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Mohammad Hamza Bajwa

Saqib Kamran Bakhshi

Muhammad Shahzad Shamim

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Role of intra-operative ultrasound in brain tumour surgeries

Mohammad Hamza Bajwa, Saqib Kamran Bakhshi, Muhammad Shahzad Shamim

Abstract

The use of intra-operative ultrasound remains a largely underutilized option in brain tumour surgeries. The widespread availability of neuronavigation may be the reason why such a useful modality has become less popular even though recent advances in ultrasound technology have greatly improved its utility. The available literature also clearly shows that it offers additional advantages especially when used with neuronavigation. Herein the authors have briefly touched upon the available literature on the role of intraoperative ultrasound in brain tumour surgeries.

Keywords: brain tumour, neurosurgery, ultrasound.

Introduction

During the last few decades, maximum resection of intra-axial brain tumours has increasingly been shown to result in better outcomes.[1] The infiltrating nature of intra-axial tumours, and their stark similarity with adjacent brain parenchyma, often makes it difficult to accurately ensure complete resection. The use of advanced neuro-navigation often allows the surgeon to delineate tumour boundaries. However, shift in brain parenchyma following CSF drainage after durotomy and tumour debulking, makes neuro-navigation unreliable.[2] Intra-operative imaging such as intra-operative MRI is another option but is expensive and is only available in a handful of centres.[3] Intra-operative ultrasound (IoUS) is an old technique, introduced first in neurosurgery in 1978.[4] It was initially used for spinal cord tumours, and later for brain tumours as well, but later fell out of favour when neuronavigation was introduced. However, it may still offer a cost-effective solution and is thus increasing in popularity. The purpose of this review article is to look at some of the available literature on intraoperative use of ultrasound in brain tumour resection.

Review of Evidence

A study done by Roux et., al in 1992 showed that the majority of brain tumours, including low grade gliomas, are visible on ultrasound imaging.[5] The study is almost two decades old, and since then the quality of ultrasound imaging has also improved significantly. Ultrasound scans also have the advantage that they may be repeated as frequently as needed without requiring the cost or time needed for other imaging modalities. However, this modality is heavily operator dependent, and requires training and experience, currently not incorporated in most neurosurgery residency curriculums.[6] Even trained radiologists require additional practice to prepare them for IoUS as it is done on an exposed cortical surface requiring extreme care to avoid contusion of the underlying brain or breach of the sterile environment. Ultrasound is also unable to penetrate the skull and can only be used effectively once a craniotomy has been done.

In one of the earliest studies conducted in 1996, Hammoud et al., were able to show significantly improved postoperative outcomes with the use of IoUS.[7] Seventy patients were selected, out of which 36 were gliomas and 34 were metastatic lesions. Ultrasound scanners were used to evaluate the surgical field before the tumour resections were attempted, and later on to help resect margins that were found to be hyperechoic in comparison with the surrounding brain tissue. After closure of the dura, ultrasound was used once again to gauge the extent of resection. Volumetric assessment of tumour resection was done on pre and postoperative MRI scans using a geometric formula based on maximum sagittal, coronal, and anteroposterior diameters. In all patients with primary gliomas, the extent of resection was well defined, as confirmed on post-operative MRI. Five patients with recurrent gliomas showed a well-defined extent of resection in four cases (80%) and poorly defined in one (20%). For patients with radiation-induced changes, the extent of resection was poorly defined in all (100%) of these patients. Extent of resection was well defined by ultrasound imaging in all cases of metastatic tumours. Postoperative tumour volumes assessed using IoUS were also found to significantly correlate with calculation done with postoperative MRI scans, for all groups of patients.[7]

Further evidence was published by Erdogen et al., in 2005, where 32 patients were included with intracranial tumours.[8] All patients were evaluated preoperatively and postoperatively with MRI and IoUS scans. IoUS was done

Section of Neurosurgery, Aga Khan University Hospital, Karachi, Pakistan.
Correspondence: Muhammad Shahzad Shamim.
Email: shahzad.shamim@aku.edu

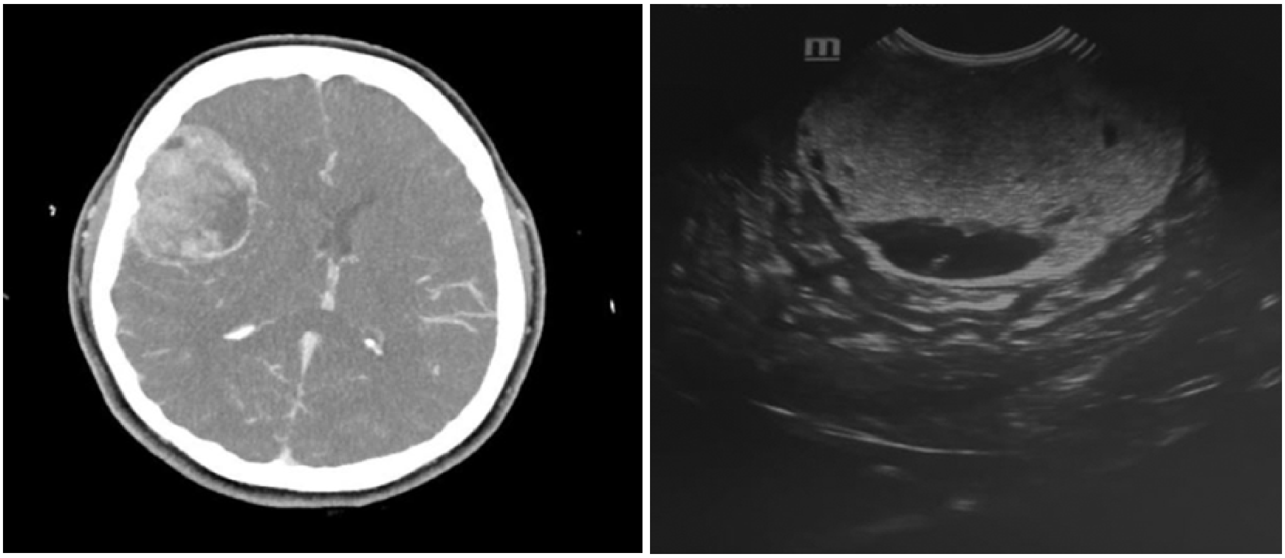

Figure : Figure 1 and 2 are CT scan with contrast image of a right convexity meningioma and a corresponding IoUS image of the same tumour.

by a radiologist after standard craniotomies were done. Acquired images were examined with regards to tumour size, location, peritumoural oedema, contrast enhancement characteristics, and cystic component within tumour parenchyma. Agreement between IoUS and postoperative MRI was evaluated by analysis which showed fair-to-good level of inter-method agreement on kappa analysis (Kappa number =0.72). There was no agreement in four cases with negative IoUS findings, which showed residual tumour in postoperative MRI. Obstacles identified were surgical (a synthetic haemostatic agent commonly used in cranial surgeries) which made it difficult to identify underlying residual tumour; and peritumoural oedema, which appears echogenic relative to the surrounding brain.[8]

IoUS also has shown good outcomes for use in paediatric population. In 2010, El Beltagy et al., conducted a retrospective study on 25 paediatric patients.[9] As before, a radiologist performed the IoUS to identify the tumour, consistency, borders, and relations to nearby landmarks. After tumour excision, the ultrasound was once again used to identify residual tumour. In this series, the authors were able to report 100% tumour localization regardless of the histopathological diagnosis. They were able to differentiate between solid and cystic components of the tumour, and the border of tumour and healthy tissue was well-established. The technique was found particularly helpful in tumours of the posterior fossa and intraventricular region. In craniopharyngiomas, it was helpful in the localization of cystic components as well as showing residual solid tumour in one case.[9]

Since these earlier studies, several ground breaking papers involving large series of patients have been published on the utility of IoUS with and without the use of neuronavigation.[10-14] More recently, the use of 3D ultrasound has been advocated in conjunction with neuronavigation for best results. Saether et al., used 3D IoUS with neuro-navigation in glioblastoma resection and published a retrospective data of 192 glioblastoma patients.[11] They showed statistically significant increase in estimated survival seen in their center after implementation of IoUS with an annual reduction in mortality as well as a 15-year cumulative reduction. They also showed significant improvement in survival that was maintained even after adjusting for age, WHO performance status, resection grades, chemotherapy, and type of radiotherapy given.[11]

Conclusion

IoUS offers great promise in helping surgeons improve surgical outcomes of brain tumour surgeries. Moreover, its utility is greatly enhanced when it is used in conjunction with other modalities such as neuronavigation.

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