

The Role of Multidetector Computed
Tomography Liver Perfusion and
Tumor Tissue in Assessment of
Hepatocellular Carcinoma

Essay

*Submitted for Partial Fulfilment of Master Degree
In Radio-Diagnosis*

By

Ahmed Mohamed Mohamed Hamad
M.B., B.Ch.

Supervised By

Prof. Dr. Hisham Mahmoud Mansour

*Professor of Radio-Diagnosis
Faculty of Medicine - Ain Shams University*

**Prof. Dr. Amany Mohamed Rashad
Abdel-Aziz**

*Professor of Radio-Diagnosis
Faculty of Medicine - Ain Shams University*

**Radio-Diagnosis Department
Faculty of Medicine
Ain Shams University
2010**

List of Contents

Title	Page
• Introduction and Aim of the Work	1
• Anatomy of the Liver	3
• Pathology of Hepatocellular Carcinoma	29
• CT Liver Techniques	55
• CT Perfusion Liver and Tumor Tissue Findings in Hepatocellular Carcinoma	76
• Summary	86
• References	89
• Arabic Summary	--

Anatomy of the Liver

▪ Surfaces of the liver	4
▪ Porta hepatic	6
▪ Hepatic lobe.....	7
○ Anatomic division	7
○ Segmental division.....	8
▪ Ligaments of the liver.....	12
▪ Blood supply of the liver	13
○ Hepatic arteries	13
○ Portal vein	17
○ Hepatic veins	19
▪ Biliary system	21
○ Intrahepatic biliary anatomy	21
○ Extrahepaticbiliary anatomy	21
○ Arterial supply of the biliary system.....	23
○ Anatomic variants of the biliary tree.....	23
▪ Normal CT anatomy of the liver.....	25

Pathology of Hepatocellular Carcinoma

▪ Epidemiology	29
▪ Risk factors.....	30
▪ Possible mechanisms	32
▪ Gross pathology	33
▪ Microscopically	38
▪ HCC variants	43
○ Fibrolamellar HCC	43
- Incidence	43
- Gross picture	43
- Microscopically	43
○ Combined HC oncology	44
- Incidence	44
○ Scirrhou HCC.....	45
○ Sclerosing HCC.....	45
- Macroscopically	45
○ Carcinosarcoma.....	45
▪ Staging of HCC	46
- TNM staging.....	47
- BCLC staging.....	59
- CLIP staging.....	50
- AJCC/UICC staging.....	51
- ALTSG staging	52
▪ -Spread and metastases.....	53

CT Liver Techniques

▪ CT Examination of the Liver.....	55
▪ Multidetector row CT of the liver	55
▪ Scanning protocol.....	57
▪ Types of scans	57
▪ Non-contrast scans.....	57
▪ Contrast scans.....	58
○ Dual phase CECT scans.....	58
○ Triphasic CECT scans.....	59
▪ CT angiography.....	60
▪ CT perfusion	64
▪ Oncological application of CT perfusion	66
▪ CT perfusion technique of the liver in assessment of HCC.....	68
▪ Inclusion criteria.....	69
▪ CT perfusion technique.....	70

CT Perfusion Liver and Tumor Tissue Findings in Hepatocellular Carcinoma

- CT Perfusion Parameters between Primary
HCC, Background Liver, and Spleen..... 76
- CT Perfusion Parameters in Primary HCC 78
- CT Perfusion Parameters in Extrahepatic
Metastases 82

List of Figures

Fig. No	Subjects	Page
1.	Anterior view of the position of the liver in the right upper human abdomen	4
2.	The superior surface of the liver.....	5
3.	Posterior and inferior surfaces of the liver	6
4.	Inferior surface of the liver	7
5.	Segmental anatomy of the liver according to Bismuth's classification	8
6.	A transverse image through the liver segments	9
7.	On the diagrammatic surface, the falciform ligament divides the liver into the right & left anatomic lobes.....	12
8.	Overview of intrahepatic vascular and biliary anatomy.....	13
9.	Angiogram of the hepatic arterial anatomy.....	14
10.	Shows anatomic variations in the hepatic artery.....	16
11.	Schematics illustrate the normal portal vein (PV) branches from anterior (a) and inferior (b) perspectives.....	17
12.	Intrahepatic portal vein variations	18
13.	Three major hepatic veins drain the liver	20
14.	Normal and variant biliary ducts.....	24
15.	(A-E) Dual-phase-contrast, enhanced liver scans on different levels.....	28
16.	HCC.....	35
17.	HCC in a chronic hepatitis C carrier	37

List of Figures (Cont.)

Fig. No	Subjects	Page
18.	HCC with portal invasion	38
19.	Hepatocellular carcinoma	39
20.	Grade 1 HCC	40
21.	Grade 2 HCC	40
22.	Grade 3 HCC	41
23.	Grade 4 HCC	42
24.	Liver CT imaging.....	56
25.	CT angiography.....	62
26.	Transverse oblique MIP image reveals the hepatic venous anatomy	63
27.	Portal venous anatomy.....	63
28.	Simple compartment model	72
29.	Normal liver perfusion image	73
30.	Transverse contrast material-enhanced CT image and (b) functional CT perfusion color map of BF demonstrate technique of CT perfusion with HCC in right lobe of liver.....	75
31.	Transverse contrast material-enhanced CT image and (b) functional CT perfusion color map of BF demonstrate technique of CT perfusion in a patient with HCC in right lobe of liver	76

List of Figures (Cont.)

Fig. No	Subjects	Page
32.	Transverse CT perfusion functional maps of BF, BV, PS, and MTT show large mass in right lobe of liver that has a distinct range of colors compared with background liver parenchyma.....	77
33.	Liver perfusion image of well differentiated HCC at right posterior lobe	78
34.	Functional CT perfusion map show low BF value in angio-invasive HCC.....	79
35.	Functional CT perfusion map show high BF value in nonangio-invasive HCC compared with previous figure	80
36.	MTTmaps between controls and cirrhotic patients (a&b) and between cirrhotic and non cirrhotic patients with HCC(c&d) MTT in a control subject	81
37.	Transverse contrast-enhanced CT image and (b) functional CT perfusion map of BF with lung metastasis (arrow) from HCC show high BF compared with adjacent muscle.....	82
38.	Hepatic Perfusion Index (HPI).....	84
39.	Patient with liver metastasis	85

List of Tables

Tab. No	Subjects	Page
1.	Segmental anatomy of the liver	10
2.	Normal Hepatic Anatomy	11
3.	Description and frequency of hepatic arterial variations.....	15
4.	TNM staging of liver tumors	47
5.	The Barcelona Clinic Liver Cancer (BCLC) Staging Classification	49
6.	CLIP staging system	50
7.	AJCC/UICC staging system	51
8.	American Liver Tumor Study Group Modified TNM Classification and Staging System	52

List of Abbreviations

3D	angiogram	Three-dimensional angiogram
AFP		Alfa feto protein
AJCC		American Joint Committee on Cancer
BF		Blodo flow
BV		Blood volume
CECT		Contrast enhancement CT scan
CHA		Commun hepatic artery
CHD		Common hepatic duct
CLIP		Cancer of the liver Italian program
CT		Computed tomography
FNH		Focal nodular hyperplasia
GN		Gall bladder
HAP		Hepatic artery phase
HBF		Hepatic blood flow
HCC		Hepatocellular carcinoma
HCT		Helical computed tomography
HCV		Hepatitis C virus
HPI		Hepatic perfusion index
HU		Field unit
IVC		Inferior vena cava

List of Abbreviations (Cont.)

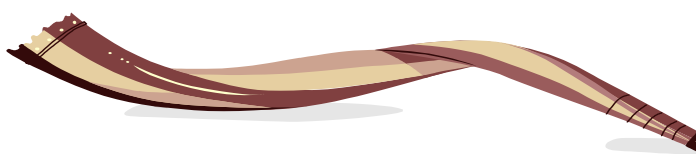
LHA	Left hepatic artery
MDCT.....	Multi-detector computed tomography
MIP	Maximum intensity projection
MTT	Mean transit time
NCECT.....	Non-contrast enhancement CT scan
Ps	Permeability-surface area product
PV	Portal vein
PVP.....	Portal vein phase
RHA	Right hepatic artery
ROI	Region of interest
TAC.....	Time attenuation curves
TDC	Time-density curve
UICC	Union International Contre le Cancer
VEGF	Vasculr endothelial growth factor

Acknowledgment

First, thanks are all due to God for blessing this work until it has reached its end as a part of his generous help throughout my life.

I wish to express my thanks and profound gratitude to Prof. Dr. Hisham Mahmoud Mansour, Professor of Radio-Diagnosis, Faculty of Medicine, Ain Shams University, for suggesting the idea of the work and for his kind encouragement and advice.

Words fail to express my sincere appreciation, great indebtedness to Prof. Dr. Amany Mohamed Rashad Abdel-Aziz, Professor of Radio-Diagnosis, Faculty of Medicine, Ain Shams University, whose continuous supervision advice and fruitful criticism have been of great help in performing this work. It has been an honour and privilege to work under her generous supervision.



*Ahmed Mohamed
Mohamed Hamad*



قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ
الْحَكِيمُ

صدق الله العظيم

سورة البقرة الآية

(32)

Introduction

Hepatocellular carcinoma (HCC) is the fifth most common malignancy worldwide and is responsible for more than 500 000 deaths every year globally. HCCs are highly vascular and derive neovasculature through the process of angiogenesis. Tumor angiogenesis is a complex process mediated by several angiogenic and antiangiogenic factors and is critical for tumor growth and metastasis. Therefore, quantifying tumor angiogenesis is important for risk stratification, evaluation of disease progression, and monitoring response to therapy (*Miles et al., 2000*).

Currently, tissue sampling for the evaluation of tumor microvessel density is considered the most accurate direct marker of angiogenesis. However, tissue sampling is invasive and therefore impractical for longitudinal patient monitoring. Consequently, an accurate noninvasive method to quantify tumor angiogenesis would be highly desirable (*Miles et al., 2000*).

Computer tomographic (CT) perfusion is a technology that allows quantitative assessment of various parameters, such as tumor blood flow (BF), blood volume (BV), mean transit time (MTT), and permeability–surface area product (PS). Results suggest that CT perfusion is a feasible and, from the limited data, reproducible technique for quantifying tumor vascularity and angiogenesis in advanced HCC (*Miles et al., 2000*).