

**The Role of PET CT In Comparison To
Triphasic CT in Early Follow Up of
Hepatocellular Carcinoma after
Transarterial Chemoembolization**

Thesis

*Submitted for Partial Fulfillment of the MD
Degree in Radio-Diagnosis*

By

Hany Rafat Atyia EL -Malah

M. Sc of Radiodiagnosis

Faculty of Medicine- Ain Shams University

Supervised by

Prof. Dr. Mounir Sobhy Guirguis

Professor of Radiodiagnosis

Faculty of Medicine- Ain Shams University

Ass. Prof. Dr. Enas Ahmed Azzab

Ass. Professor of Radiodiagnosis

Faculty of Medicine- Ain Shams University

Ass. Prof. Dr. Waleed Hetta

Ass. Professor of Radiodiagnosis

Faculty of Medicine- Ain Shams University

Faculty of Medicine

Ain Shams University

2019



Acknowledgment

- ✍ First and foremost, my deep gratefulness and indebtedness is to **Allah**, the Most Gracious and the Most Merciful.
- ✍ I wish to express my deep gratitude and respect to **Prof. Dr. Mounir Sobhy Guirguis** Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for his valuable advices, continuous encouragement, judicious guidance and kind support at this study.
- ✍ I would like to express my great thanks to **Ass. Prof. Dr Enas Ahmed Azzab** Ass. Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for her patience, sincere advice and kind support all through this study.
- ✍ Special thanks are due to **Ass. Prof. Dr Waleed Hetta** Ass. Professor of Radiodiagnosis Faculty of Medicine, Ain Shams University for his sincere efforts and fruitful encouragement.
- ✍ I would also like to thank all **my colleagues** who extended to me a helping hand for this work.
- ✍ Lastly and not least, I send my deepest love to my parents, **wife and my daughter Habiba** for their care and ever lasting support.

✍ **Hany Rafat Atyia EL-Malah**



List of Contents

<i>Title</i>	<i>Page</i>
List of Abbreviations	I
List of Tables	IV
List of Figures	V
Illustrated Cases	VIII
Introduction	1
Aim of the work	4
Review of literature	
Radiological anatomy of the liver	5
Pathological considerations	15
Technique of PET CT and Triphasic CT	24
Role of PET CT and Triphasic CT in the early follow up of HCC after transarterial chemoembolization	44
Patients and methods	52
Results	61
Illustrative cases	68
Discussion	86
Summary and conclusion	96
References	99
Arabic summary	

List of Abbreviation

AFP	Alpha-fetoprotein
BGO	Bismuth germanate
CBD	Common bile duct
CECT	Contrast enhanced computed tomography
CHA	Common hepatic artery
CHD	Common hepatic duct
CT	Computed tomography.
CTAC	Computed tomography attenuation correction
EASL	European Association for the Study of the Liver
FDG	Fluorodeoxyglucose
GB	Gall bladder.
GDA	Gastroduodenal artery
GLUT	Glucose transporter
GSO	Gadolinium oxyorthosilicate
HCC	Hepatocellular carcinoma
HCV	Hepatitis C virus
HK enzyme	Hexokinase enzyme
IMV	Inferior mesenteric vein
IVC	Inferior vena cava
kBq	Kolobecquerel

☞ List of Abbreviations ☜

Kev	Kiloelectron volt
Kg	Kilogram
LGA	Left gastric artery
LHA	Left hepatic artery
LHV	Left hepatic vein
LPV	Left portal vein
LSECs	Liver sinusoidal endothelial cells
LSO	Lutetium oxyorthosilicate
mCi	Millicurie
MHV	Middle hepatic vein
MIP	Maximum intensity projection
MPV	Main portal vein
mRECIST	Modified Response Evaluation Criteria in Solid Tumors
MRI	Magnetic Resonance imaging
N/C ratio	Nuclear/cytoplasmic ratio
Nal	Sodium iodide
NASH	Nonalcoholic steatohepatitis
PET	Positron Emission Tomography
PMT	Photomultiplier tube
PV	Portal vein
PVTT	Portal vein tumoral thrombosis
RAPV	Right anterior portal vein
RECIST	Response Evaluation Criteria in Solid

≡ List of Abbreviations ≡

	Tumors
RFA	Radiofrequency ablation
RHA	Right hepatic artery
ROI	Region of interest
RPPV	Right posterior portal vein
RPV	Right portal vein
RRA	Right renal artery.
SA	Splenic artery
SMA	Superior mesenteric artery
SMV	Superior mesenteric vein
SPD	Sum of the product diameters
SUV	Standardized uptake value
TACE	Transarterial chemoembolization
WHO	World Health Organization
18- FDG	18- fluorodeoxyglucose

List of Tables

Table No.	Title	Page
2.1	Okuda staging system	19
2.2	American Joint Committee on Cancer/ TNM 7 th edition	20
3.1	Physical properties of different scintillators for positron emission tomography (PET)	30
4.1	World Health Organization (WHO) Criteria	47
4.2	Response Evaluation Criteria in Solid Tumors	48
4.3	Modified Response Evaluation Criteria in Solid Tumors (mRECIST)	49
6.1	Statistical data analysis including sex and age.	61
6.2	Statistical data analysis of hepatic segmental distribution and size of the chemo-embolized lesions.	62
6.3	Sites of extra hepatic spread.	65
6.4	Statistical data analysis of SUV max and TSUV max / L SUV max.	65
6.5	Illustrating the Diagnostic Value of FDG PET/CT and Triphasic CT in post TACE follow up.	66

List of Figures

Figures No.	Title	Page
1.1	Anatomy of the liver segments.	5
1.2	Cross sectional anatomy of the liver segments.	6
1.3	Radiographic segmental anatomy of the liver.	7
1.4	Normal hepatic arterial anatomy. Axial MIP image shows the normal anatomy of the hepatic artery. CHA common hepatic artery.	9
1.5	3D reconstruction CT angiography on upper abdominal aorta.	9
1.6	Normal portal venous Image from 3D CT portography shows the portal vein (PV) branching into the left portal vein (LPV) and right portal vein (RPV).	11
1.7	Hepatic venous confluence. Coronal MIP image from multidetector CT shows the confluence of the left hepatic vein (LHV).	12
1.8	Normal biliary tree anatomy on MRCP.	14
3.1	Uptake of FDG. FDG is a glucose analog that is taken up by metabolically active cells by means of facilitated transport via glucose transporters (<i>Glut</i>) in the cell membrane.	26

≡ List of Figures ≡

Figures No.	Title	Page
3.2	Annihilation reaction positrons annihilate with electrons, releasing two coincidence 511-keV photons, which are detected by scintillation crystals (blue rectangles).	28
3.3	A schematic of a current PET-CT scanner design. The dimensions of the gantry are 228 cm wide, 200 cm high and 168 cm deep.	32
3.4	Current commercial PET/CT scanners from 3 vendors.	32
3.5	Axial PET CT images showing physiological symmetrical uptake in the nasopharyngeal tonsils.	37
3.6	Symmetrical uptake is noted in the neck, supraclavicular fossa and paravertebral regions consistent with typical appearance of brown fat activity (black arrow).	40
3.7	(A) 58-y-old man with colon cancer. Lesion at dome of liver is mislocalized to right lung (arrow) because of respiratory motion (B) Image without attenuation correction shows that all lesions are confined to liver.	42

☞ List of Figures ☜

Figures No.	Title	Page
4.1	a–d Representative case of rim-shaped FDG uptake. A63-year-old women who had hepatocellular carcinoma (HCC) in segment 8 received radiofrequency ablation (RFA) treatment.	46
4.2	Different imaging response criteria used in evaluation of hepatocellular carcinoma (HCC) after treatment.	49
6.1	Pie chart demonstrates the distribution of cases in both sexes in our study.	61
6.2	Hepatic segmental location of the lesions.	63
6.3	Illustrating the Diagnostic Value of FDG PET/CT and Triphasic CT in post TACE follow up.	67

Illustrative cases

Title	Page No.
Case 1	68
Case 2	70
Case 3	72
Case 4	74
Case 5	76
Case 6	78
Case 7	80
Case 8	82
Case 9	84

Introduction

Hepatocellular carcinoma (HCC) represents the commonest primary hepatic tumor of adults. It is the 6th most common tumor in the world and the third commonest cause of cancer related deaths (*Dai et al., 2014*).

Liver cancer represents about 11.85% of the malignancies of all GIT organs and 1.78% of the total malignancies among Egyptians (*Holah et al., 2015*).

HCC is caused by malignant transformation in hepatocytes due to chronic liver diseases resulting in cirrhosis (*Tsurusaki et al., 2014*).

From the selective treatment options of liver tumors, interventional procedures such as Trans arterial chemo-embolization (TACE), has been widely used. The powerful cytotoxic effect of TACE by combined action of ischemia followed by chemoembolization of the tumor's feeding artery has been proved to result in therapeutic efficacy (*Song et al., 2013*).

Despite good results, this interventional procedure needs close monitoring to effectiveness of treatment because the rate of residual viable malignancy in tumors larger than 3 cm can reach 48% (*Tsurusaki et al., 2014*).

Follow up of tumor response after TACE is important to determine whether the tumor is completely eradicated or additional treatment is required. Magnetic resonance imaging or computed tomography has been widely used for the assessment of treatment response after TACE. The determination of treatment response using size criteria, based on the Response Evaluation Criteria in Solid Tumors (RECIST), does not necessarily apply well to interventional therapy in such patients, so most radiologists have relied on the presence or absence of local contrast enhancement at the treated tumor in addition to changes in tumor size (*Kim et al., 2011*).

The methods which are used to detect tumor viability depend on showing arterial enhancement for reporting treatment responses. However, this concept does not adequately consider the biological activity of HCC (*Song et al., 2013*).

Positron Emission Tomography (PET) is a non-invasive imaging tool that uses 18- fluoro-deoxy-glucose (18- FDG) as radioactive material showing difference in metabolism between tissues thus demonstrates the functional status of suspicious lesions (*Saif et al., 2010*).

After interventional procedures, CT or MRI at one month are routinely performed to assess for residual tumors but there has been increasing evidence that PET can detect residual tumors earlier than CT and MRI (*Tsurusaki et al., 2014*).

PET/CT is a new imaging tool, whose advantages are useful in clinical oncology. The combination of anatomical and functional image has been the true evolution in diagnosis (*Saif et al., 2010*).

So, PET/CT can be used in the assessment of hepatocellular biological activity as an additional predictive tool (*Song et al., 2013*).

Aim of the Work

The aim of this study is to emphasize the role of PET/CT in early follow up of HCC after transarterial chemoembolization in comparison to triphasic CT.