmedetomidine provides superior analgesia compared to placebo and reduces postoperative opioid requirements for up to 12 hours, with the added benefit of reduced emergence tachycardia and hypertension.[2,5] There is conflicting evidence on the risk of delayed recovery and emergence, with 1 RCT supporting delayed emergence and sedation,[24] 1 RCT reporting lower postoperative Ramsay sedation scores[25] and 2 RCTs reporting no significant differences in emergence time or postoperative sedation.[26,27] There is inconclusive evidence on the effects on postoperative nausea and vomiting (PONV).[2,4,5,12,25–27] Clonidine has not been shown to significantly improve analgesia after supratentorial craniotomy.[4] The PROSPECT guidelines recommend the use of dexmedetomidine for analgesia after craniotomy with the caveat that it may cause delayed recovery and emergence.[5] If an intraoperative dexmedetomidine infusion is used, one must consider discontinuing it early enough to avoid delayed emergence.

Ketamine

Ketamine has inconsistent effects on cerebral physiology, with some studies showing increases in cerebral blood flow, metabolic rate, and intracranial pressure, while others report no change or a decrease in these parameters, especially when administered with other anaesthetics. It may also cause hallucinations that may confound neurological assessment and, therefore, should be used with caution in craniotomy surgery and in patients with raised intracranial pressure.[7,22]

Pregabalin and gabapentin

Both pregabalin and gabapentin improve early pain scores at 6-12 hours and reduce the incidence of nausea and vomiting.[2] Pregabalin demonstrates opioid-sparing effects while gabapentin does not.[5] However, their use is also associated with increased sedation and delayed extubation.[4,28]

Steroids

The use of preoperative steroids is associated with reduced post-craniotomy pain, likely due to an anti-inflammatory effect.[8,29]

Local infiltration

Local anaesthetic infiltration provides early analgesia post-craniotomy. It reduces opioid requirements, with preoperative infiltration improving pain scores for up to 8 hours postoperatively and postprocedural infiltration improving pain scores for up to 12 hours postoperatively.[2] Scalp blocks and local infiltration are also technically easier and more tolerable for the patient when performed after induction, under general anaesthesia.

Non-pharmacological

Non-pharmacological analgesic strategies include the application of heat and cold, massage therapy, aromatherapy, guided imagery, music therapy, and hypnosis. Music therapy, with patient-preferred music, has been shown to decrease stress and anxiety, but not analgesic requirements post-craniotomy.[7] Discomfort may also be related to the tightness of circumferential headdressings.[7] Transcutaneous electrical acupuncture stimulation may improve analgesia and reduce opioid requirements; however, studies are of poor quality with a high risk of bias.[4] Cold packs improve analgesia, eyelid oedema, and facial ecchymosis post-craniotomy.[4] Cold therapy has been shown to reduce pain 3 days post-craniotomy rather than in the immediate postoperative period.[22] Acupuncture has shown an analgesic effect, with one study demonstrating an opioid-sparing effect.[5] However none of these studies included the use of basic analgesics, and the use of acupuncture may be impractical and carry a risk of infection.

BENEFITS OF SCALP BLOCKS FOR CRANIOTOMY ANALGESIA

Haemodynamic stability

Skull pinning is a brief, sudden, painful stimulus comparable to an incision or laryngoscopy, often inducing hypertension and tachycardia. This can increase cerebral blood flow and intracranial pressure, especially in patients with impaired cerebral autoregulation where small increases in systemic blood pressure can cause larger changes in cerebral blood flow and intracranial pressure.[30] Alternative medications to attenuate the haemodynamic response (like opioids, propofol, and antihypertensives) can lead to inadvertent periods of hypotension after the stimulus is over.

The use of a scalp block prior to skull pinning improves haemodynamic stability from incision to dural opening.[31] Compared to placebo, patients who receive scalp blocks have lower intraoperative heart rates and mean arterial pressure.[32] It is superior to local infiltration and opioids for haemodynamic stability during pining and incision, with some studies showing no haemodynamic change with pinning.[30,31,33] Additionally, scalp blocks reduce the requirements for postoperative antihypertensive agents.[4]

Post-craniotomy pain

Scalp blocks are recommended by the PROSPECT Working Group of ESRA as part of an optimal multimodal pain management regimen after craniotomy.[5] A systematic review and meta-analysis concluded that scalp blocks with ropivacaine were likely the most efficacious method for pain control and reduction of opioid consumption and suggested scalp blocks should be included in craniotomy ERAS protocols due to this.[13] Scalp blocks have been demonstrated to reduce post-craniotomy pain for up to 48 hours, with the greatest effect in the first 12 hours, and decrease opioid and additional analgesia requirements.[2,3,5,13,28,33] They lower pain scores in both adult and paediatric patients and reduce additional analgesia requirements and time to first analgesic request.[2,5,13,32,34,35]

Reduced opioid requirement and adverse effects

Scalp blocks reduce opioid requirements within the first 24 hours after surgery when compared with placebo.[1,3,5,13,32,36,37] PONV is also reduced when scalp blocks are used.[2,5,35] To date, no studies address sedation as an outcome, although this potential could be extrapolated secondary to reduced opioid requirement.

Chronic post-craniotomy pain

There is some evidence that the incidence of chronic pain is lower with scalp blocks, with one study demonstrating less persistent pain at 2 months postoperatively after scalp infiltration with ropivacaine.[10] Another study demonstrated reduced pain at 14 days post surgery with pre-emptive scalp blocks.[38] Patients also had a lower likelihood of neuropathic symptoms if scalp blocks were used when compared with placebo.[10,31]

Compared to local infiltration

Infiltration of local anaesthetic at the surgical site doesn't block nociception to deeper tissues, such as temporalis muscles, which are often divided and reflected as part of a myocutaneous flap. Scalp blocks, on the other hand, target both superficial and deep tissue layers.[3] Scalp blocks are superior to infiltration for haemodynamic stability during pins and incision,[3] yielding improved pain scores and reduced opioid consumption.[5,13,28,37] In addition the efficacy and duration action for local infiltration was variable especially when compared with scalp blocks, which are longer lasting, thus providing superior analgesia.[5,13,39]

Adjuvants added to the local anaesthetic mixture

One RCT showed that the addition of dexamethasone to the local anaesthetic mixture prolonged its analgesic effect.[40] Intravenous dexamethasone is often administered during craniotomy to reduce tumour-associated oedema and for antiemesis, and can reduce postoperative pain and opioid consumption.[41–44] However, given that the effect of analgesic prolongation with dexamethasone is similar whether or not it is given perineurally or systemically, we recommend dexamethasone be administered systemically, especially if access to preservative-free dexamethasone is limited.

The addition of adrenaline to the local anaesthetic solution did not reduce postoperative 24-hour pain scores.[13]

The addition of dexmedetomidine to the local anaesthetic mixture improved the analgesic effect of both local infiltration and scalp block, with a greater effect when added to scalp blocks over local infiltration.[45] However, this study also showed there was a degree of systemic absorption of dexmedetomidine, resulting in slightly higher postoperative Ramsay sedation scores. As there is minimal evidence for benefit, the addition of adjuvants to local anaesthetic mixtures is not recommended.[5]

ANATOMY

The scalp is innervated by the trigeminal nerve anteriorly (supraorbital, supratrochlear, zygomaticotemporal, auriculotemporal), and cervical nerve roots C2 and 3 posteriorly (lesser and greater occipital) (see Figure 1).[37]

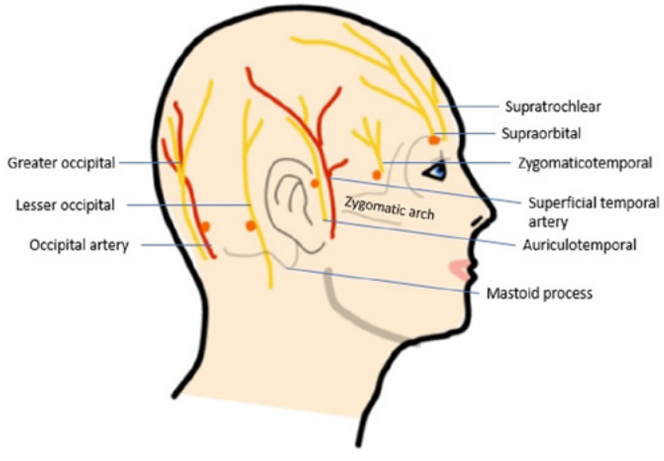


Figure 1. Scalp block nerves and injection sites (orange dots)

TECHNIQUE FOR SCALP BLOCKS

Landmark techniques are time efficient and allow for judicious use of local anaesthetic compared to a haphazard field or ring block. In practice, scalp blocks can be easily performed with the patient supine, post-intubation, during the additional routine preparations taking place prior to shaving and establishing the surgical site. Local anaesthetic concentration of at least 0.5% has the most consistent benefit.[31] Some of the anatomical landmarks are assisted by visualising the closed or open eye. As such, ensure any taping of the eyes (if the blocks are conducted after induction of general anaesthesia) does not interfere with needle insertion or distort the orbital/periorbital anatomy. Key considerations for each block are summarised in Table 1.

Supraorbital nerve block

Palpate the supraorbital notch, which usually lies at the medial one-third of the supraorbital ridge or at the medial edge of the iris. Insert the needle perpendicularly to the skin, 0.5cm above the supraorbital rim, till bone is contacted. Injection of 0.5ml of local anaesthetic is sufficient to block the nerve. Maintain the needle under the skin at the conclusion of the block, which can be redirected for the supratrochlear nerve block.

Supratrochlear nerve block

Positioning for this block is the same as for the supraorbital block. As such, it is ergonomically efficient to perform this block after the supraorbital block. The supratrochlear nerve runs parallel and roughly 1cm medial to the supraorbital nerve. Using the same puncture site as the supraorbital nerve block, redirect the needle medially under the skin by about 1cm and inject 0.5ml of local anaesthetic.

Zygomaticotemporal nerve block

Approaching the patient's head from its profile, identify the corner between the lateral orbital rim and zygomatic arch at the level of the lateral canthus of the eye. Insert the needle to contact bone (temporal surface of the greater wing of the sphenoid bone), withdraw slightly, and inject 2ml of local anaesthetic below the temporalis fascia. This nerve branches extensively as it pierces the temporalis fascia, so superficial and deep injections are required, which involves withdrawing the needle for a second injection of 2ml, above the fascia. Even then, blockade is sometimes incomplete and may require surgical supplementation in awake craniotomy.[1,30,31]

Auriculotemporal nerve block

This nerve is traditionally blocked with an injection near the superficial temporal artery at the tragus. However, there is a risk of also blocking the facial nerve adjacent to it. To decrease the risk of inadvertent transient facial nerve palsy, inject posterior to the superficial temporal artery, 1cm cephalad to the tragus, and limit the injectate volume to 2ml below the temporalis fascia and 1ml superficial to fascia as the needle is withdrawn.

If a facial nerve palsy is detected postoperatively, the presence of *forehead sparing* can differentiate peripheral and central nerve palsy. Forehead sparing is a sign of central palsy, whereas forehead paresis is a sign of peripheral or inadvertent facial nerve block. Central facial palsy is often associated with other focal deficits like tongue or upper limb paresis, while peripheral facial nerve palsy is usually isolated.

Greater and lesser occipital nerve block

These nerves are located by dividing an imaginary line between the occipital protuberance and mastoid process into thirds. The lesser occipital nerve is often situated at the point of the lateral third, while the greater occipital nerve sits at the point of the medial third (or adjacent to the occipital artery). It is ergonomically easier in a supine patient to turn the head and infiltrate along the superior nuchal line between the occipital protuberance and mastoid process. As this block is done by linear infiltration, it often requires 2-3ml on each side.

Table 1. Summary of scalp block nerves, technique, and considerations

Nerve	Location	LA vol	Special considerations
Supraorbital	Supraorbital notch 0.5cm from upper margin of supraorbital rim, 3cm from midline	0.5-1ml	Caution to prevent orbital injury
Supratrochlear	1cm medial to supraorbital or 1.5cm from midline below upper margin of supraorbital rim	0.5-1ml	Caution to prevent orbital injury
Auriculotemporal	1cm superior to tragus, posterior to superficial temporal artery	1-2ml below temporalis fascia, 1ml superficial to fascia	Superior to tragus, low vol to prevent inadvertent facial nerve palsy
Zygomaticotemporal	Corner between lateral orbital rim and zygomatic arch near lateral canthus of eye	2ml below temporalis fascia, 2ml above temporalis fascia	Frequently incomplete and challenging block due to extensive and early nerve branching
Lesser occipital	Lateral 1/3 distance along nuchal ridge between occipital protuberance and mastoid process, or 2.5cm lateral to greater occipital	2-3ml	Consider superficial wheal along nuchal ridge for both occipital nerves
Greater occipital	Half to medial 1/3 distance along nuchal ridge between occipital protuberance and mastoid process, or inject just medial to occipital artery	2-3ml	Caution injury to occipital artery Consider superficial wheal along nuchal ridge for both occipital nerves

Practical tips

Coordinate the timing and extent of the block with the surgical team. Anaesthetists should consider the site of surgery and the use and positioning of pins, as not all nerves may need to be blocked in an asleep craniotomy, especially if not using pins. Scalp blocks are most useful in craniotomies where muscle, like the temporalis, is manipulated or cut for surgery in the temporal or parietal area and for cranioplasties.

Consider performing the block preoperatively, especially if the bone flap is not being replaced, due to the risk of accidental intracranial injection. In an asleep craniotomy, scalp blocks can be performed post-intubation and before surgical incision so as not to cause a delay. It is important to limit the volume of local anaesthetic injected, to not excessively distort facial anatomy, as this may interfere with surgical stealth navigation. The application of some gentle pressure on injection sites with gauze helps to reduce bleeding from injection sites and reduce the extent of swelling from the local anaesthetic injection. Performing scalp blocks in asleep craniotomies increases the volume of practice for these blocks, increasing familiarity with the technique, which is beneficial for awake craniotomies, where block success is important.

Complications

Complications from scalp blocks are rare.[3] Potential complications include inadvertent transient facial nerve palsy, local anaesthetic toxicity, haematoma, infection, and allergic reactions. The auriculotemporal nerve block can cause transient facial nerve palsy, which is self-limiting and should resolve as the block wears off. Scalp nerves are superficial terminal sensory branches, so the risk of permanent nerve damage is low.[31] The scalp is vascular, so systemic absorption is quick, and peak plasma concentrations occur in 16 minutes following local anaesthetic injection.[31] There are no published reports of proven local anaesthetic systemic toxicity from scalp block despite some doses in studies being above the recommended total local dose. It is advisable, however, to use ropivacaine due to its better safety profile compared to bupivacaine.[31] Caution should be exercised in skull defects, where bone has not been replaced, to avoid inadvertent subarachnoid injection.

ULTRASOUND GUIDED GREATER OCCIPITAL NERVE BLOCK AT C2

Greater occipital nerve blocks are beneficial for the treatment of refractory migraines, occipital neuralgia, cervicogenic headache, cluster headache, and post-dural puncture headaches.[46] These blocks have also been shown to provide a benefit in posterior fossa operations. Compared to standard care with systemic medication, they provide superior quality and duration of analgesia and a better haemodynamic profile for posterior fossa surgery.[47]

Infratentorial surgical approaches are associated with a higher risk of severe pain and a greater incidence of severe chronic post-craniotomy pain compared to supratentorial procedures.[7,9]

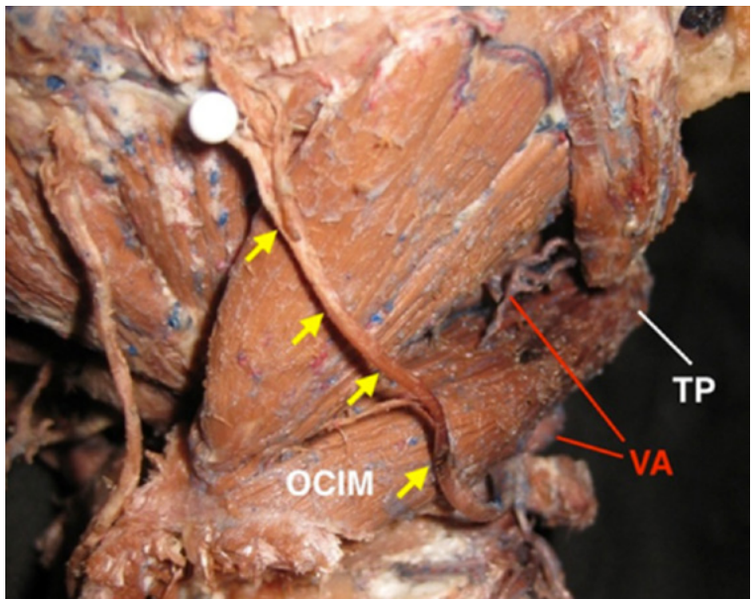
A randomised controlled trial comparing ultrasound-guided greater occipital block versus control in children undergoing elective posterior fossa craniotomy showed a clinical improvement in pain scores, significantly longer time (13.4 hours compared with 1.8 hours) to first analgesic request, reduced opioid consumption, and lower systolic blood pressure intraoperatively and postoperatively, with no block related complications.[47]

Complications of greater occipital nerve blocks are rare, especially if ultrasound-guided. Only one complication has been reported, involving inadvertent subarachnoid injection in a patient with previous posterior fossa surgery. The injection was not ultrasound-guided and resulted in a coma, but the patient made a full recovery shortly afterwards.[48]

Anatomy

The greater occipital nerve is a sensory branch of the C2 spinal nerve and, together with the lesser occipital nerve, innervates the sensation of the occipital region up to the vertex.[46] The greater occipital nerve leaves C2 posterior to the lateral atlantoaxial joint and travels laterally to emerge at the inferior border of the obliquus capitis inferior muscle (OCIM) (see Figure 2a). The nerve then ascends while sandwiched between the OCIM and the semispinalis capitis muscle (SsCM), pierces SsCM and terminates as a superficial nerve, where it lies adjacent to the occipital artery, usually medial (see Figure 2b). There is high variability (1.5-7.5cm) of its position when it becomes superficial along the line between the mastoid process and external occipital protuberance. Because of its variability and branching at this superficial location, successful landmark techniques requiring higher volumes and ultrasound identification at this location are more difficult. The nerve position is most consistent at the OCIM, which is, therefore, an important muscular landmark.[46] The OCIM connects the spinous process of C2/axis medially to the transverse process of C1/atlas laterally.

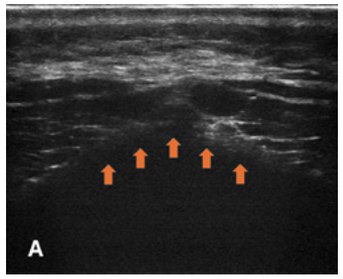
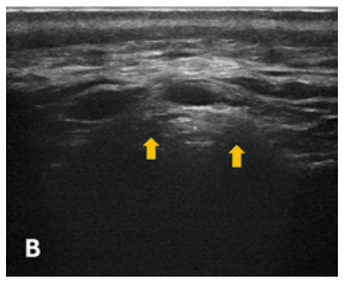
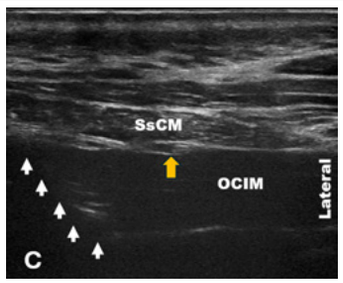
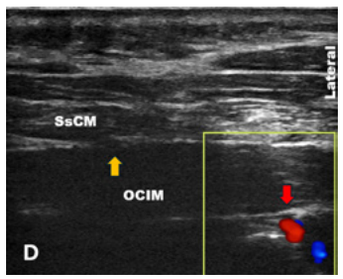
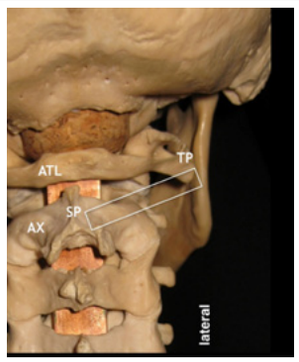
Figure 2. The greater occipital nerve shown on the posterior surface of OCIM (yellow arrows). The vertebral artery (VA in red) is located anterior and deep to the OCIM close to its attachment at the transverse process of C1/atlas (TP in white). (Reproduced with permission from USRA.ca)[49]



Ultrasound technique and practical tips

This can be performed prone, sitting, or in the lateral decubitus position. In posterior fossa surgery, it is easily performed after induction, with the patient in the prone position, after the hair has been removed for surgical exposure. A high-frequency linear transducer is used along with a 50mm echogenic needle and 3-5ml of long-acting local anaesthetic, such as ropivacaine 0.5% per side (see Figure 3).

Figure 3. Ultrasound scanning technique.[49]

	A: The probe is initially placed midline on the occiput and moved inferiorly where the surface of the posterior arch of C1/atlas (orange arrows) is seen. Note that it has no spinous process.
	B: moving the transducer caudally visualises the bifid C2/axis spinous process (orange arrows), which is an important osseous landmark to locate OCIM.
	C: translating the transducer laterally visualises the OCIM and SsCM. The best images are obtained if the transducer is rotated obliquely such that its lateral end is shifted superiorly towards the transverse process of C1, and tilted slightly cephalad to enhance visualisation of fascia and the nerve. The OCIM is typically hypoechoic relative to the overlying SsCM and sandwiches the greater occipital nerve (orange arrow). The lamina of C2 is visible deep to OCIM (white arrows).
	D: the vertebral artery (red arrow with colour doppler) can be seen laterally, near the transverse process of C1/atlas and deep to OCIM when the probe is moved laterally. Note that the greater occipital nerve (orange arrow) is a safe distance from the artery.
 Reproduced with permission from USRA.ca	Final position of the transducer: rotated obliquely between the spinous process of C2 and the transverse process of C1. ATL: atlas AX: axis SP: spinous process of C2/axis TP: transverse process of C1/atlas White rectangle: outline of transducer position

Analgesia and enhanced recovery for craniotomy

Enhanced recovery protocols include interventions to optimise patients for surgery. Preoperatively this can include education, risk assessment, and medication management. Intraoperative measures include minimally invasive surgical approaches, selection of anaesthesia, and multimodal analgesia techniques. Postoperative measures include pain service consultation, where required, rehabilitation and return to normal diet and activity. Pain assessment and effective analgesia are key.[7]

Preoperatively, identification of high-risk patients may improve pain management by establishing multidisciplinary communication about pain expectations and outcomes, referral for pain consultation, or psychological cognitive intervention.[7] Patients are concerned about pain and value education and communication about the perioperative journey, thus education material about expected pain and its multimodal management may improve their experience. This is a recommended component of enhanced recovery for oncological craniotomy.[7]

Postoperatively, the goal should be to provide consistent pain assessment, analgesia, side effect attenuation, minimisation of breakthrough pain, and early initiation of oral medications.[7] Adequate multimodal therapies improve analgesia while minimising opioid adverse effects and may allow earlier mobilisation, decreased length of stay, and decreased hospitalisation costs.[19] Scalp blocks have been recommended in some systematic reviews as part of a multimodal analgesic regimen for enhanced recovery after craniotomy.[14]

CONCLUSION

Significant post-craniotomy pain is common, and analgesia is often suboptimal secondary to concerns of confounding neurological assessments. A multimodal analgesic approach throughout the perioperative period reduces opioid requirements and opioid-related adverse effects, improves patient experience, and facilitates earlier mobilisation and return to normal function. Mitigation of severe acute post-craniotomy pain may reduce progression to chronic post-craniotomy headache.

Scalp blocks are recommended by the PROSPECT Working Group of the European Society of Regional Anaesthesia and Pain Therapy (ESRA) as part of an optimal multimodal pain management regimen after craniotomy.[5] Scalp blocks improve haemodynamic stability during pining, incision, and closure and are superior to local infiltration or isolated treatment with opioids. They significantly reduce opioid requirements and are thus a good opioid-sparing analgesic option to consider implementing more frequently. Scalp blocks are simple to perform with minimal risk of adverse outcomes.

Ultrasound-guided greater occipital nerve blocks at the level of C2 may be beneficial for infratentorial procedures, which are often more painful. It is important to assess and consider patient and surgical factors when formulating an individualised perioperative analgesic approach to facilitate improved post-craniotomy recovery.

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