Evaluation of trans burr hole ultrasonography usefulness in a resource-limited setting

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ABSTRACT

Purpose: Transcranial ultrasound (US) imaging of intracranial structures is a reliable technique that requires an opening in the skull. In young children the fontanelle serves this purpose, but in adults a postoperative skull defect or some other acquired skull bone defect could be used as potential windows for transcranial US imaging. This study is an audit on the usefulness of the trans burr hole US intracranial imaging technique in a neurosurgical unit in Cameroon (sub-Saharan Africa). **Materials and Methods:** From January 2001 through December 2004, all files of patients consecutively operated in the neurosurgical unit of the Central Hospital of Yaounde, who underwent an US exploration in the postoperative period through the acquired bone defect or through a skull fracture were reviewed. Transcranial US results were validated by a complementary CT scan or postoperative findings. **Results:** Seventeen patients were included. Trans burr hole US was effective in diagnosing or in excluding postoperative complications. Hydrocephalus was diagnosed (two cases) or excluded (five cases) after posterior a fossa surgery (five cases) or in case of suspicion of drain dysfunction (two cases). Abscess (one case) or chronic subdural hematoma (two cases) were detected or excluded after cranial surgery for tumours (three cases), aneurysm (one case), compound depressed skull fracture (one case), or intracranial hematoma (three cases). In one case of posttraumatic swelling of the scalp, the US technique revealed an acquired meningoencephalocele. In one case, residual subdural empyema was detected through trans burr hole US. **Conclusion:** Trans burr hole US technique may be considered in the diagnosis of postoperative complications (abscesses or hematoma) in adults after intracranial surgery or ventriculoperitoneal drain dysfunction especially in resource-limited setting as it is both cheap and widely available.

Key words: Abscess, hematoma, hydrocephalus, trans burr hole ultrasound, transcranial postoperative sonography

INTRODUCTION

Transcranial sonography is an imaging technique used for the diagnosis of several intracranial pathologies. It is cheap and available in many hospitals. The transcranial ultrasound (US) exploration is commonly used in young children through an opened fontanelle; in adults, its usefulness is precluded by the presence of the closed skull. In a series of 17 patients, the authors evaluated the usefulness of the US technique through an acquired bone defect of the skull.

The aim of this study was to report the audit of the usefulness of US technique for intracranial exploration of patients in the postoperative course or with an acquired skull bone defect.

Access this article online	
Quick Response Code:	Website: www.ijns.in
	DOI: 10.4103/2277-9167.110224

MATERIALS AND METHODS

From January 2001 to December 2004, all patients' files operated in the surgical unit of the Central Hospital of Yaounde and who underwent an US exploration in the postoperative period through the acquired bone defect or a fracture of the skull were reviewed consecutively. US was performed in all patients operated for posterior fossa tumour to rule out hydrocephalus and in other patients when clinical worsening was observed. US findings were compared with CT scan results and peroperative findings. The US apparatus used was a Siemens Sonograph. Three types of probe were available: (1) a 7-cm diameter convex-shaped probe and frequency 3.5-6 MHz (for near-field lesions), (2) a 2.5-cm diameter probe and frequency 7-12 MHz (for far-field lesions), and (3) a 5-cm diameter probe and frequency 7-12 MHz (for far-field lesions).

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RESULTS

During the study period, 17 patients (9 females and 8 males) were examined. They were initially operated for various pathologies: Posterior fossa tumours, extradural hematoma, subdural hematoma, subdural empyema, open compound skull fractures, and ventriculoperitoneal shunting for hydrocephalus. The postoperative US was done within a variable delay in patients whom neurological condition deteriorated. The US results led to significant therapeutic decisions in all the cases and were compared with CT scan and surgical findings (patients reoperated). The bone defect frequently used for US transcranial explorations was the burr hole [Table 1].

Posterior Fossa Tumours

Five patients (aged 4, 6, 6, 18, and 24 years) each operated for a posterior fossa tumour associated with hydrocephalus were included: Medulloblastoma (two cases), pilocytic astrocytoma (two cases), and ependymoma (one case). They underwent a suboccipital craniotomy or craniectomy to remove the tumour and a right parieto-occipital burr hole to insert a catheter for the CSF external drainage. The catheter was kept closed for 48 h before removal. Trans burr hole US was systematically done on the second postoperative day to rule out hydrocephalus before the removal of the CSF external drainage system and again after the first or the second week. By this technique, hydrocephalus was diagnosed in one patient. These results were similar to CT scan findings. The patient with hydrocephalus underwent a ventriculoperitoneal shunting.

Extradural Hematoma

A 29-year-old male patient was operated for a right extradural hematoma (osteoplastic craniotomy) associated with a contralateral subdural hematoma (conservative treatment). The patient was initially unconscious (GCS = 8). He progressively improved during the first postoperative week, but his condition worsened subsequently with altered state of consciousness and left hemiparesis. The US performed through the burr holes of the craniotomy revealed an ipsilateral residual collection of the extradural hematoma. CT scan confirmed the findings. The patient was reoperated and the extradural collection was removed. The second postoperative course was uneventful.

Subdural Hematoma

Two patients were operated for chronic subdural hematoma (burr hole and evacuation of the haematoma). They had generalized seizures during the second and third postoperative weeks, respectively. US revealed no significant residual bloody collection which was confirmed by CT scan.

Compound Depressed Skull Fracture

A 36-year-old patient was operated for a compound depressed skull fracture. The fracture was elevated through a burr hole and the skin was closed. Two months later, he presented an insidious onset of contralateral hemiplegia. The trans burr hole US disclosed an underlying intraparenchymal collection suggestive of brain abscess. The CT scan demonstrated the hypodense

Table 1: Patients characteristics

Type of surgery	No.	Age, years	Sex	Preoperative diagnosis	Indication for US	US findings	Management
Craniotomy	1	4	F	Medulloblastoma	Hydrocephalus	Positive	Ventriculo-peritoneal shunt
	2	6	M	Ependymoma		Negative	Nonspecific
	3	6	M	Pilocytic astrocytoma		Negative	Nonspecific
	4	18	F	Pilocytic astrocytoma		Negative	Nonspecific
	5	24	F	Medulloblastoma		Negative	Nonspecific
	6	29	M	Extradural hematoma	Recurrence	Positive	Evacuation
Burr hole	7	60	M	Chronic subdural hematoma	Seizures (recurrence)	Negative	Antiepileptic drugs
Burr hole	8	52	M	Chronic subdural hematoma	Seizures (recurrence)	Negative	Antiepileptic drugs
Burr hole [Figure 1]	9	22	M	Empyema	Seizures	Positive	Evacuation
VP shunt	10	6	F	Hydrocephalus	Recurrence	Positive	Shunt replacement
VP shunt	11	12	F	Hydrocephalus	Recurrence	CSDH	Evacuation
Craniotomy	12	34	F	Meningioma	Seizures (intracranial collection)	Negative	Antiepileptic drugs
Craniotomy	13	62	F	Meningioma	Seizures (intracranial collection)	Negative	Antiepileptic drugs
Craniotomy [Figure 2]	14	24	F	Glioblastoma	Focal signs (intracranial collection)	Cyst	Tumour removal
Fracture line	15	2*	F	Diastatic fracture	Cephalocele	Positive	Surgical repair
Craniotomy	16	11	M	Carotid aneurysm	Raised intracranial pressure syndrome (hemorrhage)	Chronic subdural hematoma	Evacuation
Burr hole elevation	17	36	M	Compound depressed skull fracture	Intracranial collection	Abscess	Evacuation

*Age in weeks; US – Ultrasound; F – Female; M – Male; VP – Ventriculoperitoneale (shunt); CSDH – Chronic subdural haemorrage

Figure 1: Case 9; (a) pre-operative CT scan showing empyema; (b) the trans burr hole US technique; (c) the Trans burr hole US picture demonstrated the regression of the collection; the control CT scan validated the US results

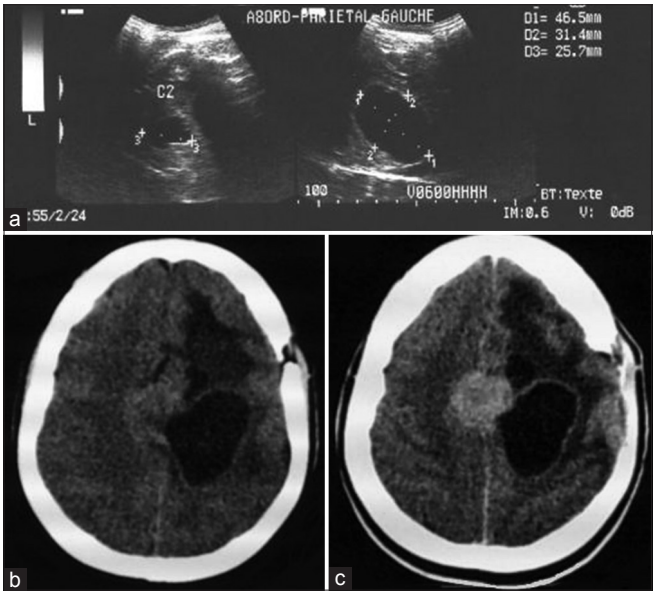

Figure 2: Case 14; (a) Trans burr hole ultrasound; (b) CT Scan without contrast, and (c) CT Scan with IV contrast

intraparenchymal collection, with peripheral ring enhancement and oedema. The patient was reoperated and the pus was evacuated with subsequent clinical improvement.

Skull Fracture

A 2-week-old female baby presented with a posttraumatic focal cephalhematoma. A fracture line was clinically evident. US through the fracture line disclosed a dural tear below the bone defect, entrapping the underlying brain tissue with associated leptomeningeal cyst. CT scan confirmed these findings. The child was successfully operated and the dural tear was closed.

Shunt Dysfunction

Two patients aged 6 and 12 years were operated for hydrocephalus (ventriculoperitoneal shunt). In the first patient, the symptoms recurred 3 months after the operation. The trans burr hole US disclosed the recurrence of the ventricular dilatation and the shunting system was replaced. The second patient presented with focal signs (left hemiparesis) and headaches 2 months after the operation. Trans burr hole US revealed a large extraparenchymal collection. CT scan demonstrated a subdural chronic hematoma with a significant mass effect. The hematoma was evacuated and the shunting system was replaced (medium pressure).

Tumour of the Convexity

Two female patients (34 and 62 years) were operated for parasagittal meningioma. They all presented with status epilepticus within 24 h of operation. The trans burr hole US was negative for any postoperative intracranial hematoma. This result was confirmed by CT scan.

A third 24 years patient was operated for a frontal glioblastoma. During the follow-up period, she presented an insidious onset of contralateral hemiplegia. The US through the burr hole revealed the recurrence of the tumour with a cystic component. This result was confirmed by CT scan findings. She underwent surgery and the tumour was removed.

Aneurysm Surgery

An 11-year-old boy was operated for a ruptured left carotid aneurysm (posterior communicating artery). Two months later, he presented with a progressive onset of headaches and vomiting. Trans burr hole US revealed a chronic subdural haematoma which was confirmed by CT scan. The collection was evacuated with clinical recovery.

DISCUSSION

Ultrasound through an acquired skull defect can be used both per- and post-operatively. The use of peroperative US in Neurosurgery was first reported in 1980[1] and has since become widespread[1-8] before the era of neuronavigational systems.

Unlike the preoperative, postoperative use of this technique has not been extensively reported in the literature. As far as we are aware of, only two preliminary studies[3,9] are available on its usefulness in the

postoperative period via the artificial skull bone defect: Slovie[9] used the US through the burr hole to detect ventriculomegaly in five children and compared the result with the trans fontanelle US, while Ott-Tannenbaum[4] compared the results with CT scan. Trans burr hole US is probably underused.

Trans burr hole US is effective in detecting or ruling out hydrocephalus. It is also a sensitive technique for detecting postoperative collections: Subdural and extradural hematomas, intracranial abscess. The nature of the collection (blood or pus) is suggested by the clinical context. The assessment of residual or recurrent tumour may be limited by the field of exploration, restricted by the small window. In the case of posttraumatic encephalocele, the US resolution (via the diastatic fracture) was more discriminative on the cortex than that of the CT scan.[10] The US demonstrated the dural defect and the herniation of a gyrus in the bone defect.[10]

To obtain good-quality US images, all the burr holes of the craniotomy should not be filled with sawdust bone. Trephine craniotomy is still used in some neurosurgical centres, but it does not provide any postoperative window on the skull.[11,12]

A great deal of the US exploration of intracranial pathologies has been based on transfontanellar echography. The major indications are hydrocephalus, intracranial hematomas, abscess, or other collections. The diagnosis of hydrocephalus is always easy. The detection of intracranial collection is also easy, but the nature is usually suggested by the clinical feature (pus, old blood or CSF). The purpose was not to compare two techniques, notably US and CT scan, but to use a usual intracranial imaging technique as CT scan to validate the US findings. The results of US also depend on the experience of the examiner. Neurosurgeons, surgeons, and neurologists should also be familiar with this type of examination technique, especially in developing countries where radiologists are not always available. Trans burr hole US was reliable, available, and cheaper. It was possible to repeat as more as needed and then it was suitable for beside exploration in this series. CT scan or MRI is not always accessible in our environment: It is unavailable or it is temporary out of service (problem of maintenance). When it is available, it is not affordable for many patients (financial reasons). This limit is often a major problem for managing emergency situations. Trans burr hole US is a reasonable alternative to CT scan and MRI in such conditions. Then, the potential of trans burr hole US is important for pathologies as intracranial suppurations (abscess, empyemas, or pyoventriculitis) where a sequential postoperative CT scan series (after 7 days, 21 days, 2 months, and 3 months) is recommended to evaluate the emptying of the cavity after the burr hole puncture.[13-15]

The physical characteristics of the probes are important to obtain the appropriate acquisitions. The depth of penetration is inversely proportional to the frequency; the spatial resolution is inversely proportional to the depth of penetration: The 3.5-6 MHz probes are appropriate for deeper areas and the 7-12 MHz probes are used for superficial targets. The small size of the probe is appropriate for small access. A mechanically generated signal requires a large access (18-20 mm) while an electronic signal is smaller and can be used via a standard burr hole (10 mm of diameter). In two of the authors' cases, the diameter of the burr hole was 5-6 mm but good images were still obtained.

The CT scan that was used to validate the US results was free of charge for patients in this preliminary study. Since those positive preliminary results, US is now used with a reasonable degree of confidence in the postoperative period in our institution to balance our decisions. We acquired (gift of The French Speaking African Network for Telemedicine)[16] a simplified US system made of two probes and a laptop to function as the US machine and the monitor. This is easy to transport to the operative room, the intensive care unit (without a major problem of maintaining asepsis), and in the patient's room for bedside exploration. The pictures are viewed on the laptop screen by the manipulator (surgeon) or at distance via Internet (wireless) by a radiologist who gives an opinion (telemedicine) if needed. This aspect may be useful for the intraoperative exploration (neuronavigation is not available in our institution). Further studies are needed to popularize this technique in resource-limited or remote settings. A protocol is now in discussion in our institution to use and to follow-up this technique with our new equipment in the purpose of gathering information for a more large series.

CONCLUSION

In this small series, trans burr hole has been useful in detecting and excluding some common postsurgical complications. Although the design of the study and the small number of patients do not allow any comparison between trans burr hole US and CT or MRI, our findings suggest that it is an alternative to CT and MRI in resource-limited settings in postoperative management of brain surgery. It is reliable, available, and assessable. It can be repeated as more as needed. It is non-invasive and suitable for bedside explorations. A field of research is also the intraoperative use of

trans burr hole US when neuronavigational system is not available (with or without the possibility of distant interpretation).

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How to cite this article: de P. Djientcheu V, Njamnshi AK, Ongolo Zogo P, Mvogo T, Bello F, Essomba A. Evaluation of trans burr hole ultrasonography usefulness in a resource-limited setting. Indian J Neurosurg 2013;2:61-5.

Source of Support: Nil, **Conflict of Interest:** None declared.