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EVALUATION OF INTRACRANIAL SPACE OCCUPYING LESIONS BY CT PERFUSION STUDY

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Abstract

Introduction: CT perfusion plays an invaluable role here as it detects microscopic differences in the internal vascularity of lesions and aids in their characterisation and significantly raises the diagnostic accuracy. In this Retrospective study, we performed CT Perfusion in various intracranial focal lesions and studied their perfusion characters and tried to evaluate & differentiate between them.

Methods: This Retrospective Analytical study involved data of 100 of the randomly selected patients (candidates / study subjects .CTP was performed with dual-slice dynamic multi-detector CT scanner in 100 patients prior to surgery or stereotactic biopsy with age ranging from 15 to 70 years. Patients below 15 years, pregnant women, and very old patients with compromised renal functions were not included in this study. It was noted that Informed consent was taken from all patients .

Results: Perfusion parameters like rCBF and rCBV were calculated with ROI including the whole of the lesion and 1-2 cm in the periphery of the lesion. The rCBF and rCBV of neoplastic lesions with statistically significant difference in rCBF and rCBV of low-grade gliomas from high-grade gliomas, lymphomas, and metastases.There was statistically significant difference in rCBF ($P < 0.002$) and rCBV ($P < 0.001$) of TWT, TOT, and abscesses.

Keyword: ICSOL , CT Perfusion , Cerebral blood flow , Cerebral blood volume.

Introduction

Extra-axial lesions like meningioma, schwannoma and macro- adenoma are often diagnosed and differentiated based on their mor- phological characteristics both on CT and MRI studies. This differentiation between lesions is invaluable for surgical planning and to decide upon the need for post-surgical radiotherapy. However, despite set morphological differences, there may sometimes be overlapping features between lesions making the differentiation impossible. Though histopathological examination after performing a biopsy of such lesions remains a gold standard, there can be sampling errors due to the heterogeneity of a lesion leading to inconclusive histopathological report. During the last few years, the role of magnetic resonance imaging (MRI) as a diagnostic tool in neuroradiology is well established. With advanced MR imaging techniques like perfusion, diffusion, and spectroscopy, it is now possible to differentiate between various intracranial lesions. MR perfusion studies are done to differentiate neoplastic focal lesions in brain from infective pathologies, to grade gliomas, and also to differentiate recurrent tumor from radiation necrosis.[1-2] But MR imaging is relatively costly, not readily available (predominantly in developing countries), and contraindicated in patients with implants and pacemakers. Thus, a good alternative to assess similar hemodynamic parameters of intracranial lesions is CT perfusion (CTP) study. There are very few CTP studies done to assess tumor vascularity and permeabilities.[3-7] However, attempts are also made to validate and assess the accuracy of CTP.[8]

CT perfusion plays an invaluable role here as it detects microscopic differences in the internal vascularity of lesions and aids in their characterisation and significantly raises the diagnostic accuracy. Briefly, the principle of dynamic perfusion CT is explained as the recording of serial changes in the attenuation occurring in a fixed area of interest upon intravenous administration of iodinated contrast in bolus form. The first pass of the contrast is the initial phase where the contrast is intravascular within the local vascular bed. As the contrast material passes through the tissue, a time-density curve is generated from the contiguous dynamic CT images obtained throughout the first pass starting from the point of contrast injection. Several perfusion parameters can be assessed from such curve. These include cerebral blood volume (CBV in ml/100 g), cerebral blood flow (CBF in ml/ 100gm/min), time to peak (TTP in seconds) and Mean transit time (MTT in seconds).[1-5]

In this Retrospective study, we performed CT Perfusion in various intracranial focal lesions and studied their perfusion characters and tried to differentiate between them.

Methedology

This Retrospective Analytical study involved Prior Consent from Hospital Authorities / Medical Superintendents of the Local Randomly selected Secondary & Tertiary care Radio-diagnostic Centres / hospitals to see the records of the patients from Medical Records Department (MRD). The study was conducted within ethical standards. The Patients who were attending or admitted in randomly selected Diagnostic centres / hospitals including Our Teaching Hospital in the city were selected for the study . Randomization was done using computer tables in selecting data. All Patients underwent standard clinical examinations, routine biochemical and haematological investigations with CT. Medical record numbers were used to generate the data for analysis.

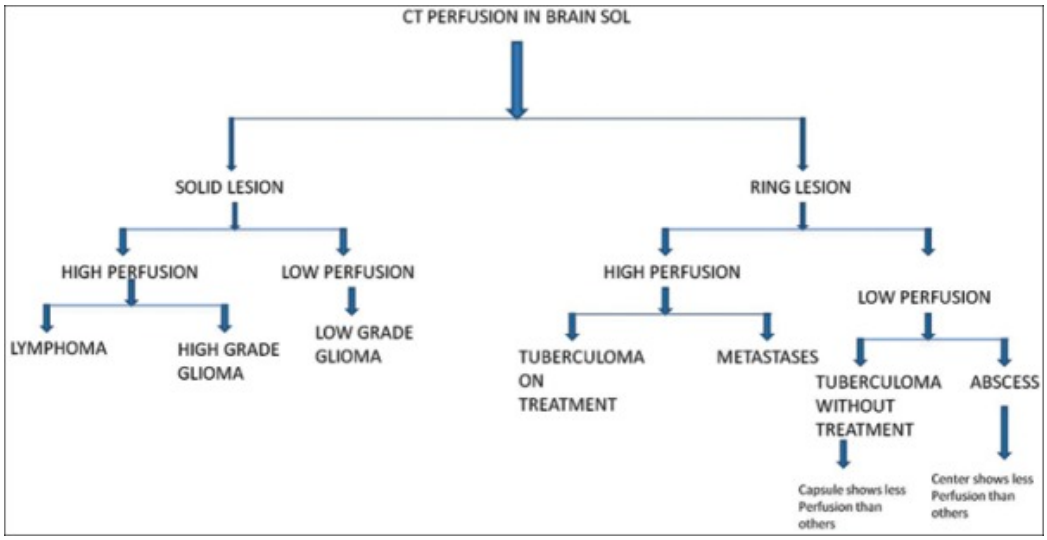
For the purpose of the present study, data of 100 of the randomly selected patients (candidates / study subjects) who seek care for care were retrospectively identified.

CTP was performed with dual-slice dynamic multi-detector CT scanner in 100 patients prior to surgery or stereotactic biopsy with age ranging from 15 to 70 years.

Patients below 15 years, pregnant women, and very old patients with compromised renal functions were not included in this study. It was noted that Informed consent was taken from all patients .

Cerebral hemodynamic parameters like relative cerebral blood flow (rCBF) and relative cerebral blood volume (rCBV) were quantitatively calculated. Approach to intracranial mass lesions by using CT perfusion is shown in the Figure 1.

A total of 100 patients who fulfilled the inclusion criteria were chosen as samples by simple random sampling technique. The data was collected into parts. Demographic variables, Clinical Variables. Statistical analysis was conducted using Statistical Package for Social Sciences-21. Statistical analysis of variance (ANOVA) and the post-hoc procedure of Student–Newman–Keuls were performed between the groups. ANOVA was done to compare the means between the groups and a P value of less than 0.05 was considered significant.



Approach to intracranial mass lesions by using CT perfusion is shown in the Figure 1.

Results

Totally 100 patients were retrospectively included in the study. All patients had histological diagnosis either by biopsy or surgical resection. Of the 100 patients, lymphoma cases were numbered 19, low-grade glioma 14 (7 astrocytoma and 7 oligodendroglioma), grade 3 anaplastic astrocytoma 18, glioblastoma multiforme 13, metastasis 10 (7 from lung, 2 from colon, and 1 unknown primary of epithelial origin), pyogenic abscess 09, and tuberculoma cases were 17 in number [07 tuberculomas without treatment (TWT) and 10 tuberculomas on antitubercular treatment (TOT) less than 2 months].

Perfusion parameters like rCBF and rCBV were calculated with ROI including the whole of the lesion and 1-2 cm in the periphery of the lesion. In ring-enhancing lesions, ROI was kept in the capsule and the center of lesion, and compared with contralateral white matter. Color maps were assessed as shown in Figure 2 (rCBV). Table 1 shows the rCBF and rCBV of neoplastic lesions with statistically significant difference in rCBF ($P < 0.002$) and rCBV ($P < 0.001$) of low-grade gliomas from high-grade gliomas, lymphomas, and metastases. Table 2 shows the rCBF and rCBV of non-neoplastic tumors. There was statistically

significant difference in rCBF (P < 0.002) and rCBV (P < 0.001) of TWT, TOT, and abscesses.

In ring-enhancing lesions, rCBF and rCBV of the capsule of metastases, abscess, and TOT showed significantly high perfusion compared to those of TWT (rCBF P < 0.013 and rCBV P < 0.002). rCBV of the center of abscess showed significantly low perfusion compared to those of metastasis, TOT, and TWT (rCBV P < 0.02).

Table 1: rCBF and rCBV of neoplastic lesions

Lesions	Mean±SD	
	rCBF	rCBV
Low grade glioma	1.08±0.35*	1.04±0.49#
Grade 3 glioma	3.03±1.61	3.22±1.74
Glioblastoma multiforme (GBM)	2.71±0.71	2.63±0.8
High grade glioma (combined grade 3 and GBM)	2.94±1.40$	2.91±1.28$
Lymphoma	2.74±0.81	3.11±0.90
Metastasis	4.71±4.61	3.90±3.33

***P<0.002, #P<0.001, $P<0.001, GBM=Glioblastoma multiforme, rCBF=Relative cerebral blood flow, rCBV=Relative cerebral blood volume, SD=Standard deviation**

Table 2: rCBF and rCBV of non-neoplastic lesions

Lesions	Mean±SD	
	rCBF	rCBV
Tuberculomas without treatment	1.12±0.35*	1.23±0.44#
Tuberculomas on treatment	3.37±1.35	3.10±0.60
Abscess	1.33±0.47*	1.59±0.70

***P<0.002, #P<0.001, rCBF=Relative cerebral blood flow, rCBV=Relative cerebral blood volume, SD=Standard deviation**

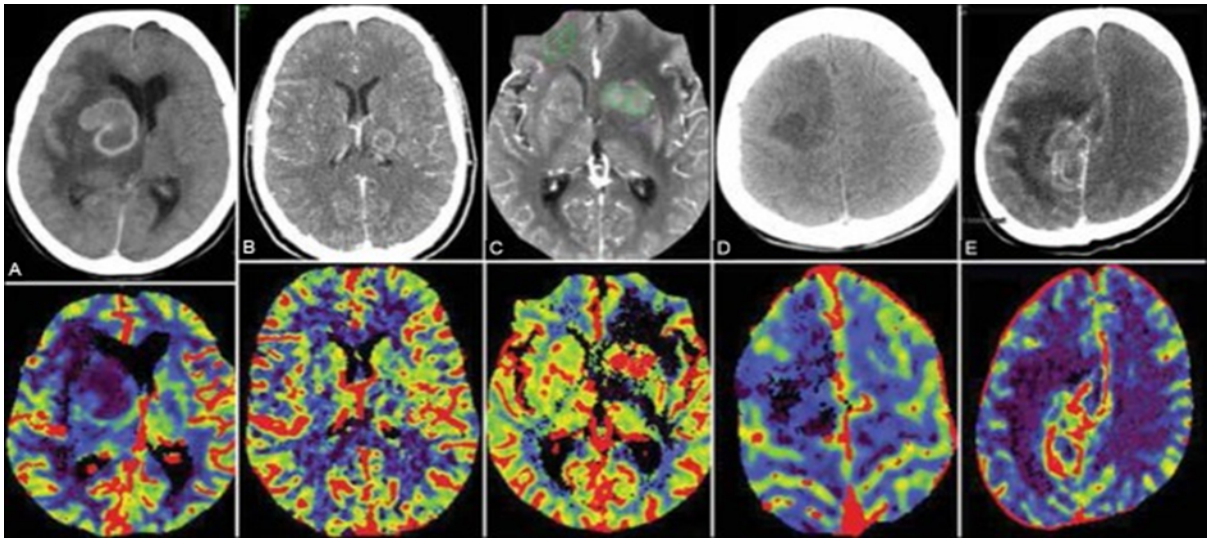


Figure 2: Upper column shows post contrast CT and lower column shows colored Perfusion maps. (A) Tuberculoma without treatment in right basal ganglia (low perfusion) (B) Tuberculoma on treatment in left thalamus (high perfusion) (C) Lymphoma in basal ganglia with ROI (high perfusion) (D) Low grade glioma in right frontal lobe (low perfusion) (E) High grade glioma (grade 3) in right parietal lobe (high perfusion)

Infected lesions like tuberculomas and abscesses showed significant difference in perfusion parameters from high-grade tumors, lymphomas, and metastases. There were differences in perfusion parameters of lymphomas, high-grade gliomas, and metastases, but these were not statistically significant. The rCBF and rCBV values from the periphery of the lesions showed no statistical significance in any of the groups.

Discussion

The most common primary neoplasm of brain is glioma.[9] Other mass lesions that involve brain are non-glial tumors, infective mass lesions, and metastases. Various imaging features of these focal mass lesions significantly overlap, making diagnosis on conventional MR imaging difficult. Advanced imaging techniques like perfusion and spectroscopy are useful in differentiating them.[1,2,4,5] There are no large CTP studies done to differentiate these various ICSOL, except a few studies that had been performed to assess the vascular permeability and perfusion in brain tumors and gliomas.[6,7] CTP techniques are validated and can be compared with xenon CT and MR perfusion techniques, and have shown agreement with quantitative results.[10,11]

We have done CTP in various neoplastic and non-neoplastic lesions, and have tried to differentiate between them, grade gliomas, and also differentiate various ring-enhancing lesions. In our study, we found low perfusion in low-grade gliomas, TWT, and pyogenic abscesses. Aronen et al. observed that low-grade glioma had rCBV less than 1.5.[2] Abscesses have low[12] perfusion than high-grade tumors, and TWT also have lower perfusion as shown by Batra et al.[13] Other infectious lesions like toxoplasmosis show lower perfusion compared to tumors like lymphoma.[14] Similarly, cryptococcomas and paracoccidioidomycosis show lower perfusion.[1] Differentiation between low-grade and high-grade gliomas was done successfully with perfusion studies, as low-grade tumors show lower perfusion compared to high-grade tumors. We found statistically significant difference between rCBF and rCBV of low-grade glioma and high-grade glioma with an rCBV cut-off value to differentiate between them, which had a sensitivity of 86.36% and a specificity of 100%. Similarly, Aronen et al. found that none of the low-grade gliomas had rCBV more than 1.5.[2]

Wide variation in rCBF and rCBV values between grade 3 astrocytomas and glioblastoma multiforme was reported by Cha et al.[15] Similar results were obtained in the present study. CTP study can help in differentiating high-grade tumors from low-grade tumors.[16,17]. Lymphomas also pose diagnostic dilemma, especially in immunocompromised patients where toxoplasmosis and lymphoma have similar imaging features on conventional imaging. Ernst et al. were able to differentiate between lymphoma and toxoplasmosis in AIDS patients where lymphoma showed higher perfusion compared to toxoplasmosis.[14] .Perfusion study alone is perhaps unable to differentiate between lymphoma and high-grade gliomas, though it can be differentiated from infective masses like tuberculomas and abscesses. Previous studies have also shown both increased[14] and reduced perfusion in lymphomas.[17] There was statistically significant difference in perfusion of metastases from low-grade gliomas, abscesses, and tuberculomas, but no statistical difference between high-grade gliomas and lymphomas. Similar results were observed by Cho et al.[17]. Thus, based on perfusion parameters, it is possible to differentiate between tuberculomas, abscesses, and metastases. Few recent studies have shown high perfusion in ring-enhancing metastases compared to ring-enhancing tuberculomas.[18]

Conclusion

In summary, CT perfusion can differentiate between low-grade gliomas and high-grade gliomas, lymphomas, and metastases, but CT perfusion alone cannot differentiate between low-grade gliomas, tuberculomas, and abscesses. It can also differentiate between various ring-enhancing lesions like metastases, abscesses, and tuberculomas. In the present study, we found higher perfusion in grade 3 gliomas compared to grade 4 gliomas. Contrary to previous reports, we found no statistical difference in the perfusion of peritumoral region between metastases and high-grade gliomas. An rCBV cut-off value of 1.64 can be used to differentiate between low-grade glioma and high-grade glioma, with a sensitivity of 86.36% and specificity of 100%.

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