Preface

Evolving Role of PET in Pediatric Disorders

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Editors

All along, performing imaging studies in children has posed significant challenges to practicing radiologists and technical staff, and this has limited their routine use in certain settings. Such limitations have deprived pediatric patients from the benefits of certain very powerful and useful imaging techniques. Many pediatric imaging studies are performed with some degree of sedation and at times under complete anesthesia. Up until 3 to 4 decades ago, radiologic imaging in children was primarily confined to planar x-ray radiography and to some limited extent to ultrasonography. Obviously, the introduction of tomographic techniques in the 1970s and the 1980s substantially enhanced the role of medical imaging in medicine. These modalities have played a critical role in the management of many serious diseases and disorders in both the adult and the pediatric populations. Over the years both x-ray computed tomography (X-CT) and MR imaging have been adopted as essential tools in both adult and pediatric medicine, and this has enhanced the impact of many invasive and noninvasive procedures/interventions. In recent years, concerns have been raised about the safety of X-CT as a routine diagnostic test, particularly in the pediatric population. Some epidemiologic studies have shown a high incidence of malignancy following exposure to significant radiation doses from modern X-CT instruments. This has led to a source of concern about the role of this imaging technique on a routine ba-

sis in pediatrics. Therefore, MR imaging has gained significant popularity as a safe imaging modality in recent years despite its limitations in assessing certain pediatric pathologic conditions. During the past few years, some concerns also have been raised about the toxicity of MR imaging contrast agents in adults as well as in children. Particularly, the retention of such agents in organs like the brain and elsewhere may potentially prove to be harmful.

PET was introduced as an imaging modality in the 1970s and was used as a powerful investigational tool at major research institutions. PET imaging for the first time allowed imaging normal function and disease activity at the molecular and cellular levels. During the 1980s and 1990s, such molecular studies were performed by using PET alone as a single instrument. However, the introduction of PET-CT in 2001 substantially enhanced the role of this imaging technique during the ensuing 2 decades. PET-CT has been increasingly used in the adult population for the management of many serious diseases and disorders. In fact, imaging with this modality is the fastest growing domain in radiology and is expected to become the study of choice for certain disorders in the coming years. PET-CT as a single modality allows generating structural and molecular images with a single data acquisition.

Currently, most specialized pediatric hospitals provide PET-CT imaging on a routine and daily

basis. This is particularly true for institutions that are major referral centers for serious diseases and disorders in children. The impact of PET-CT has been particularly recognized in the management of patients with a variety of malignancies. PET is routinely used for diagnosis, staging, assessing response to treatment, monitoring the course of the disease, and detecting recurrence in many malignancies. It is expected that the unparalleled impact of PET in the adult cancer population will be soon replicated in children. The majority of adult malignancies assessed by PET-CT includes solid tumors in organs such as the lungs, head and neck, breasts, prostate, colon, and other miscellaneous organs. In contrast, pediatric studies are mostly confined to imaging sarcomas, brain tumors, or hematologic malignancies, such as lymphomas and leukemias. PET has proven to be essential for the management of patients with lymphoma and their optimal management on a routine basis. We believe that in the future, patients with other hematologic malignancies, such as leukemias, will be assessed with these techniques because of their importance in detecting and characterizing of the disease process at the molecular and cellular levels. This approach will also play an important role in introducing novel therapeutic interventions in hematologic malignancies and assessing the efficacy of the modern cell-based treatment modalities.

PET imaging, particularly with fluodeoxyglucose (FDG) as the main and routinely available radio-tracer, has been extensively tested and validated as an effective modality for managing patients with infectious and inflammatory disorders. Since such diseases and disorders are also frequently encountered in the pediatric population, there is a high probability of adopting PET in children to detect and manage inflammatory disorders in the near future. Musculoskeletal infections could be the main domains for these applications. Also, FDG-PET is frequently used to assess patients with fever of unknown origin (and occult infections) to determine the location and its underlying causes, such as cancer and inflammation.

PET is increasingly used for the diagnosis and follow-up of many neurologic diseases in adults, and we foresee a similar trend for this modality in the field of pediatric neurology. FDG-PET is often utilized to detect the epileptogenic trigger points before surgical intervention in children and adult patients with seizure disorders.

During the past 2 decades, PET imaging with fluorodopa (FDOPA) has proven to be essential for the management of patients with hyperinsulinism. This approach has allowed distinguishing focal lesions from the diffuse process in the pancreas due to this disease. FDOPA-PET imaging has truly revolutionized the management of patients with this serious and disabling disorder. Before the introduction of this approach, patients with hyperinsulinism were subjected to hours of dangerous diagnostic procedures, while FDOPA-PET has allowed such diagnosis to be made within 20 to 30 minutes. Furthermore, the time required to perform surgery to treat this disease has decreased from 8 hours to less than 60 minutes based on the results from this imaging technique. Furthermore, the rate of successful outcome is frequently higher if surgery is performed following the results from FDOPA-PET.

While PET-CT played a major role in enhancing the impact of this modality in the day-to-day practice of medicine, the introduction of PET-MR imaging over the past decade has opened a new era in both adult and pediatric imaging. MR imaging has been extensively used to examine children for a variety of benign and malignant disorders. In particular, MR imaging has been of great value in detecting and characterizing soft tissue abnormalities. Efforts have been made to avoid CT scans because of the substantial radiation dose from this modality in the pediatric population. This has led to frequent applications of MR imaging in children. Similarly, PET-MR imaging is an attractive modality for assessing domains where MR imaging alone has made an impact over the past decades. This applies to disorders of the brain and the cardiovascular and musculoskeletal systems. Therefore, it is expected that combined hybrid PET-MR imaging will play a major role in the optimal management of pediatric diseases. We should emphasize that PET tracers may obviate administering MR imaging contrast agents that are implicated as being toxic in pediatric patients. This may support PET-MR imaging as the modality of choice in managing many pediatric malady.

The recent advances in PET imaging include the development of total-body instruments that can image the entire body with 1 data acquisition. This revolutionary approach greatly reduces the imaging time compared with that of conventional PET-CT instruments with a limited field of view. Prototype instruments that have been introduced

to the field allow imaging the entire body of adults in only several minutes. This invention not only allows for shorter imaging times but also can be successfully performed with substantially smaller doses of the intended radiopharmaceuticals. Both of these benefits support the use of total-body PET imaging in children. For example, the pediatric population can be examined without sedation or general anesthesia, which is typically induced during most imaging techniques in children. Furthermore, the radiation dose, which is of major concern in this population, will be substantially reduced with this approach. It is expected that total-body PET machines designed specifically for applications in children will have a shorter field of view that is in the range of 80 to 100 cm, and this will accommodate the majority of the pediatric population. This will also reduce the cost of manufacturing such instruments for pediatric applications.

Overall, we believe that PET-CT-MR imaging will substantially enhance the role of medical imaging

in children and therefore lead to more effective therapeutic interventions and successful outcomes in this population.

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