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Jitin Bajaj,
Sharad Narayan Sharma,
Gopal Maravi,
Aamir Iqbal,
Y.R. Yadav,
Ankur Shrivastav,
Ketan Hedaoo,
Ambuj Kumar,
Mallika Sinha,
Shailendra Ratre,
Vijay Parihar,
Narayan Swamy

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Awake focussed craniotomy for oedematous/large brain lesions. A pilot study for safety and feasibility

Jitin Bajaj[1], Sharad Narayan Sharma[2], Gopal Maravi[2], Aamir Iqbal[3], YR Yadav[1], Ankur Shrivastav[1], Ketan Hedaoo[1], Ambuj Kumar[1], Mallika Sinha[1], Shailendra Ratre[1], Vijay Parihar[1], Narayan Swamy[1]

[1] Department of Neurosurgery, NSCB Govt. Medical College, Jabalpur, INDIA
[2] Department of Anesthesiology, NSCB Govt. Medical College, Jabalpur, INDIA
[3] Department of Surgery, NSCB Govt. Medical College, Jabalpur, INDIA

Keywords
anaesthesia,
awake craniotomy,
brain tumour,
keyhole surgery

ABSTRACT

Aim: Awake craniotomy has been proven to be safe and effective. It has generally been used for non-edematous conditions. If done in edematous states, large craniotomies are advised. Here, we report the combined use of techniques of awake anaesthesia and focussed craniotomy for dealing with large/edematous brain lesions.

Materials and methods: This was a prospective single-centre study from May to October 2019. Included were adult cooperative patients presenting with edematous brain lesions. A completely awake cycle was used using ring scalp block, Dexmedetomidine loading, and maintenance infusion, and use of Midazolam and Fentanyl. The dural flap was lifted limited to the lesion, and sometimes in stages to tackle the bulging brain. Data was collected for resection volume, pain scores using visual analogue scale (VAS) during the surgery, seizures, complications, new deficits, blood loss, duration of surgery, ICU, and postoperative hospital stay.

Results: Fifteen patients underwent the procedure. Pathologies were high-grade gliomas (7), low-grade gliomas (3), tuberculoma (2), metastasis (1), ependymoma (1), and meningioma (1). Fourteen patients underwent total, and one underwent subtotal excision. Brain bulge could be handled with the staged opening of the dura and intratumoral decompression. No patient required postoperative ventilatory support. Intraoperative pain scores ranged from 2-3. The duration of surgery ranged from 60-280min. Blood loss ranged from 75-300ml. Postoperative stay varied from 3-20 days. There were two intraoperative seizures (managed), two CSF leaks, and two infections. Two patients developed transitory motor deficits.

Conclusion: Awake focussed craniotomy was found safe and effective for large/edematous brain lesions in appropriately selected patients.

Corresponding author:
Jitin Bajaj

Department of Neurosurgery, NSCB Govt. Medical College, Jabalpur, India

bajaj.jitin@gmail.com

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Introduction

Awake craniotomy (AC) has been proven to be safe and effective in several conditions, including low-grade gliomas, epilepsy surgeries, and vascular diseases.2,12,13 It provides several advantages over craniotomy done under general anesthesia (GA). Firstly, it gives the ability to use intraoperative monitoring of eloquent regions, including speech, motor, and visual areas. Secondly, pulmonary complications due to intubation, ventilation, etc., that can occur with GA can be avoided. Thirdly, positional complications like ulcers, spinal torsions, etc. can also be prevented. Since the level of sedation is lesser than GA, the AC is essentially more physiological. The use of newer drugs like Dexmedetomidine has proved to be safe and effective in awake craniotomies, perioperative, and ICU situations.1,3.

AC has been generally used in non-edematous conditions, possibly due to the apprehension of intraoperative brain bulge. If done in edematous states, large craniotomies have been advised.4 Also, for the lesions with midline shift, the asleep-awake-asleep cycle has been used, and the data regarding the size of craniotomy is missing.5 Small craniotomies are associated with lesser operative time, blood loss, wound complications, etc. than large craniotomies. We have reported minicraniotomy and endoscopic-assisted excision of deep-seated brain tumors and hematomas in the past.8,9 In this article, we report the combined use of techniques of awake and focussed craniotomies for dealing with large or edematous brain lesions.

Materials and methods

This was a prospective study done at a single center from May 2019 to October 2019. Institutional ethics committee permission was taken. The trial was registered under the clinical trials registry of India with reference number CTRI/2019/05/019338.

Patient inclusion criteria were adult cooperative patients presenting with large or edematous brain lesions defined as either the tumor volume 30 cc3, or edema volume 60 cc3, or the total volume of tumor + edema 60 cc3. Patient denying taking part in the study, or with cardiac or respiratory illnesses were excluded from the study. Karnofsky status and Minimental status examination (MMSE) were calculated both before and after the surgery.

Anesthesia protocol

Patients were explained about the procedure and habituated with the types of questions to be raised before the surgery. Once in the operation theatre, glycopyrrolate 0.2mg, fentanyl 100mcg, and Ondansetron 4mg were administered intravenously, and an oxygen mask (O2) was applied. Monitoring included an electrocardiogram, pulse oximetry, blood pressure (BP), End-tidal CO2, and urine output. Ring scalp block was performed with 20 ml of 0.5 percent bupivacaine. The infiltration was given in the territories of Supraorbital, Supratrochlear, Zygomaticotemporal, Auriculotemporal, Lesser occipital and Greater Occipital nerves. The incision site was again infiltrated with 2% Lignocaine and 1:100,000 Adrenaline. Infusion of Dexmedetomidine (1ug/kg/hr) was then started and stopped 10 minutes before the neurocognitive testing. The level of sedation was assessed by the Ramsay sedation score and was maintained between a score of 3 to 5 until neurocognitive testing was started. Bispectral index monitoring was not available at our center and was not used in any of the cases.

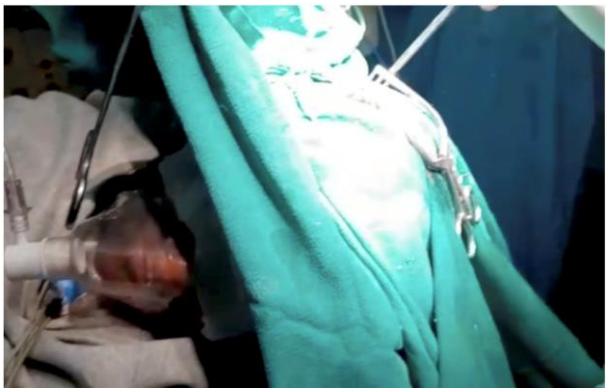

Figure 1. Shows the patient positioning. An 'L' shaped rod allows the surgeon to work in a sterile field and anesthetist to have face accessible for interacting with the patient and emergency airway management if the need arises.

Surgical protocol: We defined focussed craniotomies as bone opening not more than 1 cm and dural opening not more than 0.5 cm of tumor edges. All surgeries were done by the same surgeon. A preoperative dose of antibiotic (Ceftriaxone) and 4mg of Dexamethasone was given in every case. Patients were placed supine with neck tilt in order to make the surgical trajectory as perpendicular to the ground as possible. A three-pin Mayfield head clamp was applied for immobilization. Patients were

allowed to move their limbs within the limits of safety. An L-shaped stand was placed right across the patient's face, and draping was done in a way to have the face always accessible to the anesthetist (figure 1).

The scalp flap was elevated according to the need, and a small craniotomy was lifted depending upon the lesion. The deeper the lesion, the smaller the craniotomy was made, according to the inverse funnel-shaped principle of keyhole surgeries. The brain bulge, if anticipated, was tackled with the initial small opening of dura, tumor decompression and later rest of the dural opening if needed. The bipolar cautery settings were used at the minimum. Cold saline was always kept ready to abort the seizure if it happens. The lesions were resected with the standard bimanual dissection technique. Cortical mapping with direct cortical stimulation was done in the last five cases. It was initially assessed over the exposed surface, and the absence of the eloquent region allowed the resection. Mapping was repeatedly done during the procedure, along with the clinical testing. There was no difficulty in achieving the hemostasis in any of the cases. Stopping the Dexmedetomidine raised blood pressure to be normal, and asking the patient to cough confirmed the hemostasis. Dura was closed, the bone was reposited, and standard closure techniques were followed in all the cases.

Table 1. Demographic details of the patients.

S. No.	Age in Years / Gender	Loc.	Side	Diagnosis	Tumor vol. (cc^3)	Edema vol. (cc^3)	Hydro-cephalous	Resection	Intraope --rative brain bulge	Blood loss (ml)	Duration of surgery (min)	Procedure related complication
1.	55/M	PF	Right	Metastasis	5.4	60	Absent	Total	Present	100	60	Intraoperative seizure
2.	25/F	AF	Left	Recurrent HGG	36.6	66.32	Absent	Total	Present	200	120	CSF leak, infection
3.	30/M	AP	Left	Tuberculoma	14.4	75	Absent	Total	Present	75	60	None
4.	32/M	PF	Right	Recurrent HGG	40	100	Absent	Subtotal	Present	150	200	CSF leak, infection
5.	45/M	MF	Left	Tuberculoma	37.63	67.32	Absent	Total	Present	100	150	None
6.	53/M	PF	Right	Convexity meningioma	22.8	110.7	Absent	Simpson Grade 1	Present	200	120	None
7.	40/M	AF	Right	HGG	38.5	22	Absent	Total	Present	200	150	None
8.	34/M	AF	Left	Ependymoma	42.75	20.4	Absent	Total	Present	200	280	None
9.	45/M	PF	Right	HGG	40.1	21	Absent	Total	Present	180	200	None
10.	24/M	PF	Left	HGG	44.5	23.2	Absent	Total	Present	300	180	Transient speech slurring
11.	30/F	AP	Right	HGG	40.2	21.1	Absent	Total	Present	250	210	None
12.	40/M	PF	Right	LGG	38.5	24.5	Absent	Total	Present	250	180	Intraoperative seizure
13.	22/M	AP	Right	LGG	40.2	23.1	Absent	Total	Present	250	150	Transient shoulder weakness
14.	29/M	AP	Left	HGG	30.5	40.2	Absent	Subtotal	Present	250	200	None
15.	42/F	MF	Left	LGG	41.2	21.2	Absent	Total	Present	200	220	None

Postoperative care

Postoperatively, they were given IV antibiotics for three days, and oral antibiotics for five more days. Dexamethasone, anticonvulsants, and analgesics were given for a minimum of one week and tapered thereafter.

Surgical resection

The resection was termed as gross total resection (GTR) (100% removal), near-total (91-99% removal), subtotal (STR) (51-90% removal), and tumor biopsy (<10% removal). These were determined based on a comparison of preoperative and postoperative imaging volumetrically.

The duration of surgery was calculated from the time of incision to the last stitch. Subtracting the amount of irrigation fluid from the drain fluid and weighing the gauges after surgery calculated blood loss.

Pain score

Patients were asked to rate the degree of maximum pain during the surgery on the visual analog scale (from 0-10, where 0 means no pain, and 10 means life-threatening pain).

Results

Fifteen adult patients (12 males, 3 females) ranging from 22-55 years were operated in the study period. The diagnosis included high-grade gliomas (7), low-grade gliomas (3), tuberculoma (2), metastasis (1), Ependymoma (1) and meningioma (1). Three gliomas were previously operated and were recurrences. All tumors were located either cortically or subcortically. Seven patients had a history of seizures before the surgery. The demographic details, including the location of tumors, are given in table 1.

Neurological status and deficits

The preoperative MMSE of the patients ranged from 22-30 (mean = 27.26 ± 2.49). Postoperatively at six weeks MMSE ranged from 28-30 (mean = 29.38 ± 0.76). The preoperative Karnofsky status of the patients ranged from 50-100 (mean = 77.33 ± 15.79), and it improved to range from 80-100 (mean = 91.53 ± 8.98) at six weeks. There were four patients with prior hemiparesis. One of them had an increase in shoulder weakness that resolved in six weeks. Another patient had new speech slurring, which resolved in four weeks. For these two patients, the surgery had to be stopped after the new deficit. None of the patients had a permanent new neurological deficit.

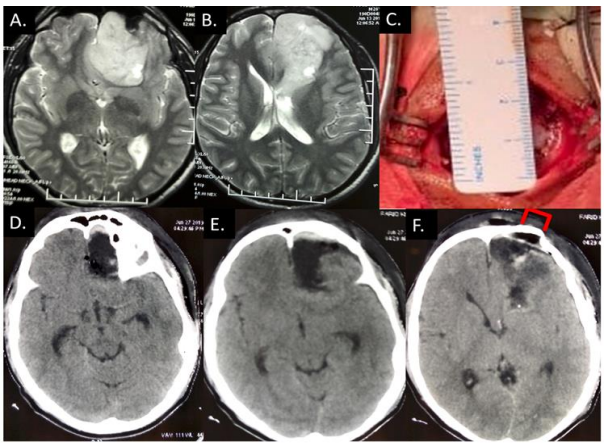

Figure 2. A & B shows the T2 weighted MRI with a large left parafalcine mass arising from the ventricle approached with awake minicraniotomy. C shows the 3cm sized bone opening. D-E shows the postoperative scan of the patient showing complete tumor excision. The red bracket shows the minicraniotomy on the scan.

Tumor volume and perilesional edema

Lesion volume ranged from 5.4cc3 to 44.5 cc3. The mean tumor volume was 34.21 ± 11.30 cc3. Perilesional edema volume ranged from 20.40 cc3 to 110.7cc3 with a mean of 46.4 ± 31.2 cc3.

Surgical resection

The dura was opened in a limited manner over the tumor or just more than the tumor. Fourteen patients underwent total, and one underwent subtotal excision of the masses (due to tumor invasiveness). Focussed craniotomies were lifted based on the methodology described. Figure 2 shows a Parafalcine mass arising from the ventricular wall (Ependymoma) approached through an awake frontal minicraniotomy. One of our patient (Case 4) had a significant bulging brain and for it staged dural opening and tumor resection was carried out. In the end, the brain was lax (figure 3). One patient (recurrent grade III glioma) had a previous large craniotomy. Going through it needed resection of a wedge of normal brain tissue to tackle the bulging brain. Therefore a new minicraniotomy with a direct trajectory was planned that allowed us to hit the tumor only and prevent the venous compression of the normal brain (figure 4). There was no difficulty in achieving hemostasis in any of the cases.

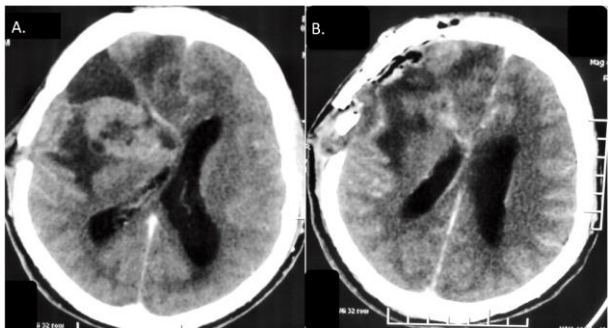

Figure 3. 'A' is the preoperative MRI of a large recurrent glioma grade III. 'B' shows the postoperative scan of the patient. The dura was opened in a staged manner with the tumor resection to tackle the bulging. The mass could be excised subtotal due to its invasion into the surrounding eloquent region.

Blood loss and duration of surgery

Average blood loss was 146.66 ± 57.37 ml. Although

no direct objective comparison was made with the cases done under GA, the blood loss was found subjectively equal to them. The mean duration of surgery was 131.33 ± 61.86 min, and similar was observation for it.

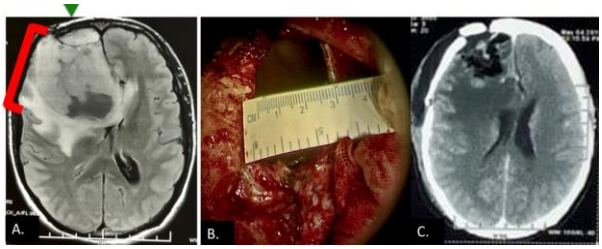

Figure 4. A Shows the preoperative scan of the patient with a large mass. It shows the prior site of craniotomy (I) and a newer approach (II). B shows a 3 cm size width dural opening. C shows the postoperative scan of the patient with a newer mini-craniotomy site visible and total resection of the mass.

Intraoperative vitals

Mean blood pressure fell by 12.66 ± 4.16 mm Hg, and the mean pulse fell by 13.06 ± 5.79/min after the bolus dose of Dexmedetomidine.

Pain score

Postoperatively, patients were asked to rate their maximum level of pain on a score of 1-10 (1-minimum, 10-maximum as possible). The pain score for all the patients ranged from 2-3, with the mean score being 2.6 ± 0.63.

Postoperative hospital stay

All patients could be discharged without any new neurological deficit with a mean hospital stay of 7 ± 4.08 days ranging from 3-20 days.

Complications

There was one event of intraoperative focal facio-brachial seizure, which possibly occurred due to the high value of bipolar coagulation. It was managed with pouring cold saline over the brain and giving 1.5mg Midazolam intravenously. On reducing the value of bipolar coagulation, there was no other seizure. One case (recurrent GBM) developed a cerebrospinal fluid leak, which was controlled with the resuturing of the wound. Another patient (recurrent glioma - grade III) developed a wound site infection, which required prolonged antibiotics. We believe both the latter complications should not be attributed to the AC since they were recurrent cases and can happen with craniotomies under GA also. There was one case of speech slurring (recovered in 6 weeks) and one case of shoulder weakness (recovered in 2 weeks). Neuromonitoring in the speech slurring case was not done, while in the shoulder weakness case didn't show the localization of the shoulder area. There was no procedure-related permanent morbidity or mortality. No case of any pressure-related injury or cautery burns etc. happened.

Follow-up

One patient of metastasis (Case 1- metastasis from melanoma) succumbed to his illness one month later. Another patient - Tuberculoma with TBM (case 3), also died one month later due to basal infarcts. Rest patients were neurologically intact, having a follow-up of 3-6 months.

Discussion

AC has been done for a long time.6,7 However, the safety and efficacy of small craniotomies in edematous brain lesions have not been described before. Traditionally, for AC, a large bone flap has been recommended to avoid brain compression at the edges.4 The present set of technology with the newer concept of keyhole surgery allows us to explore in this direction.10,11 This study is probably the first one in the literature to report the safety and feasibility of focussed AC for large or edematous brain lesions.

We found that small craniotomies were beneficial in large or edematous lesions, contrary to the previous observation.4 The reasons may be the usage of principles of keyhole surgery. We found three things to be required for awake focussed craniotomies.

1. Patient selection: All patients were adults and cooperative, as is required for all awake surgeries.
2. Proper positioning: Patients were positioned to make the operative site highest and trajectory perpendicular to the ground. This made the surrounding brain to fall apart and pushed the tumor out towards us. We used a Mayfield head clamp to make these positions. It also inhibited any untoward movement of the patient.
3. Small craniotomy: This avoided the compression of the surrounding brain and veins between

tumor and dural edges. Points 2 & 3 are explained in Figure 5.

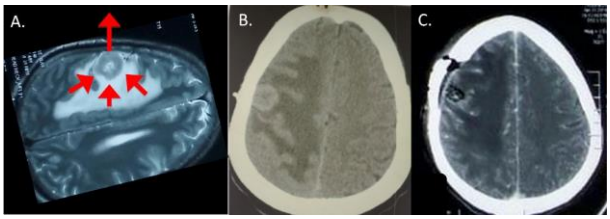

Figure 5. Shows the technique through which small craniotomy works. 'A' is the preoperative MRI of the patient showing a small metastasis with significant perilesional edema. If proper positioning is made with the tumor at the highest position, the edematous forces (red arrows) will aid in forcing it out. Since the site of the craniotomy is near to the tumor, no brain tissue/veins get compressed between the edges of the tumor and dura. 'B' shows the marker CT depicting a radio-opaque marker at the site of the mass. 'C' shows the postoperative scan with a small craniotomy. Note the surrounding cortex expands and takes space of the tumor.

The face was always accessible to the anesthetist that provided the ability to use non-invasive ventilation or laryngeal mask airway ventilation if the need arise, although we didn't need them in any of the cases. The duration of the action of Bupivacaine is 4-8 hours and this allowed us to perform the surgery with minimal pain. Dexmedetomidine decreased the blood pressure and pulse rates mildly but these were always under control. This drug also has an analgesic effect which allowed the procedure to be performed for the convexity meningioma and parafalcine mass (cases 6 and 8).

The cases in our series were heterogeneous with tumor size ranging from 5.4 cc3 to 44.5 cc3, and edema volume ranging from 20.40 cc3 to 110 cc3. This showed that the procedure was safe in cases with high intracranial pressure, in lesions of various etiologies, and with a variable amount of tumor size and edema.

The GA helps in decreasing the intracranial pressure (ICP) by deep sedation. However, during its reversal, it also makes the patient susceptible to a sudden rise in ICP, BP, pulse rate, etc. which can create postoperative complications like hematomas. We believe that awake surgeries are more physiological than the surgeries done under GA. The level of sedation, heart rate, BP, ICP, etc. are close to the baseline in the awake state, while all of these vary a lot in the GA state. Although there were cases of operative site hematoma in Taylor et al. series,13 we found none in our series. We believe that after tumor removal, the stoppage of Dexmedetomidine leading to the restoration of BP and asking the patient to cough helped in confirmation of hemostasis, which carried to the postoperative state.

The average blood loss and operative duration were similar to the personal experience of the surgeon. A direct objective comparison was not possible with surgeries done under GA due to the variability of the diagnosis and vascularity of the tumors operated. There was no procedure-related complication apart from one intraoperative seizure, which was easily controlled with cold saline and Midazolam.

The costs of the procedures done under awake conditions are less due to the lack of need of anesthesia gases, endotracheal tube, and postoperative ICU stay. The cost of Dexmedetomidine with Midazolam is very less compared to the anesthesia gases and ventilatory support. These factors play a very important role in resource-limited settings.

Limitations of our study include small sample size and a single team's experience, which may create bias. A multicenter randomized controlled trial between craniotomies under awake and GA conditions will be better to show its superiority/inferiority for the rates of the degree of surgical resection, duration, blood loss, and brain bulge. The intraoperative seizure is a critical limitation of AC, but these can be managed as mentioned. All tumors were located near the surface in our series, and safety and efficacy in deeper lesions need to be established. However, despite these limitations, this study shows the safety and feasibility of awake focussed craniotomies in large or edematous brain lesions.

Conclusion

Awake focussed craniotomy was found safe and effective for large or edematous brain lesions in appropriately selected patients.

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