Original article:

Role of Intraoperative Ultrasonography on Neocortical Brain Tumor Surgery

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Abstract:

Objective: Among imaging modalities, ultrasonography (US) is one of the most versatile choice, with its low cost, lack of radiation exposure, and minimally disrupted surgery flow. We described the use and characteristics of intraoperative ultrasonography (US) in selected cases in our center to assist the intracranial tumor resection. ***Methods :*** Seventy patients were operated from 2011 to 2018 at Kariadi Hospital with the help of intraoperative US. Fifty six percents of cases were cystic tumors, 25% were abscess and 19% were metastatic tumors We used seven parameters to measure the utility of intraoperative US and a utility score was devised (0 minimum, 7 maximum). ***Results:*** The utility score for intraoperative US was 7 in 3 cases (4%), 6 in 28 cases (54%), 5 in 21 cases (31%), 4 in 8 cases (11%), while no case had score ≤3. ***Conclusion:*** Intraoperative US is not only helpful in localizing lesions but also it can be used in determining the morphology of the lesion for some cases, which was glioma in our case. Intraoperative US is also helpful when to start planning the site of entry and complete resection.

Keywords: brain tumor surgery; intraoperative ultrasonography; utility score

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Introduction

The utilization of intraoperative imaging has prompted an increasingly complete resection of infiltrating tumors coming about to the probability of expanded patient survival time.[1,2] Among imaging modalities, ultrasonography (US) is one of the most flexible decision, with its ease, absence of radiation presentation, and insignificantly disturbed medical procedure flow.[3,4] Several authors have previously reported the benefits of intraoperative US for imaging and guidance in brain surgery.[2,5] Woydt *et al.* and LeRoux *et al.* compared the result of intraoperative US with histopathological finding of low grade gliomas and concluded that intraoperative US could improve the extent of tumor resection.[5-8]

Ultrasonography has been widely used as a noninvasive diagnostic method in assessing thyroid and ovarian lesions.[9,10] Since 1970, US has been used as an intraoperative diagnostic tool.[11,12]The restriction of subcortical brain tumors, in any case, has constantly

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presented issues to neurosurgeons.[12]Stereotactic devices and intraoperative magnetic resonance imaging (MRI) are hardly available especially in limited settings such as in developing countries. Meanwhile, ultrasonic real-time visualization of the brain following removal of the bone flap is effectively cultivated and promptly recognizes tumors as limited zones of increased echogenicity.[13,14] In this study, we describe our experience of using intraoperative US in selected cases in our center to assist the intracranial tumor resection.

Materials and methods

This is a retrospective observational study. Seventy intracranial tumor surgeries were performed during a seven year period from 2011 to 2018 at Kariadi Hospital, Semarang, Indonesia. Pathologically, 56% of cases were cystic tumors, 25% were brain abscess, and 19% were metastatic tumors. We limited our scope to cystic lesions since it could be difficult to distinguish them based on clinical appearance and preoperative imaging alone. All surgeries were assisted intraoperatively with a mechanical sector scanner. The scanhead contained two crystals, 5 MHz, and 7.5 MHz. The 5-MHz crystals permitted visualization of deep structures, and the 7.5-MHz for superficial areas (Hitachi Corp., Japan). After the bone flap was created, we used the intraoperative US to determine the exact position of intracranial mass, prior and after the durotomy. The probe was covered with sterile sheath and jelly for better acquisition of image.

We used parameters developed by Moiyadi, *et al*. To measure the utility of the intraoperative USin our center and determine the final utility score (minimum 0 and maximum 7, see Table.1)[15]. Individual parameters and overall scores were calculated for each surgery based on provided questions. All operators were asked to assess whether the intraoperative US contributed in determining the location, extent, border, and complete resection of intracranial cystic lesions.

Table 1. Parameters of IOUS utility

Parameter	Interpretation	Score
Lesion identification	Lesion discernable	1
	Not discernable on IOUS	0
Lesion delineation	Well defined margins	1
	Poorly defined margins but discernably distinct from normal brain	1
	Imperceptibly diffuse. No use of IOUS	0
Utility in craniotomy/ laminectomy modification	IOUS prompted a modification/extension in the craniotomy/ laminectomy	1
	No modification of bone removal needed	0
Use in durotomy planning	Useful/helped optimize the durotomy site and extent	1
	Not needed/useful	0
Use in corticectomy/ myelotomy planning	Useful to plan the entry site	1
	Not needed/useful	0
Use for assessment of extent of resection	Used for assessing extent of resection/ residue	1
	Not needed/useful	0
Visualization of adjacent structures	Useful and needed	1
	Not needed/useful	0

Ethical clearance: Kariadi General Hospital Ethical Committee has approved this study.

Results

Our study proved that intraoperative US was considered helpful during the brain tumor surgery (see Table.2). From 70 cases analyzed in this study, 3 cases scored 7, 38 cases scored 6, 21 cases scored 5, and 8 cases scored 4 in usefulness (mean utility score 5.51). There was no report of utility score below 4, while the majority (54%) of cases considered intraoperative US helpful on 6 out of 7 parameters. Intraoperative US was very useful to characterize and assist the resection of the tumor.

Table 2. IOUS utility outcomes

Overall scores	Number of cases	Percentages (%)
≤3	0	0
4	8	11
5	21	31
6	38	54
7	3	4

Selected case. A 39-year-old man was presented with seizure. The T2 with contrast demonstrated a lesion in his left frontoparietal lobe and was contrast-enhanced (see

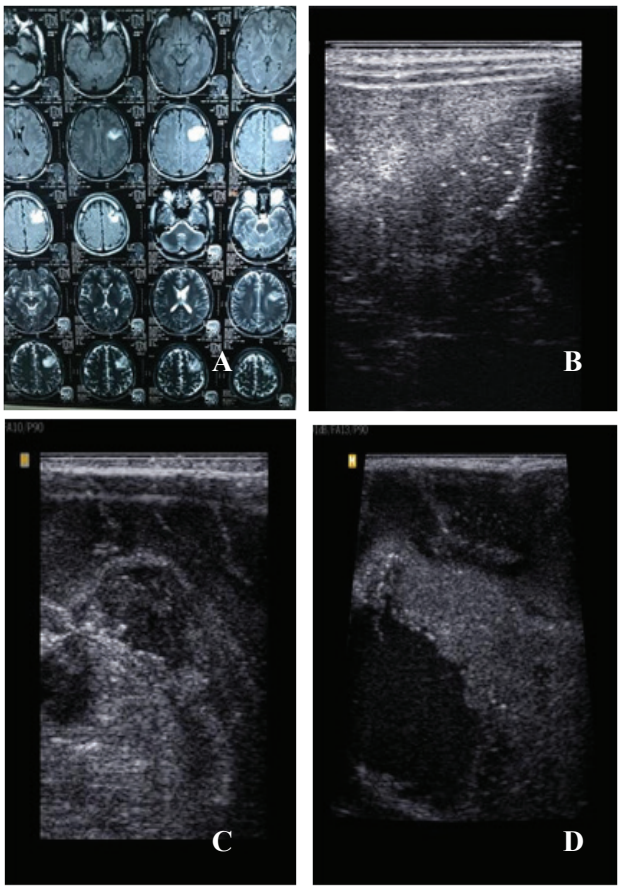

Fig.1). We were performing intraoperative US during the surgery to help resect the mass. The mass was confirmed later to be a glioma.

Fig, 1. (a) Preoperative MRI of the lesion on left frontal lobe. The lesion was contrast enhanced and was later confirmed to be a glioma. (b-d) Intraoperative ultrasound of glioma.

Discussion

Intraoperative US has been performed in our center in Semarang, Indonesia from 2011. It has been used worldwide to assist surgery which requires intraoperative guidance and considered as an effective and efficient means especially in limited settings. Many authors has reported the advantage of intraoperative US in distinguishing solid and cystic lesions and determining the margin of tumor.[16,17] Ultrasonography is considered useful in distinguishing low grade glioma, high grade glioma, intracranial calcification,or metastasis, although it posed some difficulties in differentiating peritumoral edema with normal brain parenchyma[16,18-19]

One of the major advantage of intraoperative US is its ability to provide real-time information to the surgeon. The brain might undergo shifting during surgery as a result of gravitation, edema, pneumocephalus, and surgical procedure.[20] The same goal could be achieved by intraoperative MRI or computed tomography (CT) scan, however, both require astronomic cost, specialized operating theatre, and longer duration of imaging accessing. The ionizing radiation of CT should also be considered especially for pediatric patients. In places with limited resources available, intraoperative US might be the best choice for intraoperative imaging modality.

Our results showed that in selected cases the intraoperative US was deemed to be very useful to assist the resection of cystic tumors. In majority of cases, intraoperative US was considered important in assisting the surgeon performing craniotomy. The compatibility between topographical and real time information during surgery is very crucial for the neurosurgeon. Our experience recorded that intraoperative US has satisfyingly aided the surgery by providing the visualization of brain tumor and its surrounding structure. However, definitive diagnosis of intracranial mass should be confirmed from histopathological findings to support or oppose clinical diagnosis based on clinical appearance and radiologic findings.

Conclusion

Intraoperative US holds a significant role in brain tumor resection surgery. Our experience demonstrated that intraoperative US successfully contributed in determining the location, extent, border, and complete resection of intracranial cystic lesions. This might be the best choice for intraoperative imaging in limited resource settings.

Acknowledgments

MTA and ZM conceived of the presented idea. YB developed the theory and performed the computations. AS and JB verified the analytical methods. MTA encouraged AS to investigate Intraoperative Ultrasonography on Neocortical Brain Tumor Surgery and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest:

All authors declare there is no conflict of interests regarding the publication of this article.

Author's contributions:

Author's contribution

Muhamad Thohar Arifin developed the concept and contributed to design, analysis, interpretation of data, and manuscript writing of the study. Muhamad Thohar Arifin organized and collected data. All authors helped in the editing and refining of the manuscript. All authors read and approved the final manuscript.

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