Original Research Paper

Volume-9 | Issue-3 | March-2019 | PRINT ISSN - 2249-555X

Radiology

ROLE OF COMPUTED TOMOGRAPHY PERFUSION IN CHARACTERISATION OF SOLITARY RENAL LESIONS

Dr Swarnalakshmi S	Barnard Institute Of Radiology, Madras Medical College, Chennai.
Dr. K. Shivashankar*	Barnard Institute Of Radiology, Madras Medical College, Chennai. *Corresponding Author
Dr. D. Ramesh	Barnard Institute Of Radiology, Madras Medical College, Chennai.

ABSTRACT

AIM: To study the differences among the CT perfusion parameters (BF - Blood Flow, BV - Blood Volume, PMB - Permeability) obtained from various renal lesions and to correlate with the histopathological diagnosis, and grading.

METHODOLOGY: It was a prospective study conducted in Barnard Institute of Radiology with a sample size of 40. Patients referred from Urology department with renal lesion diagnosed on US / Conventional CT, who are willing for CT perfusion were included in this study. All CT perfusion studies were done using 16 SLICE CT scanner (SOMATOM EMOTION, SIEMENS HEALTHINEERS). First, an unenhanced scan was obtained covering entire kidneys, following which, perfusion study was done. After image analysis and post processing, quantitative perfusion parameters were obtained. These findings were correlated with histopathological reports.

RESULTS: All three parameters (BF, BV, PMB) were significantly lower (P<0.01) in RCC than oncocytomas. Permeability was better in differentiating RCC and oncocytoma with 93.8% sensitivity and 100% specificity. Also, BF, BV, PMB were significantly higher in clear cell RCC than other subtypes of Renal cell carcinoma (P<0.01).

CONCLUSION: These data may justify the more routine use of this technique in the characterisation, assessment and follow-up of renal lesions especially small and indeterminate ones.

KEYWORDS : Computed tomography perfusion, Chromophobe renal cell carcinoma, Oncocytoma, Clear cell renal cell carcinoma, Papillary renal cell carcinoma, Blood volume, Permeability surface area product, Mean transit time.

INTRODUCTION:

The basic principle of CT perfusion is based on the temporal changes in the tissue density following administration of iodinated contrast media intravenously.The chronological change in the tissue density depends on the iodine concentration and reflects the nature of tissue vascularity. During the passage of contrast in the tissues, by rapid sequential acquisition of images perfusion CT allows in the quantification of tissue vascularity.

Dynamic contrast enhanced imaging is the most common method used for imaging studies of the microcirculation in the tissues other than brain. The temporal kinetics of enhancement following contrast injection depends on the local circulatory system, the mode of injection, injection dose, rate, type and concentration of the contrast agent. It can then be analysed using various strategies to obtain visual criteria, semi-quantitative criteria or better, microvascular physiological parameters.

AIM: To study the differences among the CT perfusion parameters (BF - Blood Flow, BV - Blood Volume, PMB - Permeability) obtained from various renal lesions and to correlate with the histopathological diagnosis, and grading. To find out the sensitivity and specificity of the CT perfusion parameters that can be used to differentiate malignant tumours like renal cell carcinoma from other benign tumours of the kidney. To analyse the correlation between the CT perfusion parameters values of normal renal parenchyma with that of various benign and malignant renal lesions.

SUBJECTS: This study was conducted in our institute for a period of one year and included 40 patients who were selected by the following inclusion and exclusion criteria.

INCLUSION CRITERIA:

- Age between 20 and 80 years, both sexes.
- The presence of solitary renal lesion diagnosed by USG / Conventional CT, with suspected Renal cell carcinoma(RCC) scheduled for resection.

EXCLUSION CRITERIA:

- Lactating and pregnant females whatever the gestational age.
- Patients with impaired renal function (serum creatinine level higher than 1.3 mg/100 ml).
- Presence of more than one renal lesion.
- Patients with metastasis.
- Patients with simple renal cysts (Bosniak 1 & 2).
- Patients with history of allergy to contrast material.
- Uncooperative patients / patients with breathing difficulties.

All CT perfusion (CTp) studies were done using 16 SLICE CT scanner (SOMATOM EMOTION, SIEMENS HEALTHINEERS). First, an unenhanced scan was obtained covering entire kidneys. Predefined scan volume for the tumour was determined in the -axis for the CTp study.50 ml contrast (Iohexol) was injected at a rate of 5ml/sec followed by dynamic contiguous cine acquisition of images started after a delay of 6 seconds. Image analysis and post processing was done using syngo® Body Perfusion CT (Body PCT) software.

After motion correction and automatic segmentation, a circular ROI was placed in the proximal abdominal aorta is to obtain the arterial input function. An arterial time-density curve for the entire acquisition time of the study was generated automatically. Time-attenuation curves were obtained and quantitative perfusion parameters were calculated by applying body perfusion software using Patlak analysis. Histopathology reports were obtained from the pathology department and the results were correlated with the CT perfusion study findings and values.

RESULTS:

Out of the 40 renal lesions, 32 were RCCs,5 were Oncocytomas and 3 were Angiomyolipoma with minimal fat.

1. All three parameters (BF, BV, PMB) were significantly lower (P<0.01) in RCC than oncocytomas.
2. Permeability was better in differentiating RCC and oncocytoma with 93.8% sensitivity and 100% specificity.
3. Also, BF, BV, PMB were significantly higher in clear cell RCC than other subtypes of Renal cell carcinoma (P<0.01).
4. No significant differences were seen in BF, BV, PMB between chromophobe and papillary RCC.
5. Significant differences were seen in BF and BV between clear cell RCC and AML, and also between low grade and high-grade clear cell RCC (P<0.01).
6. The Receiver Operator Characteristic (ROC) curve analysis of the CT perfusion parameters showed the following cut off values in discriminating Renal cell carcinoma from oncocytoma.

a. 366.2 ml/100ml/min for BF with sensitivity of 87.50%, specificity of 100%, Positive Predictive Value (PPV) of 100%, Negative Predictive Value (NPV) of 55.56%

b. 254.8 ml/1000ml [or] 25.48 ml/100ml for BV with sensitivity of

81.3%, specificity of 100 %, PPV of 100% and NPV of 45.45%

c. 174.8(0.5ml/100ml/min) [or] 87.4 ml/100ml/min for PMB with sensitivity of 93.8%, specificity of 100%, PPV of 100% and NPV of 71%.

Permeability (PMB) was found to be a better parameter than the remaining two parameters namely, Blood flow (BF) and Blood volume (BV) helpful in differentiating between RCC and oncocytoma.

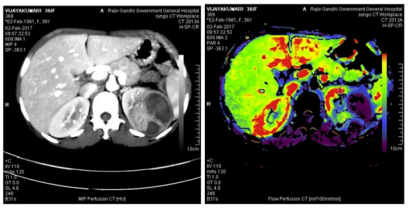
CONCLUSION:

CT perfusion is a non-invasive, quantifiable, and feasible technique which allows the quantitative assessment of hemodynamic changes in the lesion. More studies in future in CT perfusion will determine whether adding CT perfusion parameters to the routine CT could further refine the predictive ability in the evaluation and proper characterisation of renal masses and facilitating targeted therapy. To conclude, perfusion CT can be readily incorporated into the existing CT protocols, as the combined use of conventional CT and perfusion imaging may contribute to better characterization of renal lesions, which may be difficult on the basis of conventional CT features alone and thus paving way to a better and more targeted approach and management.

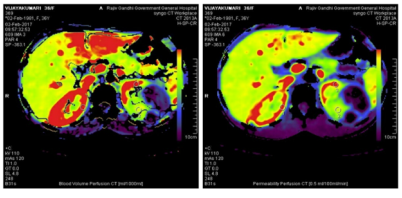
REPRESENTATIVE CASES:

CASE 1

History: 36 years old female patient presented with a partially exophytic left renal mass with both cystic and solid components, and thick septations.



MIP PERFUSION CT (HU) BLOOD FLOW (BF)



BLOOD VOLUME (BV) PERMEABILITY (PMB)

CT Perfusion Interpretation:

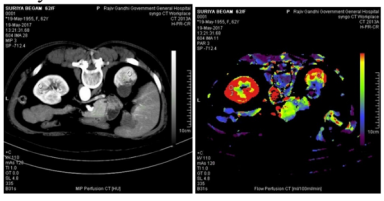
Parameters	Unit	Within the lesion (Mean values)	Normal Renal Cortex (Mean Values)
MIP	HU	153.9	159.1
BF	ml/100 ml/min	284.8	410.5
BV	ml/1000 ml ml/100ml	203.7 20.37	290.3 29.03
PMB	0.5 ml/100ml/min ml/100ml/min	162.3 81.15	208.3 104.15

The solid component of the lesion showed higher blood flow, blood volume and permeability than the cystic component, but reduced values when compared to that of the normal renal cortex.

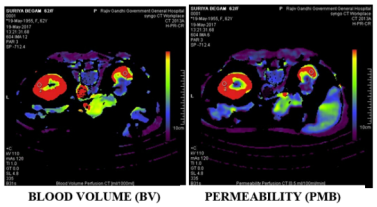
HPE – CLEAR CELL RENAL CELL CARCINOMA (LOW GRADE)

CASE 2

History: 62 years old female patient with right loin pain diagnosed with a right upper pole, hyper vascular renal lesion, with an adjacent simple cortical cyst.



MIP PERFUSION CT (HU) BLOOD FLOW (BF)



BLOOD VOLUME (BV) PERMEABILITY (PMB)

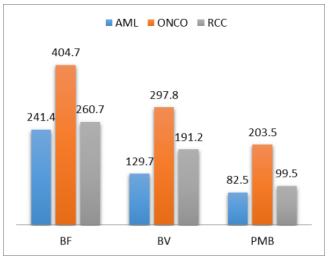
CT Perfusion Interpretation:

Parameters	Unit	Within the lesion (Mean Values)	Normal Renal Cortex (Mean Values)
MIP	HU	171.4	164
BF	ml/100 ml/min	408	430.3
BV	ml/1000 ml ml/100ml	326.9 32.69	316.9 31.69
PMB	0.5 ml/100ml/min ml/100ml/min	202.1 101.05	200.3 100.15

The lesion showed higher blood flow, blood volume and permeability more or less similar to that of the normal renal cortex.

HPE – ONCOCYTOMA

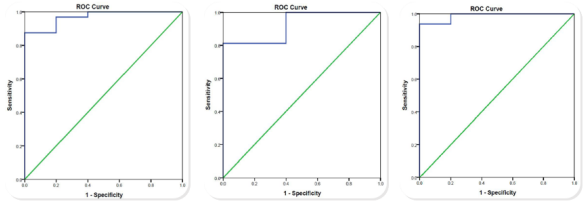
CT PERFUSION PARAMETERS – COMPARISON AMONG RENAL LESIONS (MEAN VALUES):



COMPARISON OF VALUES OBTAINED FROM VARIOUS LESIONS AND THEIR SIGNIFICANT DIFFERENCES:

RENAL LESIONS	STATISTICAL SIGNIFICANCE (P-VALUE < 0.01) "++"		
	BF	BV	PMB
Comparison among various Renal Lesions			
RCC vs ONCO	++	++	++
RCC vs AML	-	-	-
AML vs ONCO	-	++	++
AML vs CCRCC & NON CCRCC			
CCRCC vs AML	++	++	-
NON CCRCC vs AML	++	-	-
Comparison between RCC subtypes			
CCRCC vs ChRCC	++	++	++
CCRCC vs PapRCC	++	++	++
ChRCC vs PapRCC	-	-	-
High grade vs Low grade RCC			
HGRCC vs LGRCC	++	++	-

ONCOCYTOMA vs RCC – ROC CURVE ANALYSIS:



BLOOD FLOW (BF)	BLOOD VOLUME (BV)	PERMEABILITY (PMB)
CUT OFF VALUE: 366.2 ml/100ml/min	CUT OFF VALUE: 25.48 ml/100 ml	CUT OFF VALUE: 87.4 (ml/100ml/min)
SENSITIVITY 87.50%	SENSITIVITY 81.30%	SENSITIVITY 93.80%
SPECIFICITY 100.00%	SPECIFICITY 100.00%	SPECIFICITY 100%
PPV 100.00%	PPV 100.00%	PPV 100%
NPV 55.56%	NPV 45.45%	NPV 71%

REFERENCES:

1. García-Figueiras, Roberto, et al. "CT perfusion in oncologic imaging: a useful tool?." American Journal of Roentgenology 200.1 (2013): 8-19.
2. 64.Cuenod, C. A., and D. Balvay. "Perfusion and vascular permeability: basic concepts

and measurement in DCE-CT and DCE-MRI." Diagnostic and interventional imaging 94.12 (2013): 1187-1204.
3. Choudhary S, Rajesh A, Mayer NJ, Mulcahy KA, Haroon A. Renal oncocytoma: CT features cannot reliably distinguish oncocytoma from other renal neoplasms. Clin Radiol 2009; 64: 517-522 [PMID: 19348848 DOI: 10.1016/j.crad.2008.12.011]
4. Milner J, McNeil B, Alioto J, Proud K, Rubinas T, Picken M, Demos T, Turk T, Perry KT. Fat poor renal angiomyolipoma: patient, computerized tomography and histological findings. J Urol 2006; 176: 905-909 [PMID: 16890650 DOI: 10.1016/j.juro.2006.04.016]
5. Chen, Chao, Qi Liu, Qiang Hao, Bing Xu, Chao Ma, Huojun Zhang, Qianjin Shen, and Jianping Lu. "Study of 320-slice dynamic volume CT perfusion in different pathologic types of kidney tumour: preliminary results." PloS one 9, no. 1 (2014): e85522..
6. Chen Y, Zhang J, Dai J, Feng X, Lu H, et al. (2010) Angiogenesis of renal cell carcinoma: perfusion CT findings. Abdom Imaging 35: 622–628.