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Original Research Article

Frequency of gross total resection in intra-axial brain tumors with help of neuronavigation

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ABSTRACT

Background: Neuronavigation has become a ubiquitous tool in the surgical management of brain tumors. Neuronavigation is most useful as an adjunct to other brain-mapping techniques such as awake mapping and electrocorticography in the resection of lesions within eloquent motor and language areas. Neuronavigation is also commonly used in skull base tumors, especially for planning an operative trajectory in regions containing vital neurovascular structures and may be used for cerebrovascular surgery. The current study was planned to determine the frequency of gross total resection in intra-axial brain tumors with the help of neuronavigation.
Methods: This cross-sectional study was carried out in the Department of Neurosurgery, Nishtar Medical College and Hospital, Multan, from September 2014 to March 2015. After approval from institutional ethical committee, seventy-seven patients fulfilling the inclusion criteria were selected from the patient admitted in the Neurosurgical Department through the Out-Patient Department and patients referred from other departments. After thorough counseling with the patient and his/her relatives, informed consent for procedure was taken.
Results: Total 78 patients were included in the study. Out of these 78 (100%), 41 (52.6%) were male and 37 (47.4%) were female. As concern to the outcome variable (gross total resection), out of 78 (100%), in 61 (78.2%) patients gross total resection was present. On cross tabulation it was further clarified that in male patients' gross total resection present in 32 patients and absent in 9 patients. Similarly, in female patients gross total resection present in 29 patients and absent in 8 patients. P value was 0.747.
Conclusions: Conclusion of present study is that neuronavigation is a useful technique in for better gross total resection of intra axial brain tumors.

Keywords: Brain tumors, Gross total resection, MRI, Neuronavigation

INTRODUCTION

Neuronavigation has become a ubiquitous tool in the surgical management of brain tumors.[1] Neuronavigation provides intraoperative orientation to the surgeon and helps in planning a precise surgical approach to the targeted lesion and defines the surrounding neurovascular structures. There are many important applications of neuronavigation in the fields of functional, vascular and spinal neurosurgery. Neuronavigation is most useful as an adjunct to other brain-mapping techniques such as awake mapping and electrocorticography in the resection of lesions within eloquent motor and language areas.

Neuronavigation is also commonly used in skull base tumors, especially for planning an operative trajectory in regions containing vital neurovascular structures and may be used for cerebrovascular surgery.[2]

The ability to pinpoint tumors and other nonneoplastic surgical targets was standardized and became increasingly precise as the stereotactic coordination system and headframe emerged through the work of Leksell and Spiegel.[3,4] The logistical challenges of frame-based stereotactic navigation were dramatically reduced as frameless navigation systems emerged. The need for a reliable means of accessing deep brain lesions with high accuracy has been recognized within neurosurgery since the early 1900s. The earliest neuronavigational systems relied on an arc-centered stereotactic frame system in which points of interest in the surgical field could be correlated with points in the imaging data set.[5]

The components of frameless stereotactic navigation systems include a computer-based image processing module, a reference frame and a pointer that is recognized by an optical or electromagnetic detector. The basic arrangement for frameless stereotactic navigation relies on the spatial registration of anatomic landmarks in the operative environment to identical landmarks in a 3D model based on a reconstruction of cross-sectional imaging studies. The spatial coordinates of anatomic landmarks that are established through the use of a tracking system that pairs an optical or electromagnetic detector with a complimentary probe. The most-widely used tracking systems utilize dual infrared cameras that track the position of a probe relative to a fixed reference frame. The main limitation of infrared-based systems is the need for maintaining a direct line of sight between the camera, the reference frame and the probe during navigation.[6]

Detailed clinical studies suggest that frameless stereotactic navigation can achieve positional accuracy comparable with that of frame-based stereotaxy. Electrode-based studies using pre- and post-operative MRI suggested that modern frameless methods for localization yield positional accuracy within 2–3 mm during surgery, which is equivalent to the accuracy of frame-based stereotaxy. The error inherent in frameless stereotactic navigation systems relates to the accuracy of probe tracking as well as the quality of preoperative images and the method of image-to-patient registration. Clinical factors that cause shift of the brain or a lesion, such as cerebrospinal fluid loss, cyst decompression and cerebral edema or sag, may also diminish navigational accuracy.[7]

Senftet al reported a trial with 58 high-grade glioma patients undergoing neuronavigation and demonstrated radiographically complete resection (68%).[8] A larger study of 40 patients undergoing pituitary surgery with the guidance of intraoperative neuronavigation found a higher rate of gross total resection (82.5%).[9] Martin et al showed complete resection of the tumor mass with the aid of neuronavigation in 18 patients (72%).[10]

The rationale behind carrying out current study was to determine the extent of resection in intra-axial brain tumors with the help of neuronavigation at present centre. Many recent papers have reported that the degree of resection of gliomas correlates with both progression-free and overall survival. The current study will show the effectiveness of neuronavigation and if found efficient will be the treatment of first choice in all patients who are having intra-axial brain tumor.

METHODS

This study was carried out in the Department of Neurosurgery, Nishtar Medical College and Hospital, Multan, Pakistan from September 2014 to March 2015 after approval of synopsis by Institutional Ethical Review Board.

Sample size of 78 patients is calculated with 95% confidence level, 10% margin of error and taking anticipated population proportion 72% for this cross-sectional study.

Inclusion criteria

- Age 12 years to 60 years
- Both sexes
- Intra-axial brain lesion diagnosed on Magnetic Resonance Imaging (lies within brain parenchyma).

Exclusion criteria

Extensively vascular lesion, intraventricular lesion and calcified lesions diagnosed on Computed Tomography and Magnetic Resonance Imaging.

Data collection

After approval from local ethical committee, patients fulfilling the inclusion criteria were selected from the patient admitted in the Neurosurgical Department through the Out-Patient Department and patients referred from other departments.

After thorough counseling with the patient and his/her relatives, informed consent for procedure was taken. On especially designed proforma, demographic profile was recorded on specially designed proforma.

The procedure was comprised of four stages: image acquisition, registration, planning and intraoperative navigation. Image acquisition was done in the evening prior to the morning of resection and requires bony landmarks followed by MRI scan with 2mm slices from vertex to foramen magnum. These images were form a virtual cranium and were transferred to the intra-operative computer. Registration was done once the patient is positioned in the operating room and involves coordinating or co-registration of the virtual cranium derived from the preoperative imaging study, and the patient's actual cranium in three-dimensional space of the operating room. Once these steps were completed, the

surgeon monitored the position of any point inside the brain in three-dimensions relative to the tumor or functional cortex with an accuracy of approximately 1-2 mm. Whole procedure was carried out by the same consultant. Post-operative MRI brain within 48 hours was done to see gross total resection and data was recorded on specially designed proforma.

Statistical analysis

All the data were entered and analyzed using computer program SPSS-19. Frequencies were calculated for gender and gross total resection and stratification were undertaken on age, gender and gross total resection. Mean and standard deviation were presented for age. Chi-Square test was applied. P<0.05 were taken as significant.

RESULTS

Total 78 patients were included in the study. Out of these 78 (100%), 41 (52.6%) were male and 37 (47.4%) were female (Table 1).

Table 1: Frequency of gender.

Gender	Frequency	Percent
Male	41	52.6
Female	37	47.4
Total	78	100.0

Considering the age of patients, mean age of male patients was 33.12±13.5. Similarly, in female patients mean age was 32.5±11.9 (Table 2).

Table 2: Mean age of the patients.

Age		
Gender	**Mean**	**Std. deviation**
Male	33.12	13.513
Female	32.54	11.957
Total	32.85	12.720

Regarding the outcome variable (gross total resection), out of 78 (100%), in 61 (78.2%) patients gross total resection was present and gross total resection was absent in 17 (21.8%) patients (Table 3).

Table 3: Frequency of gross total resection.

Gross total resection	Frequency	Percent
Yes	61	78.2
No	17	21.8
Total	78	100.0

On cross tabulation, it was further clarified that in male patients' gross total resection present in 32 patients and absent in 9 patients. Similarly, in female patients gross total resection present in 29 patients and absent in 8 patients. P value was non-significant (Table 4).

Table 4: Comparison of gender and gross total resection.

Gender	Gross total resection		Total	P-value
	Yes	No		
Male	32	9	41	1.00
Female	29	8	37	
Total	61	17	78	

Table 5: Comparison of age groups and gross total resection.

Age groups	Gross total resection		Total	P-value
	Yes	No		
13-30	24	5	29	0.747
31-45	19	6	25	
46-60	18	6	24	
Total	61	17	78	

Among 78 patients, gross total resection was done in 61 patients. There were 24 patients with gross total resection in the age group 13-30 years, 19 patients in age group 31-45 years and 18 patients in age group 46-60. When authors compared the gross total resection among different age groups, an insignificant statistical association was observed (Table 5).

DISCUSSION

In the beginning, cranial neuronavigation was used for a better anatomical orientation. As neuronavigation bases on preoperative images, inaccuracies, commonly summarized as brain shift, may occur due to CSF loss and deformation of the brain anatomy by self-retaining retractors and tumor reduction. Brain shift can be minimized using appropriate surgical techniques described and refined by Kelly et al.[11] Although this problem is overestimated in present opinion, other real time imaging techniques are brain shift independent. Therefore, intraoperative sonography, open MRI or mobile CT have the advantage over neuronavigation in this aspect.

In present study, as concern to the outcome variable (gross total resection), out of 78 (100%), in 61 (78. %) patients gross total resection was present and gross total resection was absent in 17 (21.8%) patients. Nevertheless, these techniques do not solve two major problems of contemporary neurosurgery. First, they only offer anatomical information. For a functional preservation, intraoperative monitoring still is mandatory. To date, only motor cortex and speech area can be monitored by conventional cortical stimulation or SSEP's. Second, especially in low grade or recurrent gliomas, MRI or CT often are not capable to distinguish between tumor and edema, respectively gliosis. fMRI, MEG and PET may be the solution of these problems. As these techniques are available only preoperatively, they have to be integrated into cranial neuronavigation. Otherwise,

their information cannot be used reliably and comfortably during surgery.

Meanwhile functional MRI is not only able to show the Brodmann areas 4, 44 and 45, but also many other functional brain areas like short-term memory or visual fields.[12] With constantly improved paradigms, other complex cortical functions might be visualized in future. Especially the combination of different paradigms helps to detect and localize specific intellectual functions (K. Friston, London: Workshop Functional Imaging, Aachen, Germany 10/12/99). These areas cannot be monitored neither by electrophysiological, nor by intraoperative imaging techniques. Prior to the integration and monitoring of these complex cortical functions, it has to be proven, that fMRI indeed shows, what it intends to do. As fMRI bases on minimal differences in blood flow levels, its results might be interfered by many pathophysiological conditions.

The BOLD effect diminishes, if arterial pCO2 increases, or if the parent vessel is stenotic. As T2* images are very sensitive for blood vessel, contralateral and postcentral co-activations may occur. Although it seems to be highly probable, that the motorcortex can be localized by fMRI, still no evidence exists. Recently two study groups in Aachen and Zürich reported their experiences of the correspondence between fMRI and cortical stimulation.[13-15] Like in present initial experiment, both groups matched their findings indirectly by comparing anatomical landmarks. Granslandt et al were the first to publish their experiences with a direct integration of functional images into cranial neuronavigation.[16,17] They could show that the motor cortex localization of MEG (magnetic encephalography) and cortical SSEP corresponded well in all their 50 patients. The present study is the first report of direct integration of fMRI into neuronavigation. Although it includes only a few patients yet, fMRI seems to be highly reliable for the localization of the motorcortex and probably the Broca area as well. As mentioned above in low grade or recurrent gliomas, conventional imaging techniques like MRI or CT often are unable to distinguish between tumor and edema, respectively gliosis. The rapid progess of PET imaging during the last years seems to solve this problem. Primarily 18-FDG PET was used for this purpose.[18-20]

Recently amino acids like 11C-methionine or methyl-11-C-Thymidine were increasingly used with promising results.[21-23] Especially the amino acid studies show, that PET seems to be superior to other imaging techniques to distinguish between tumoral and non-tumoral lesions. But comparable to fMRI studies, only one article is published so far, which aimed to prove these results intraoperatively. Levivier et al used 18-FDG PET information to target their stereotactic biopsy in patients with suspected intracranial tumoral lesion. They could show, that 6/35 (17 %) biopsies based on CT only were nondiagnostic. In contrast, all 55 biopsies defined on FDG-PET could be used.

CONCLUSION

Conclusion of current study is that neuronavigation is a useful technique for better gross total resection of intra axial brain tumors.

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