

The Efficacy of Intra-Operative Ultrasound for Tumour Resection Compared to Post-Operative MRI Brain

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Dear Editor,

We report a non-randomised prospective study looking at the efficacy of intra-operative ultrasound (IOUS) for tumour resection in comparison with post-operative Magnetic Resonance Imaging (MRI) brain. Suitable patients based on the inclusion criteria were selected from Jan 2016 to Jan 2017. Total of 20 patients were selected for the study based on the selection criteria. Only adult patient having intra axial tumour located in the supratentorial region were taken for the study. The patient selected were given detailed explanation regarding the study and informed consent was taken. These patients will have to undergo a post-operative MRI within 24 to 48 hours once they participate in the study. This study was approved by the Medical Research and Ethical Committee, Ministry of Health Malaysia (NMRR-15-2265-27264 (IIR)).

The surgery was performed in the neurosurgery operating theatre at the Kuala Lumpur Hospital. Surgeons in the department performed the surgeries and were assisted by the registrars. Patients were selected based on the inclusion criteria's for the surgery. The duration of the study was between Jun 2014 and June 2016. Those patients selected were those with

supra tentorial intra-axial lesions aged above 18 years old. Those patients with the exclusion criteria were those with infra tentorial lesion and in the paediatrics age group.

Patients selected for the study will undergo normal operating procedure but the only difference would be the ultrasound which will be used as an adjunct during the surgery. The ultrasound will be performed by the neuroradiologist from Department of Radiology, Hospital Kuala Lumpur. The ultrasound equipment used was from BK medical the Flex Focus 800 model ultrasound machine with 3D ultrasound image facilities. The probe used was the burrhole type transducer with variable frequency (13-6MHz). The IOUS was utilised whenever the need for intra-operative imaging was deemed desirable by the operating surgeon. The radiologist accompanied the neurosurgeon during the procedure. In each of these cases, the insonation was performed both before and after the dural opening. The selected probe was draped in a sterile cover filled with jelly and all air bubbles were eliminated. Sterile irrigation with saline was employed during the procedure to ensure optimal coupling. The probe frequency was adjusted to suitably insonate both superficial and deep structures as required. The best image

showing the whole lesion was measured and the length, width and height of the lesion measured and written down on the data collection sheet. Prior to closure the resection cavity will be assessed to see any suspicious hyperechoic regions which could possibly suggest residual tumour or bleed. Once the surgeon is satisfied with the resection the final assessment will be done and any residual tumour if any will be measured and noted down. In certain cases, some portion of the tumour may be left behind as it may be near vital structures and the aim of the surgery is mainly to debulk the tumour. Post-operatively patient will be subjected for MRI brain within 24–48 hours of the surgery. The MRI machine used is the 1.5T by Siemens. From the MRI the residual tumour will be measured based on the T1, T2 Gado images and reported. The MRI report will be traced and the measurement will be documented in the data collection sheet. The MRI will also be interpreted by the neuroradiologist. The same radiologist will interpret the IOUS for all the surgeries and the same goes for the MRI. This is to reduce the operator dependant variation in the study.

Data collected was analysed using JMP 11 statistical software and the paired *t*-test and interclass correlation are the statistical test used to analyse the data to compare the correlation and reliability of the ultrasound as compared to MRI for tumour resection. Probability (*P*) value < 0.05 was considered statistically significant.

Data collected was compared between ultrasound (USG) and MRI for the tumour size pre-operatively and intra-operatively (USG)

and post operatively (MRI). In cases where the resection was limited due to various factors like eloquency (near important vital structures which resection may cause severe morbidity), stability intra-operatively (anaesthetic cause or blood loss) and location (near major sinuses or vessels), those reasons will be documented intra-operatively. The data is managed through the use of JMP 11 Statistical Software. The data is presented in the form of tables and graphs when appropriate. Variability plot, paired *t*-test, regression plot and intraclass correlation were used when appropriate. Probability (*P*) value < 0.05 was considered statistically significant. Statistical measures including the correlation and reliability of the two methodology used (Table 1).

Twenty patients were analysed for demography, clinical conditions and diagnosis based from histopathology results from period of June 2014 to June 2016 with age ranging from 24 to 72 years of age. All tumours were successfully removed and tumour size were measured using the both MRI and IOUS as comparison during pre- and post-operative. Table 2 below describes the patient distribution of age, race and diagnosis of which about five patients were below the age of 40 years old and majority ranging from 40–60 years old. The histopathology results of these patients mainly showed metastasis and next was Grade 4 gliomas.

Based on the statistical analysis used, Regression Model analysis done shows IOUS is significantly correlated with MRI

Table 1. Summary data of the intra-class correlation performed using both MRI and IOUS

EMP Test	Results	Description
Test-Retest Error	0	Within Error
Degrees of Freedom	19	Amount of Information used to estimate within error
Probable Error	0	Median error for a single measurement
Intraclass Correlation (no bias)	1	Proportion of variation attributed to part variation without including bias factors
Intraclass Correlation (with bias)	0.996	Proportion of variation attributed to part variation with including bias factors
Intraclass Correlation (with bias and interactions)	0.956	Proportion of variation attributed to part variation with including bias and interaction factors
Bias Impact	0.004	Amount by which the bias factors reduce the intra-class correlations
Bias Impact	0.044	Amount by which the bias and interaction factors reduce the intra-class correlations

*IOUS = Intra-operative ultrasound

(P -value < 0.05) and Rsquare > 90%. The analysis done on the data collected using sample t -test for pre- and post-operative MRI and IOUS, reveals that data collected using IOUS

is statistically equivalent and process variance between both methods is comparable (P -value > 0.05) (Table 2 and Table 3).

Table 2. Demographic data detailing the age, histopathology (HPE) of the patients and tumour size for both modalities.

Patient	Age	Race	Diagnosis	Tumour Size (cm ²)			
				Pre-op MRI	Pre-IOUS	Post-IOUS	Post-op MRI
1	49	Indian	GBM	0.7	0.7	0	0
2	56	Indian	GBM	9.28	8.58	1.5	4.14
3	60	Malay	Metastasis	14.4	16	0	0
4	29	Chinese	GBM	35.36	38.5	8.7	10.24
5	46	Malay	Rec.neurocytoma	23.76	20	0	0
6	65	Chinese	Metastasis	13.68	14	0.18	0.27
7	66	Chinese	Metastasis	26.13	24.5	10	8.16
8	45	Indian	GBM	18	18	4.2	5.7
9	64	Chinese	Metastasis	6.21	6	0	0
10	53	Chinese	GBM	36.85	38.5	10.2	10.2
11	70	Chinese	Metastasis	6.38	6	0	0.81
12	45	Chinese	GBM	64.8	62.3	12.6	17.5
13	35	Malay	Metastasis	5.74	8	0	0
14	24	Malay	Lymphoma	8.51	8	4.2	4
15	47	Malay	Low grade glioma	8	7.5	2.4	2.7
16	55	Malay	Metastasis	13.02	12	0	0
17	69	Malay	Metastasis	16.56	15.75	0	0
18	24	Malay	Low grade glioma	30.38	32.5	9.6	10.2
19	36	Malay	Astrocytoma	14.4	14.4	0	0
20	72	Chinese	Metstasis	17.1	15.75	0	0

*GBM = Glioblastoma multiforme, Pre-op = pre-operative; Post-op = post-operative; IOUS = Intra-operative ultrasound

Table 3. Summary of the data analysis using sample t -test and regression model

	Sample Size	Mean	Std Dev	t -Sample Test	Regression Model	
				P -value	R square	P -value
Tumour Size	80	10.92	13.13			
Method [IOUS]	40	10.76	13.20			
Method [MRI]	40	11.08	13.23			
Method [IOUS] Period [Pre]	20	18.35	14.73	0.95	98.74%	< .0001*
Method [MRI] Period [Pre]	20	3.18	4.42			
Method [IOUS] Period [Post]	20	18.46	14.79	0.75	93.72%	< .0001*
Method [MRI] Period [Post]	20	3.70	5.06			

*Std Dev = standard deviation

The *Intraclass Correlation Coefficient* (ICC) which is a measure of the reliability of measurements or ratings indicates that both MRI and IOUS is highly correlated. Table 3 given below shows the high correlation between IOUS and post-operative MRI making IOUS a very reliable tool as compared to MRI.

Based on this study, ultrasound has proved to be a reliable tool to aid in tumour resection intra-operative as the statistical analysis between the ultrasound and MRI for tumour resection has high correlation. Ultrasound can be equivalent to MRI in detecting residual tumour post-operatively and should be widely used intra-operatively as it is easily available, faster and cost effective (1–4).

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