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## Normative CT perfusion parameters of pancreas in relation to the age and gender

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### Abstract

**Purpose:** A variety of inflammatory and neoplastic lesions of pancreas can be characterized and prognosticated by perfusion CT (Computed Tomography). Knowing the normal perfusion values is essential before such values could be interpreted as abnormal. The aim of this study was to obtain a normative data of the perfusion parameters of normal pancreatic parenchyma with respect to the age and gender.

**Materials and Methods:** Total 33 subjects underwent perfusion CT of pancreas. The perfusion parameters like BF (Blood-Flow), PEI (Peak Enhancement Index), TTP (Time to Peak) and BV (Blood-Volume) were obtained by placing an ROI (Region of Interest) on normal pancreas. Descriptive statistics of the perfusion values was tabulated and relationship of perfusion characteristics with age and sex of the subjects were calculated applying Pearson's correlation coefficient.

**Results:** 18 subjects were males and 15 were females. 4 subjects belonged to 20-40 age group, 18 belonged to 40-60 age group and 11 belonged to 60-80 age group. BF fell within a range of 11.0 to 161.2 ml100gm<sup>-1</sup>min<sup>-1</sup> (Mean  $\pm$  SD=69.12  $\pm$  36.96), PEI ranged from 23.70 to 165.0HU (Mean  $\pm$  SD=51.82  $\pm$  26.51), BV ranged from 7.8 to 321.5 ml100gm<sup>-1</sup> (Mean  $\pm$  SD=52.31  $\pm$  54.97) and TTP ranged from 8.0 to 58.30s (Mean  $\pm$  SD=20.16  $\pm$  9.08). BF showed a negative correlation with the patient's age ( $r = -.252$ ) on applying the Pearson's correlation coefficient, indicating parenchymal perfusion of the normal pancreas declining with age ( $p>0.05$ ). The PEI showed a negative correlation with patient's age ( $P>0.05$ ) and BV and TTP showed appositve correlation with the patient's age ( $P>0.05$ ). No statistically significant differences were observed in perfusion values of normal pancreatic parenchyma between men and women.

**Conclusion:** Though not statistically significant, a tendency of BF and PEI to reduce with age, BV and TTP to increase with age was observed which require studies with large sample size to determine the true significance.

**Keywords:** Perfusion parameters, pancreas, computed tomography

### Introduction

CT perfusion imaging of the pancreas is a dynamic technique for discerning information on pancreatic vascularity and disease process <sup>[1]</sup>. Miles *et al.* <sup>[2]</sup> initially demonstrated the feasibility of pancreatic perfusion studies using dynamic CT and described the principle advantage of combining functional information and high spatial detail in a single study. The usefulness of perfusion CT for differentiation of ischaemic tissue areas in pancreatitis or malignant lesions from normal pancreatic tissue had been investigated over the last few years <sup>[3, 4]</sup>. Perfusion CT has the potential to be the preferred technique for the assessment of tumor response to antiangiogenic drugs <sup>[5, 6]</sup>.

A knowledge of normal range of the perfusion parameters of pancreas in different age range and sex bears a paramount importance before analyzing the abnormal pancreatic tissue. The aim of this study was to obtain a normative data of the perfusion parameters of pancreatic parenchyma with respect to the age and gender.

### Material and Methods

This is a prospective study performed in patients having pancreatic tumors at a tertiary care center for a period of 2 years. Institutional ethical committee approval was obtained and 49 contiguous patients having a pancreatic lesion on an ultrasound or on routine plain CT imaging were identified. Before proceeding with the contrast CT, the patients were explained about the study and informed consent was obtained.

33 patients gave an informed consent and 16 patients refused to be part of the study. Our inclusion criteria were patients more than 18 years of age and patients who were detected to have pancreatic lesion either on ultrasound or on plain CT study. The exclusion criteria were patients with serum creatinine > 2mg/dl and/ or patient with history of significant allergy to iodinated contrast media and/or patients without histopathological confirmation of diagnosis.

Imaging protocol

Computed tomography examinations was performed on Philips Brilliance 64 slice MDCT scanner. Prior to each CT examination, depending on the patients' age and clinical condition, stomach and bowel loops was pacified using 750ml of ionic contrast media (Angiograffin), 45 minutes before the procedure and 50 - 250 ml just before the CT scan.

Scan parameters

Gantry rotation time: 0.75s.  
Voltage: 120 kVp  
Current: 200 mA  
Pitch: 1.5

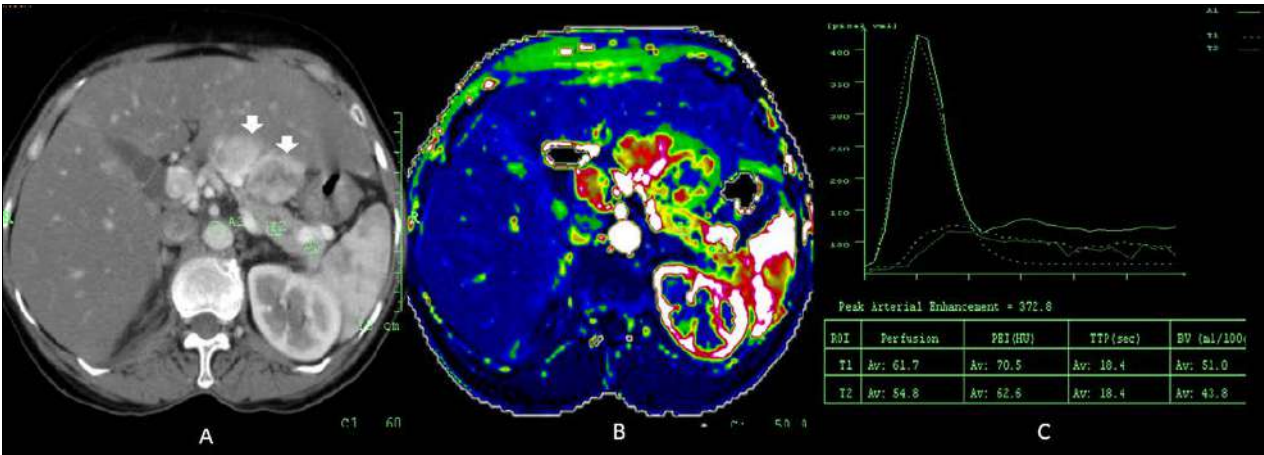
Technique

Plain CT scan of the abdomen in the supine position with breath hold for tumor localization (baseline image). A 4-cm region of interest including the tumor (portion of the tumor with enhancing components) and a part of the normal

pancreatic parenchyma was localized on the baseline image and selected for the perfusion study. 50ml of Intravenous bolus contrast (iodinated water-soluble non-ionic contrast medium, 300mg/ml) was administered at a rate of 5 ml/sec followed by a saline flush of 35ml at a rate of 5 ml/sec via a peripheral arm vein by using 18 G canula for the perfusion scan through a power injector. A delay of 8 sec was given after the start of contrast injection, followed by a continuous acquisition in the 8i transverse mode (8 sections per gantry rotation). Total of 30 dynamic acquisitions with inter - cycle interval of 2.0sec.

Image analysis and interpretation

240 perfusion images were obtained in each patient and the images were transferred to the CT perfusion analysis software as the first step of analysis. Defining free hand ROI's as the second step of analysis i.e. generation of time-density curves in the aorta, normal pancreas and the pancreatic tumor taking care to exclude areas of necrosis, calcification and blood vessels for quantitative assessment and calculation of perfusion parameters. The resulting perfusion values could be visualised on colour maps. Perfusion Parameters recorded were BF (Perfusion - ml/100gm/min), BV (ml/100gm), PEI (HU) and TTP (s) Images were interpreted by a radiologist with 8 years of experience in perfusion imaging. Descriptive statistics of the perfusion values of normal pancreatic parenchyma was tabulated and relationship of these normative values with age and sex of the subjects were calculated applying Pearson's correlation coefficient.



**Fig 1:** Perfusion CT image shows a hyper enhancing mass in the proximal body of pancreas (white arrows in A). CT perfusion color map of blood flow (B) shows mass showing a distinct range of colors compared with the normal pancreatic parenchyma (b). ROI's are placed in the aorta (A1) and within the normal tail (T2) and distal body (T1) of pancreas with their corresponding enhancement curves and perfusion parameters table shown in image C.

Observation and Results

**Table 1:** Descriptive statistics of the perfusion values from the normal pancreas

Statistics	BF	PEI	TTP	BV
Min.	11.0	23.70	8.00	7.80
Max.	161.2	165.0	58.30	321.5
Mean	69.86	52.18	20.16	52.31
S.D	37.96	26.51	9.08	54.97

BF of normal pancreas fell within a range of 11.0 to 161.2 ml100gm<sup>-1</sup>min<sup>-1</sup> (Mean ± SD=69.12 ± 36.96), PEI ranged from 23.70 to 165.0HU (Mean ± SD=51.82 ± 26.51), BV

ranged from 7.8 to 321.5 ml100gm<sup>-1</sup> (Mean ± SD=52.31 ± 54.97) and TTP ranged from 8.0 to 58.30s (Mean ± SD=20.16 ± 9.08).

**Table 2:** Relationship of perfusion characteristics of the normal pancreas with the age of the subjects

AGE	BF	PEI	TTP	BV
Correlation	-.252	-.083	.042	.029
P value	.171	.657	.822	.876

Perfusion of the normal pancreas in 33 patients showed a negative correlation with the patient's age (r = -.252) on

applying the Pearson's correlation coefficient, indicating that parenchymal perfusion of the normal pancreas measured by dynamic CT appears to decline with age. This was however not statistically significant in our study ( $p > 0.05$ ).

Although not statistically significant, we also observed that the PEI showed a negative correlation and that the Blood volume and the TTP of the normal pancreas showed apposite correlation with the patient's age.

**Table 3:** Relationship of perfusion characteristics of the normal pancreas with the gender

Gender	N	Mean	S.D	STD. Error Mean
BF Female	15	61.08	34.50	9.22
Male	18	77.09	40.15	9.74
PEI Female	15	49.39	15.46	4.13
Male	18	54.48	33.34	8.09
TTP Female	15	23.37	11.82	3.16
Male	18	17.51	4.95	1.20
BV Female	15	44.99	24.49	6.54
Male	18	58.34	71.37	17.31

No statistically significant differences were observed in perfusion of normal pancreatic parenchyma between men and women on applying the Pearson's correlation coefficient.

## Discussion

### Perfusion characteristics of normal pancreatic parenchyma

In a study by Miles *et al.* [2], values for perfusion in eight normal pancreases fell within a narrow range of 1.25 and 1.66 ml min<sup>-1</sup> ml<sup>-1</sup> (mean: 1.52 ml min<sup>-1</sup> ml<sup>-1</sup>). Tsushima Y *et al.* [7] in their study, reported perfusion values of normal pancreatic parenchyma in 23 patients which ranged from 0.554 to 1.698 ml min<sup>-1</sup> ml<sup>-1</sup> (mean  $\pm$  SD, 0.963  $\pm$  0.064). Sonja Kandel *et al.* [8] observed perfusion values ranging from 0.75  $\pm$  0.55 min<sup>-1</sup> in the head, 0.94  $\pm$  0.59 min<sup>-1</sup> in the body and 0.92  $\pm$  0.57 min<sup>-1</sup> in the tail of the pancreas in 30 patients. They also observed a lower perfusion in the head than in the body and tail of the pancreas, although this was not statistically significant.

Jin Xu *et al.* [9] did not record any significant difference between the distribution of BF, BV, and PS values in different regions of the pancreas, namely the head, neck, body, and tail ( $P > 0.05$ ) in 36 subjects. The BF, BV, and PS of normal pancreas were recorded as 135.24  $\pm$  48.36 ml min<sup>-1</sup> 100g<sup>-1</sup>, 200.55  $\pm$  54.96 ml 100g<sup>-1</sup>, and 49.75  $\pm$  24.27 ml min<sup>-1</sup> 100g<sup>-1</sup>, respectively. They concluded that the normal pancreas appears homogeneous on perfusion CT. Xue H D *et al.* [10] measured perfusion parameters of normal pancreatic parenchyma in 19 subjects as follows: BF, 104.9  $\pm$  28.9 ml min<sup>-1</sup> 100g<sup>-1</sup>, BV, 166.4  $\pm$  41.8 ml 100g<sup>-1</sup>, TTP, 133.3  $\pm$  24.4 seconds, Permeability, 81.3  $\pm$  24.4, and PEI, 121.3  $\pm$  31.1 HU.

In this study, the values of the perfusion parameters of normal pancreatic parenchyma in 33 subjects are as follows. BF: 69.12  $\pm$  36.95 ml min<sup>-1</sup> 100g<sup>-1</sup>, BV: 51.14  $\pm$  53.63 ml 100g<sup>-1</sup>, TTP: 19.99  $\pm$  8.85 seconds and PEI: 51.82  $\pm$  26.06 HU. The higher perfusion values in normal pancreatic tissue found by some of the above mentioned authors as compared to our results might be accounted for by the low number of subjects in these studies.

### Relationship of perfusion characteristics of normal pancreatic parenchyma with age of the subjects

Tsushima Y *et al.* [7] observed that perfusion values of normal pancreatic parenchyma in 23 subjects ranged from 0.554 to 1.698 ml min<sup>-1</sup> ml<sup>-1</sup> (mean  $\pm$  SD, 0.963  $\pm$  0.064) and showed a negative correlation with the patient's age which was statistically significant ( $r = 0.699$ ,  $p < 0.0005$ ).

Our study also showed the perfusion (BF) of normal pancreatic parenchyma to have a negative correlation with the patients age; however this was not statistically significant ( $r = -.235$ ,  $p = .189$ ).

### Relationship of perfusion characteristics of normal pancreatic parenchyma with gender of the subjects

Tsushima Y *et al.* [7] also observed no differences in perfusion values of normal pancreatic parenchyma between men and women. The current study also revealed no significant differences in perfusion values of normal pancreatic parenchyma between men and women.

One of the limitations of this study was the restricted slice number. This is because the 64 slice multidetector- row CT scanner has limited detector size and only 4cm of the tissue of interest can be imaged. So, the entire pancreatic gland could not be perfused at one go. The part of the pancreatic parenchyma for which perfusion values were calculated varied from one subject to another, i.e., while some subjects the normal head was covered while in others the normal body or the tail was included in the 4cm region of interest due to the above mentioned reason. Hence, the values of the perfusion parameters obtained for normal pancreatic parenchyma may not be applicable to the entire pancreatic gland due to its heterogeneous perfusion.

## Conclusion

Though not statistically significant, a tendency of BF and PEI to reduce with age, BV and TTP to increase with age was observed and these parameters showed no difference with respect to the sex of the subjects. To obtain more conclusive results as to the utility of this approach and its optimization, further studies in a larger patient population are needed.

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