F^{18}FDG PET/CT Pitfalls and Artifacts in Pediatric Malignancies

Thesis

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List of Abbreviations

AC	:	Attenuation Corrected
ALARA	:	As low as reasonably achievable
BAT	:	Brown Adipose Tissue
BGO	:	Bismuth germanium oxide
CCHE	:	Children’s cancer Hospital Egypt
CSF	:	Colony- stimulating factor
e.g.	:	Exampli gratia
EANM	:	European Association of Nuclear Medicine
EMS	:	Emergency Medical Services
Etc	:	Et cetera
G- CSF	:	Granulocyte colony- stimulating factor
GLUT	:	Glucose Transporter
HD	:	Hodgkin's Disease/ lymphoma
ICRP	:	International Commission Radiological Protection
kg	:	Kilogram
kV	:	Kilovolt
mAs	:	Milliampere
Max	:	Maximum
MBq	:	Megabecquerel
mCi	:	Millicurie
MIBG	:	Metaiodobenzylguanidine
min	:	Minute
MIP	:	Maximum intensity projection
mm	:	Millimeter
MR	:	Magnetic resonance
NHL	:	Non- Hodgkin’s Lymphoma
PET/MR	:	Positron emission tomography–magnetic resonance imaging
Q	:	The decay-corrected activity in the region of interest in Becquerels per milliliter, W is, and
Q inj	:	The injected dose in Becquerels.
ROI	:	Region of interest

SD	:	Standard Deviation
SPSS	:	Statistical package for social sciences
SUV	:	Standardized Uptake Value
Vs.	:	Versus
W	:	The body weight of the patient in kilograms
18F-FDG PET/CT	:	fluorine-18 Fluoro-deoxyglucose, Positron Emission Tomography–Computed Tomography
2D	:	Two-dimensional
3D	:	Three-dimensional

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INTRODUCTION

Although the incidence of childhood malignancy remains relatively stable, survival rates have significantly improved over the past 30 years. In addition to improved treatment strategies, survival gains have relied upon continuous improvements in the accurate detection, staging and follow- up of these cancers[1-7].

^{18}F-FDG PET is being applied with increasing frequency in the evaluation of children with various malignancies.[5, 8-12] However, a number of pitfalls are commonly encountered with ^{18}F-FDG PET in children, including uptake in benign lesions and normal physiologic activity, leading to possible misinterpretation as malignancy and inaccurate disease staging[8,13,14]. FDG is therefore not a tumour- specific entity and can accumulate in a number of physiological and pathological processes [7].

Accurate interpretation of ^{18}F-FDG PET and PET/CT requires a technically adequate study and knowledgeable interpretation of the resulting images. Children are not just small adults and differ in their psychology, normal physiology, and pathophysiology. Furthermore, different tumour entities or tumour subtypes with different tumour biology may be seen in children in comparison to adults, which should be taken into account when performing PET in paediatrics[6, 15, 16].

Therefore, pediatric ^{18}F-FDG PET requires age-appropriate patient preparation, technically adequate acquisition, and appropriate image interpretation. Performing PET in pediatric patients requires consideration of the developmental stage of each patient and may require decisions about

sedation and general anesthesia. A technically inadequate study can have decreased sensitivity for abnormal findings and may have technical artifacts that may obscure real findings. Accurate interpretation of the resulting images requires familiarity with the normal patterns of ^{18}F-FDG distribution in children and the ability to recognize common developmental and physiologic patterns in the body and brain[15].

It is therefore vital to address this issue due its importance in the paediatric oncology population in terms of diagnosis, staging and in turn treatment.

AIM OF WORK

- To assess prevalence of various pitfalls and artifacts in pediatric ^{18}F-FDG PET/CT that may affect image interpretation, diagnosis and in turn, patient management.
- Qualitative and quantitative assessment of various pitfalls.
- Correlating pitfalls prevalence with tumor primary.

Pediatric Definitions

The definition of a pediatric patient for the purposes of San Mateo County EMS protocols is age less than 15 years or a length-based weight of 36 kg or less. Patients who are known to be less than 15 years of age but whose weight exceeds 36 kg may still be considered pediatric patients given their chronological age; however weights will then need to be estimated and adult dosages should be used. The following are age classifications of pediatric patients that may assist pre- hospital personnel in their assessment and management of pediatric patients. [17, 18]

- Neonate: newborn up to first 28 days of life
- Infant: comprises neonatal period up to 12 months
- Toddler: 1-3 years
- Early Childhood: 2-5 years
- Late childhood: 6-11 years
- Adolescent: 12-18 years

It is important to consider developmental age, rather than chronological age when working with this population. General Approach to Caring for the Pediatric Patients:

- Allow the parent/caregiver to remain with the patient whenever possible.
- Adolescents may want to be examined without parent/caregiver. Honor their request if possible and provide them with privacy.

- Obtain history from both older children and adolescents and their parents
- Approach child slowly and calmly. Observe level of consciousness, activity level and respiratory rate/effort before touching.
- Compare assessment findings with parents'description of normal behavior.
- Be honest with the child and parent/caregiver. Explain all procedures to older children and adolescents directly.
- Allow child to hold a familiar security object. Use distraction techniques to assist in gaining cooperation.
- Acknowledge positive behaviors, no matter how small.

Paediatric Malignancies in Egypt

Treatment of childhood cancer is one of the great success stories of modern medicine.

There are marked differences between childhood and adult cancer. First, cancer is generally a rare disease among children. Annual incidence of all cancer in children under 5 years of age in developed countries is only 0.5% [19]. In European countries, 1% of all malignant neoplasms occur in patients younger than 20 years of age [20, 21]. Second, childhood cancers are histologically variable, and embryonic tumors are the most common, while the majority of adult cancers are carcinomas [19, 22,23].

Childhood cancer is relatively rare in Egypt, with an age-standardized incidence rate of 130.9 per 100, 000 (150.3 in males and 110.7 in females) [24,25]. The most common cancers diagnosed among Egyptian children are summarized in tables 1, while table 2 compares cancer incidence and mortality in Egypt to international incidence. Childhood lymphoma is especially high among Egyptians and constitutes a high proportion of all childhood malignancies in Egypt [26].