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Computed tomography (CT) perfusion evaluation of brain lesions

Dayanand Kawade[1], Samruddhi Sonwane[2], Ashish Lule[3]
[1] Medical officer, Department of Radiology, Civil Hospital, Osmanabad, Maharashtra, India
[2] Final year DNB Radiodiagnosis Resident, Ruby hall clinic, Pune Maharash
tra, India
[3] Assistant Professor, Department of Radiology, LTMMC, Mumbai, Maharashtra, India

Abstract
Introduction: Computed tomography perfusion (CTP) is a better choice for assessing hemodynamic parameters compared to Magnetic Resonance Imaging (MRI). With this perspective this study is undertaken to study perfusion characters and difference
Material Method: 100 patients (64 Males and 36 Females) with age between 17 to 68 years include. Computed tomography perfusion (CTP) was performed with Dual‑Slice Dynamic Multi‑Detector Scanner.
Result: perfusion parameters of lymphomas, low‑grade glioma, high‑grade gliomas, Grade 3 glioma and glioblastoma multiforme (GBM) were not found statistically significant. There were statistically significant differences in rCBF for lymphomas, low‑grade glioma, Grade 3 glioma, high‑grade gliomas and glioblastoma multiforme (GBM) in Lesional and PeriLesional area.
Discussion: low perfusion in low‑grade gliomas, glioblastoma multiforme (GBM) is found. It may be because of tumor heterogeneity, necrosis and vascular invasion.
Conclusion: CT perfusion can be a good aid in differentiating various lesions.

Keywords: Computed tomography perfusion (CTP), glioblastoma multiforme (GBM)

Introduction

Imaging has an important role in evaluation of patients with brain lesion. Computed tomography (CT) and Magnetic Resonance Imaging (MRI) represents the two most important imaging modalities. The inclusion of contrast material in imaging technique and introduction of new imaging techniques, improved significantly the detection and evaluation of brain lesion. Radiologic evaluation of clinically suspected lesion determines the location, extent and its relationship to the surrounding structures. This helps in deciding treatment approach whether surgery, radiation or chemotherapy. New imaging techniques include tissue blood flow (perfusion imaging), water motion (diffusion imaging), brain metabolites (Proton magnetic resonance spectroscopy) and blood oxygen level dependent (BOLD) imaging. Computed tomography (CT) was introduced in the clinical practice since 1972. With the advent of CT it became the procedure of choice for evaluation and diagnosis of brain lesion and replaced invasive procedures. The inclusion of contrast material in imaging helped in better differentiating between a lesion and surrounding normal tissue.

During the last few years role of Magnetic Resonance Imaging (MRI) in the diagnosis of brain lesion is well established. Magnetic Resonance Imaging (MRI) with perfusion, diffusion and spectroscopy advancement it is possible to differentiate between lesions. Magnetic Resonance Imaging (MRI) perfusion studies can differentiate between focal lesions and infective pathologies, can grade gliomas [1, 2, 3]. Proton magnetic resonance spectroscopy has also well-known ability to grade tumors and characterize them [4, 5]. Due to high cost Computed tomography perfusion (CTP) is a better choice for assessing hemodynamic parameters compared to Magnetic Resonance Imaging (MRI). Previous Computed tomography perfusion (CTP) studies have done to assess vascularity and permeabilities [6, 7, 8].

With this perspective this study of “Computed Tomography Perfusion (CTP) evaluation of brain lesions” is undertaken to study their perfusion characters and difference

Materials and Methods

The present study was conducted at Government Medical College Aurangabad, Maharashtra, India. Computed tomography perfusion (CTP) was performed with Dual‑Slice Dynamic Multi ‑Detector Scanner before surgery or biopsy

Sample Size

100 patients (64 Males and 36 Females)

Inclusion Criteria

1. Patients with age between 17 to 68 years.

Exclusion Criteria

1. Patients with age ≤ 15 years

2. Pregnant women
3. Patients with other disorders

Computed tomography perfusion (CTP) imaging technique

1. In all patients first non-enhanced Computed tomography (CT) of brain was performed to identify the abnormality
2. Then Computed tomography perfusion (CTP) was performed with Philips Dual-Slice Dynamic Multi-Detector Scanner.
3. First slice was taken at the level of the lesion Observed on previous plain Computed tomography (CT) scan
4. Second slice was taken 10 mm cranial to the first scan. The slice thickness was 10 mm with a matrix size of 512 × 512.
5. 50 mm of 65 percent Iodinated contrast agent was injected through a 16 G Cannula into the Antecubital vein using a pressure injector at a rate of about 6 ml/second.
6. Simultaneously 40 images taken at the rate of 1 image/second at tan area of interest after a delay time of 4 second.

The image data was processed with post-processing software. Perfusion images created (Reference to superior sagittal sinus). Irregular Region of Interest was created on lesion and 1 to 2 cm away from lesion. In the ring enhancing lesion they were drawn in the capsule and the center of lesion. They were then compared with contralateral white matter. Different cerebral hemodynamic parameters such as Relative cerebral blood flow and Relative cerebral blood volume were calculated quantitatively.

Statistical Analysis

ANOVA test was performed to compare the means between the groups and P value calculated. P value ≤ 0.05 was considered statistically significant.

Results

Out of 100 patients included in the study all were diagnosed histologically by biopsy. Out of 100 cases, with lymphoma were 25, with low-grade glioma were 20 (12 astrocytoma and 8 oligodendroglioma), with grade 3 glioma were 35, with glioblastoma multiforme (GBM) were 20, with High grade glioma were 55. An rCBV cut-off value of 1.64 is used to differentiate between low-grade glioma and high-grade glioma, with sensitivity of 86.36% and specificity of 100%.

Table 1: Perfusion parameters Lesional area

Lesion	Lesional area		P value
	rCBF	rCBV	
	Mean ± S.D.	Mean ± S.D.	
Lymphoma	2.61 ± 0.75	2.91 ± 0.90	0.20
Low grade glioma	1.15 ± 0.52	1.13 ± 0.44	0.89
Grade 3 glioma	3.02 ± 1.59	2.91 ± 1.52	0.76
GBM	2.50 ± 0.74	2.51 ± 0.56	0.96
High grade glioma (combined grade 3 and GBM)	2.83 ± 1.35	2.77 ± 1.26	0.81

P ≤ 0.05 Statistically significant*

In Table 1 Mean ± S.D. for Perfusion parameters in Lesional area are shown. In Lymphoma rCBF it is 2.61 ± 0.75 and rCBV it is 2.91 ± 0.90. In Low grade glioma rCBF it is 1.15 ± 0.52 and rCBV it is 1.13 ± 0.44. In Grade 3 glioma rCBF it is 3.02 ± 1.59 and rCBV it is 2.91 ± 1.52. In GBM rCBF it is 2.50 ± 0.74 and rCBV it is 2.51 ± 0.56. In High grade glioma rCBF it is 2.83 ± 1.35 and rCBV it is 2.77 ± 1.26. There were differences in perfusion parameters of lymphomas, low-grade glioma, high-grade gliomas, Grade 3 glioma and glioblastoma multiforme (GBM) but these were not found statistically significant

Table 2: Perfusion parameters Perilesional area

Lesion	Perilesional area		P value
	rCBF	rCBV	
	Mean ± S.D.	Mean ± S.D.	
Lymphoma	0.76 ± 0.30	0.85 ± 0.29	0.28
Low grade glioma	0.84 ± 0.25	1.07 ± 0.12	0.0007*
Grade 3 glioma	1.08 ± 0.55	1.09 ± 0.42	0.932
GBM	0.65 ± 0.15	0.81 ± 0.15	0.0017*
High grade glioma (combined grade 3 and GBM)	0.86 ± 0.35	0.95 ± 0.34	0.174

P ≤ 0.05 Statistically significant*

In Table 2 Mean ± S.D. for Perfusion parameters in PeriLesional area are shown. In Lymphoma rCBF it is 0.76 ± 0.30 and rCBV it is 0.85 ± 0.29. In Low grade glioma rCBF it is 0.84 ± 0.25 and rCBV it is 1.07 ± 0.12. In Grade 3 glioma rCBF it is 1.08 ± 0.55 and rCBV it is 1.09 ± 0.42. In GBM rCBF it is 0.65 ± 0.15 and rCBV it is 0.81 ± 0.15. In High grade glioma rCBF it is 0.86 ± 0.35 and rCBV it is 0.95 ± 0.34. There were differences in perfusion parameters of lymphomas, low-grade glioma, high-grade gliomas and glioblastoma multiforme (GBM) in Perilesional area also but low-grade glioma and glioblastoma multiforme (GBM) out of these were found statistically significant.

Table 3: rCBF in Lesional area and Perilesional area

Lesion	Lesional area	Perilesional area	P value
	rCBF	rCBF	
	Mean ± S.D.	Mean ± S.D.	
Lymphoma	2.61 ± 0.75	0.76 ± 0.30	< 0.0001*
Low grade glioma	1.15 ± 0.52	0.84 ± 0.25	0.0213*
Grade 3 glioma	3.02 ± 1.59	1.08 ± 0.55	< 0.0001*
GBM	2.50 ± 0.74	0.65 ± 0.15	< 0.0001*
High grade glioma (combined grade 3 and GBM)	2.83 ± 1.35	0.86 ± 0.35	< 0.0001*

P ≤ 0.05 Statistically significant*

In Table 3 rCBF Mean ± S.D. for Perfusion parameters in Lesional and PeriLesional area are compared. For Lymphoma in Lesional it is 2.61 ± 0.75 and PeriLesional area it is 0.76 ± 0.30. For Low grade glioma in Lesional it is 1.15 ± 0.52 and PeriLesional area it is 0.84 ± 0.25. For Grade 3 glioma in Lesional it is 3.02 ± 1.59 and PeriLesional area it is 1.08 ± 0.55. For GBM in Lesional it is 2.50 ± 0.74 and PeriLesional area it is 0.65 ± 0.15. For High grade glioma in Lesional it is 2.83 ± 1.35 and PeriLesional area it is 0.86 ± 0.35. There were statistically significant differences in rCBF For lymphomas, low-grade glioma, Grade 3 glioma, high-grade gliomas and glioblastoma multiforme (GBM) in Lesional and Perilesional area.

Table 4: rCBV in Lesional area and Perilesional area

Lesion	Lesional area	Perilesional area	P value
	rCBV	rCBV	
	Mean ± S.D.	Mean ± S.D.	
Lymphoma	2.91 ± 0.90	0.85 ± 0.29	< 0.0001
Low grade glioma	1.13 ± 0.44	1.07 ± 0.12	0.55
Grade 3 glioma	2.91 ± 1.52	1.09 ± 0.42	< 0.0001
GBM	2.51 ± 0.56	0.81 ± 0.15	< 0.0001
High grade glioma (combined grade 3 and GBM)	2.77 ± 1.26	0.95 ± 0.34	< 0.0001

$P \leq 0.05$ Statistically significant*

In Table 4 rCBV Mean ± S.D. for Perfusion parameters in Lesional and PeriLesional area are compared. For Lymphoma in Lesional it is 2.91 ± 0.90 and PeriLesional area it is 0.85 ± 0.29. For Low grade glioma in Lesional it is 1.13 ± 0.44 and PeriLesional area it is 1.07 ± 0.12. For Grade 3 glioma in Lesional it is 2.91 ± 1.52 and PeriLesional area it is 1.09 ± 0.42. For GBM in Lesional it is 2.51 ± 0.56 and PeriLesional area it is 0.81 ± 0.15. For High grade glioma in Lesional it 2.77 ± 1.26 and PeriLesional area it is 0.95 ± 0.34. There were statistically significant differences found in rCBV for lymphomas, Grade 3 glioma, high-grade gliomas and glioblastoma multiforme except low-grade glioma (GBM) in Lesional and PeriLesional area.

Discussion

Computed tomography perfusion (CTP) operates on the basic principle as non-invasive functional imaging method that uses dynamic scanning after bolus injection of contrast agent to reflect the haemodynamic status and pathophysiological changes of tissues through a series of image parameters. The scan range of Computed tomography perfusion (CTP) is usually located in the centre of the lesion, and the scan coverage is 10 mm. The present study demonstrated the Computed tomography perfusion (CTP) technique was feasible in all patients, and none of the patients experienced any adverse effects related to the study procedure. All Computed tomography perfusion (CTP) images could be evaluated without artefacts. Computed tomography perfusion (CTP) permits the assessment of lesion in their entirety and reveals the three-dimensional perfusion characteristics. The resulting images permit the evaluation of the blood supplies and draining veins and the relationship of it to the surrounding large blood vessels. Although the radiation dose required is a relative limitation, the technique permits comprehensive assessment adjacent to large blood vessels and has great value for the diagnosis and evaluation of the relationship to its surrounding large blood vessels, thus improving surgical planning.

Different mass lesions that involve brain are glioma, non-glial tumors and infective mass lesions. In the present study we found low-grade gliomas with low perfusion. Low perfusion in glioblastoma multiforme (GBM) is also found compared to grade 3 glioma. It may be because of tumor heterogeneity, necrosis and vascular invasion[9]. In the present study rCBF and rCBV values for lymphoma are closer to high-grade gliomas. So, perfusion study alone is not able to differentiate between lymphoma and high-grade gliomas. Previous studies have shown both Increased and reduced perfusion in lymphomas [10, 11]. Aronen *et al* [2]. in their study also found that none of the low-grade gliomas had rCBV more than 1.5. Wide variation in rCBF and rCBV values between grade 3 astrocytomas and glioblastoma multiforme was also reported by Cha *et al* [12]. in their study.

Conclusion

CT perfusion can differentiate between lymphomas, low-grade gliomas and high-grade gliomas. An accurate understanding of the blood supply and the relationship of surrounding large blood vessels is important in developing a detailed surgical plan, avoiding massive haemorrhage, and reducing complications. Thus, CT perfusion can be a good aid in differentiating various lesions. The disadvantages of CT perfusion include use of iodinated contrast agents and radiation exposure

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