Role of PET/CT

In

Pediatric Oncology

Essay

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بسم الله الرحمن الرحيم

" قالو سُبحانك لا علم لنا إلا ما علَّمتنا إنك أنت العليمُ الحكيم"

صدق الله العظيم

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Abstract

^{18}F-fluorodeoxyglucose positron emission tomography (FDG-PET) and FDG-PET/computed tomography (CT) are becoming increasingly important imaging tools in the non-invasive evaluation and monitoring of children with known or suspected malignant diseases. In this review, we discuss the preparation of children undergoing PET/CT studies and review radiation dosimetry and its implications for family and caregivers.

We review the normal distribution of ^{18}F-fluorodeoxyglucose (FDG) in children, common variations of the normal distribution, and various artifacts that may arise. We show that most tumors in children accumulate and retain FDG, allowing high-quality images of their distribution and pathophysiology.

We explore the use of FDG-PET in the study of children with the more common malignancies, such as brain neoplasms and lymphomas, and the less-common tumors, including neuroblastomas, bone and soft-tissue sarcomas, Wilms' tumors, and hepatoblastomas. For comparison, other PET tracers are included because they have been applied in pediatric oncology.

The recent advent of dual-modality PET-computed tomography (PET/CT) imaging systems has added unprecedented diagnostic capability in pediatric oncology by revealing the precise anatomical localization of metabolic information and metabolic characterization of normal and abnormal structures. The use of CT transmission scanning for attenuation correction has shortened the total acquisition time, which is an especially desirable attribute in pediatric imaging.

Key Words; PET/CT, FDG, pediatric oncology

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Abbreviations

ALARA: As low as reasonably achievable

CI: conventional imaging

^{11}C-Met: Carbon-11–labeled methionine

CNS: Central nervous system

CT: Computed tomography

CTA: computed tomography angiography

DFOV: display field of view

DTC: Differentiated thyroid carcinoma

ES: Ewing's sarcoma

EWS-PNET: Ewing sarcoma-primitive neuroectodermal tumor

FDG: ^{18}F- fluoroine-deoxy-glucose

GFAP: Glial fibrillary acidic protein

GIT: gastrointestinal tract

GN: ganglioneuroma

GNB: ganglioneuroblastoma

HD: Hodgkin's disease

HED: Carbon-11 hydroxyephedrine

HRCT: High resolution computed tomography

ICRP: the international commission of radiological protection

IMT: 3-^{123}I iodo-a-methyl-l-tyrosine

IVU : Intravenous excretory urography

LOR: the line of response

MET: ^{11}C-methionine

MRA: magnetic resonance angiography

MRI: magnetic resonance imaging

mSv: milli-Sievert

MTC: Medullary thyroid carcinoma

NB: Neuroblastoma

NCAMS: Neural cell adhesion molecules

NHL: non-Hodgkin's lymphoma

NPO: nothing per mouth

NSE: Neurone specific enolase

OS: osteogenic sarcoma

PNET: primitive neuroectodermal tumor

PTC: papillary thyroid carcinoma

RF: radiofrequency

SUV: standard uptake value

T/BG: tumor to background ratio

T/NT: tumor to non tumor ratio

^{99m} Tc- MDP: Technetium-99m methylene diphosphonates

TOF: time-of-flight

TYR: ^{11}C-tyrosine

US: Ultrasound

INTRODUCTION

Introduction

Although cancer is much less common in children than in adults (only about 2% of all cancers occur before 15 years of age), it is still an important cause of mortality in pediatrics. Approximately 10% of deaths during childhood are attributable to cancer, making it the leading cause of childhood death from disease ***(Robison, 1997).***

The incidence of cancer in children is estimated to be 133.3 per million children in the United States ***(Gurney et al, 1995)***.

Imaging studies with high diagnostic accuracy are especially important in children with cancer, who often undergo numerous diagnostic procedures for tumor detection, staging and follow-up. These procedures are, at times, invasive, carry the risk of sedation, and cause considerable discomfort to the children and their families ***(Gucalp et al., 1997).***

The future of diagnostic imaging depends upon the ability to change from imaging anatomy to examining the processes at work in the body ***(Wahl, 2004).***

Positron emission tomography (PET) has been at the forefront of functional and molecular imaging for a number of years. In recent years, PET has transformed the contributions of nuclear medicine to the diagnosis, staging, and follow-up of patients with cancer ***(Wahl, 2004)***.

The inherent power of PET is represented by the fact that it has been the first technology in diagnostic imaging to serve not only in the diagnosis of individual patients but also to address the wider issue of our understanding of disease mechanisms and the localization of biochemical events in the living body ***(Bar-Shalom et al. 2003)***.

In addition to the distinguished cast of physicians and researchers, scientists, working alongside physicians and physician-scientists, have done much to ensure that PET continues to evolve in at least two directions. One direction is the technical development of imaging devices, particularly in the form of hybrid detector systems to image both biochemistry and morphology simultaneously; combined positron emission and x-ray computed tomography (PET-CT) is an example of this, this hybrid imaging provides accurate co-registration of metabolic ^{18}F-fluorodeoxyglucose uptake with anatomical data which improved the diagnostic interpretation of both ^{18}F-FDG PET and CT and had an impact on the diagnostic and therapeutic aspects of clinical management and in another direction, new radio-labeled molecular probes are emerging that will take PET beyond the mapping of regional glucose metabolism ***(Czernin and Schelbert, 2004)***.

PET/CT increases the diagnostic accuracy in adult cancer patients, and it's shown that it significantly improved the characterization of abnormal ^{18}F-FDG foci in children with cancer, mainly by excluding the presence of active malignancy in sites of increased tracer activity ***(Bar-Sever et al., 2007)***.

Inconclusive ^{18}F-FDG PET results often stem from inherent limitations such as physiological tracer biodistribution, the lack of precise radiotracer localization on ^{18}F-FDG PET studies, and the inability of CT size criteria to differentiate between viable and non-viable, malignant or benign tissues ***(Wegner et al., 2005).***

^{18}F-FDG PET/CT rapidly assumes a major role in the diagnostic workup and clinical follow-up of pediatric cancer patients ***(Depas et al., 2005).***

AIM OF THE WORK

Aim of the Work

The aim of this work is to emphasize the technical and clinical issues specific to perform PET-CT in the assessment childhood malignancies such as; preparation of children, radiation dosimetry and its implications for family and caregivers, physical aspects of the PET-CT unit, the normal distribution of ^{18}F-fluorodeoxyglucose (FDG) in children, common variations of the normal distribution, and the common artifacts that may arise, the methodology of the CT portion of the examination, and the promising clinical applications of PET and PET-CT in pediatric oncology. We aim to explore the use of FDG-PET in the study of children with the more common malignancies, such as brain neoplasms and lymphomas, and the less-common tumors, including neuroblastomas, bone and soft-tissue sarcomas, Wilms' tumors, and hepatoblastomas. For comparison, other PET tracers are included because they have been applied in pediatric oncology.