

**ROLE OF PET/CT IN STAGING AND
TREATMENT MONITORING OF
COLORECTAL CANCER**

ESSAY

SUBMITTED FOR FULFILLMENT OF MASTER
DEGREE IN RADIODIAGNOSIS

BY:

MOHAMED MOUSTAFA ESMAT
(M.B.,B.Ch.,CAIRO UNIVERSITY)

Supervised By:

Dr. REDA SAAD ABDEL LATIF. MD
PROFESSOR OF RADIODIAGNOSIS
FACULTY OF MEDICINE
CAIRO UNIVERSITY

Dr. FARID GAMIL AMIN. MD
LECTURERE OF RADIODIAGNOSIS
FACULTY OF MEDICINE
CAIRO UNIVERSITY

Cairo University
2009

Table of Contents

Item	Page Number
List of Abbreviation	
List of tables	
List of figures	
Abstract	
Acknowledgment	
Introduction and aim of the work	1
Colorectal anatomy	3
Pathology of colorectal cancer	10
Positron Emission Tomography (PET)	32
PET/CT	49
Role of PET and PET/CT in evaluation of primary and metastatic colorectal carcinoma	73
Summary and Conclusion	111
Arabic Summary	
Referances	114

List of Abbreviations

ACF	Attenuation correction factor
AC/AL	Attenuation correction/Alignment
CEA	Carcinoembryonic antigen
cm	Centimeter
CMS	Centers for Medicare and Medicaid Services
CT	Computed Tomography
ECT	Emission Computed Tomography
FDG	FluoroDeoxyGlucose
18FDG	¹⁸ F- FluoroDeoxyGlucose
FLT	F-18-3-Fluoro-3-deoxy-L-Thymidine
GLUT	Glucose transporters
GSO	Gadolinium Silicate
H+	Hydrogen ion
HK	Hexokinase
HU	Hounsfield Unit
IV	Intravenous
KeV	Killo electron Volt
KV	Killo Volt
KVp	Killo Volt peak
LSO	Lutetium Oxyorthosilicate
MA	Milli Ampere
MAS	Milli Ampere Second
mCi	Micro Curies
MeV	Mega electron Volt
MRI	Magnetic Resonance Imaging

PET	Positron Emission Tomography
PET/CT	Positron Emission Tomography/ Computed Tomography
PDGF	Platelet-Derived Growth Factor
PMTs	Photomultiplier Tubes
RFA	Radiofrequency Ablation
SPECT	Single Photon Emission Computed tomography
SUV	Standardized uptake value
TNM	Tumor Node Metastasis
VEGF	Vascular Endothelial Growth Factor
β^+	Positron
β^-	Electron

List of tables

Table	Description	Page Number
Table 1	Classification of polyps and polyposis syndrome	11
Table 2	Types of adenomatous polyps	12
Table 3	Benign VS malignant polyp	12
Table 4	TNM Staging system for colon cancer	26
Table 5	Dukes classification	27
Table 6	Radionuclides used in PET	34

List of figures

Figure	Description	Page Number
Figure 1	Normal colon anatomy	3
Figure 2	Ascending colon	4
Figure 3	Transverse colon	4
Figure 4	Descending colon	5
Figure 5	Sigmoid colon	5
Figure 6	Anatomy of the anal canal & rectum	6
Figure 7	Colon layers	7
Figure 8	Colon polyp	10
Figure 9	Villous colonic adenoma	12
Figure 10	Polypoid cancer colon	21
Figure 11	FDG transport	36
Figure 12	Annihilation reaction	36
Figure 13	Radial blurring.	38
Figure 14	Mean positron range and annihilation angle blurring	38
Figure 15	Normal distribution of FDG	41
Figure 16	Physiologic diaphragmatic uptake in a 49-year-old woman with a history of abdominal lymphoma	43
Figure 17	Physiologic gastric uptake in a 52-year-old man with colorectal cancer	44
Figure 18	Physiologic bowel uptake in a 36-year-old man with malignant thymoma	45
Figure 19	Adenocarcinoma of the cecum in a 77 years old man with a cecal polyp	46
Figure 20	Liver metastasis in a 55-year-old man with rectal adenocarcinoma	47
Figure 21	Diffuse large B-cell lymphoma evaluated with FDG PET–CT before therapy	50
Figure 22	The effects of activation of brown fat in a nervous patient	52

Figure 23	A typical PET/CT scanner	53
Figure 24	A schematic illustration of a PET/CT system	55
Figure 25	Typical scout image obtained during an FDG PET/CT study	60
Figure 26	Display screen of the syngo software platform	63
Figure 27	Attenuation correction artifact	71
Figure 28	Attenuation correction artifact.	72
Figure 29	Physiologic muscle activity	72
Figure 30	Axial fusion PET/CT image demonstrates intense focal radiotracer uptake in a primary sigmoid colon mass	76
Figure 31	Midline distal left primary colon carcinoma at an unusual location related to anatomical variation	77
Figure 32	Intense hypermetabolic activity in a cecal carcinoma primary lesion with multiple adjacent foci of uptake	80
Figure 33	Focal intense radiotracer uptake in a subcentimeter left pelvic side wall lymph node is consistent with metastasis	80
Figure 34	Axial fusion PET/CT demonstrates intense focal radiotracer uptake on the lateral margin of a radiofrequency ablation site in the liver	81
Figure 35	A 54-year-old man with recent diagnosis of colon carcinoma and liver metastases.	82
Figure 36	A 75-year-old male with a history of rectal cancer	83
Figure 37	Presacral masses.	84
Figure 38	A 33-year-old man under going ascending colon cancer resection two years ago	92
Figure 39	Patient status post left hemicolectomy for colon cancer without change in CEA level.	92
Figure 40	Patient status post left hemicolectomy for colon cancer and increasing CEA level.	94
Figure 41	Axial CT and PET/CT images revealed elevated glucose metabolism within adenomatous polyp and the adjacent bowel wall	98

Figure 42	MIP image showing abnormal FDG uptake superior to the bladder and an active focus in the right lung base	102
Figure 43	Sagittal and axial views of the FDG positive presacral mass	103
Figure 44	Coronal and axial views of right lower lobe nodule showing FDG uptake	104
Figure 45	MIP image revealing bilobar liver metastases	105
Figure 46	Left and right hepatic lobe lesions seen in the axial section	106
Figure 47	Left and right hepatic lobe lesions seen in the coronal section	106
Figure 48	Rising CEA with normal CT scan. Four abnormal foci of uptake are demonstrated that correspond to peritoneal metastases	107
Figure 49	Rising CEA with normal CT scan. Abnormal focus of uptake within a small soft tissue peritoneal deposit	108
Figure 50	Rising CEA with normal CT scan. Abnormal focus of uptake within a pelvic deposit	108
Figure 51	Rectal cancer with a solitary liver metastases demonstrated on CT. Two abnormal liver lesions are seen & a soft tissue deposit in the right iliacus muscle	109
Figure 52	Rectal cancer with a solitary liver metastases demonstrated on CT. Metastatic deposit in the right iliacus muscle	109
Figure 53	Previous colonic cancer with calcified liver metastases with central photopenic necrosis	110
Figure 54	Previous colonic cancer with calcified liver metastases with central photopenic necrosis and both pancreatic tail and paraaortic involvement	110

Abstract

PET/CT is developing a major role in assessing colorectal cancer. The information provided by PET/CT is likely to combine the best imaging features of both modalities and become the gold standard for staging in colorectal carcinoma.

PET/CT proved significantly more accurate in staging, restaging, and detection of metastatic as well as recurrent colorectal cancer. PET/CT is also useful for differentiating post-treatment changes from residual/recurrent cancer and in monitoring tumor response to therapy.

Keyword PET/CT – Colorectal cancer

Acknowledgement

First and foremost, thanks to **God**, to whom I relate any success in achieving any work in my life.

I would like to express my deepest gratitude and extreme appreciation to **Professor Dr. Reda Saad Abdel Latif**, Professor of Radiodiagnosis, Faculty of Medicine, Cairo University for his kind supervision, kind advice constructive encouragement, generous help and guidance through the whole work which could not be a fact, without his guidance and kind help.

Words cannot express my appreciation to **Dr. Farid Gamil Amin**, Lecturer of Radiodiagnosis, Faculty of Medicine, Cairo University, for his loving guidance, patience, understanding and valuable time he spared in completing this work.

I would like to express my respect, appreciation and thanks for my **parents** for their assistance encouragement and their pray for me.

Finally, great thanks to my **wife** for her kind care and support throughout my life.

Mohamed Moustafa Esmat

Introduction and aim of work

Introduction

Colorectal cancer is the third leading cause of cancer worldwide; it accounts for a large number of tumor related deaths. As with all types of cancer, early diagnosis of colorectal cancer is the key for its cure. Before a true cancer develops, there are often earlier changes in the lining of the colon or rectum. If diagnosed early, before it has metastasized, the disease is considered curable. If the cancer has already spread to distant organs, the long term survival is much lower **(50)**.

Determining the stage of colorectal cancer often requires multi-modality, multi-step imaging approach. Optical colonoscopy represents the reference standard in terms of cancer detection and tissue sampling. However optical colonoscopy only offers an endo-luminal view. Complete "conventional" staging concepts require additional imaging procedures to assess potential metastatic spread to lymph nodes and solid organs **(17)**.

Of these conventional imaging procedures, contrast enhanced computed tomography (CT) is the most common for both the abdomen and pelvis. However, CT offers only morphological data for the evaluation of tumor stage.

Glucose analogue [18F] fluorodeoxyglucose-positron emission tomography (FDG-PET) can display functional information and has been found to be accurate in the detection of colorectal cancer and its distant metastasis. However, based on its limited spatial resolution, FDG-PET often makes exact anatomical localization and demarcation of the lesion difficult **(17)**.

Thus fusion of functional with morphological data may be of benefit for tumor staging. As a consequence, combined PET/CT scanner has been

introduced into clinical practice. Its ability to detect and characterize malignant lesions, with advantages over morphology and function alone, has been documented for different tumors including colorectal cancer (51).

Before PET was introduced, it was extremely difficult to monitor for suspected recurrence. The other techniques available for staging and assessment of potential recurrences lack sensitivity and precision. Moreover, frequent non-conclusive investigations result in diagnostic and therapeutic delay. In many colorectal cancer patients, pelvic CT will demonstrate a suspicious mass, but cannot distinguish mass tumor recurrence from post-operative or post-radiation scar (51).

Whole body PET/CT imaging is said to be the most accurate diagnostic test for detection of recurrent colorectal cancer, and is a cost effective way to differentiate resectable from non-resectable disease (52).

Aim of work:

The aim of this study is to evaluate the role of PET/CT in work-up, staging and treatment monitoring in colorectal cancer.

Colorectal anatomy

Colorectal anatomy

The large intestine extends from the end of the ileum to the anus. It is about 1.5 meters long, being one-fifth of the whole extent of the intestinal canal. It differs from the small intestine in its greater caliber, its more fixed position, its sacculated form, and in possessing certain appendages to its external coat, the appendices epiploicae. Further, its longitudinal muscular fibers do not form a continuous layer around the gut, but are arranged in three longitudinal bands or taeniae. The large intestine, in its course, describes an arch which surrounds the convolutions of the small intestine. The large intestine is divided into the cecum, colon, rectum, and anal canal (42).

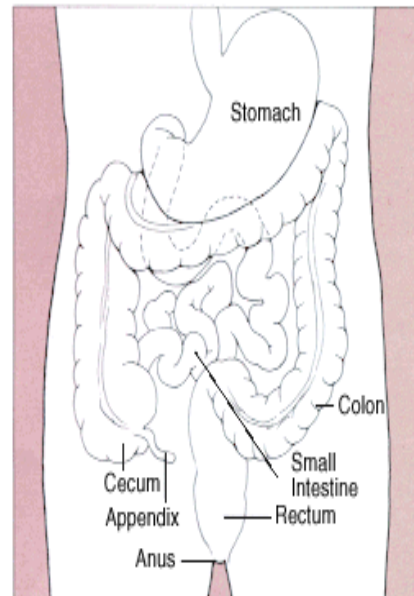


Fig 1. Normal Colon Anatomy (29).

I-The Cecum:

It is attached to the ileum and extends approximately two and one-half inches below it. The cecum in an adult usually is adherent to the posterior wall of the peritoneal cavity and has a serosal covering on its anterior wall only. The cecum forms a blind pouch from which the appendix projects (42).

Its size is variously estimated by different authors, but on an average it may be said to be 6.25 cm in length and 7.5 cm in width. It is situated in the right iliac fossa above the lateral half of the inguinal ligament. It rests on the iliacus & psoas major muscles, usually in contact with the anterior abdominal wall. However; the greater omentum and, if the cecum be empty, some coils of small intestine may lie in front of it (42).