Published in final edited form as:

J Radiol Nurs. 2017 June ; 36(2): 99–103. doi:10.1016/j.jradnu.2016.10.014.

PET/CT-Guided Interventions in Oncology Patients: A Nursing Perspective

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Abstract

In the past five years, the utilization of PET/CT guidance is more commonly used for cancer patients undergoing biopsy and ablations at this NCI-Designated Cancer Center. The interventional use of PET/CT imaging requires nurses to have a thorough understanding of the mechanisms involved in order to provide the best care in an environment that is safe for patients and staff. Evidence suggests cohesive care and safe practice measures are achieved when patients actively participate and understand their care. This article will discuss how a collaborative, patient-centered approach in caring for oncologic patients undergoing PET/CT interventions is necessary for achieving quality patient outcomes.

Keywords

Nursing; PET/CT; Ablation; Biopsy; FDG

Introduction

The foundation of positron emission tomography/computerized tomography (PET/CT) imaging dates back to the early twentieth century, with Otto Warburg learned that cancer cells will switch from oxidative glucose metabolism to anaerobic glucose metabolism even in presence of oxygen (Warburg, Posener, Negelein, 1924). In 1998, the first PET/CT imaging modality was introduced by Townsend, Nutt and Beyer (Beyer, Townsend, Brun, Kinahan, Chrron, Roddy, 2004). Fluorine-18 fluorodeoxyglucose (FDG) was first synthesized in 1970, which later led to visualization of metabolic activity of metastatic tumors with PET imaging (Czernin, Allen, Averbach, Nathanson & Herrman, 2013). In 1997, FDG was approved as a radiopharmaceutical and clinical application of FDG began to increase (Berry & Cook, 2006). The radionuclear marker, FDG, works similarly to glucose. Since malignant cells have increased levels of glucose transporters, glucose and FDG are moved across the cell membrane, allowing for illumination of malignant activity and

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malignant cells (Ott, 2010). Since the spatial resolution of PET imaging alone may not be sufficient for precise anatomical localization of areas of abnormal metabolism, they are commonly fused with simultaneously acquired CT images to overcome this problem. CT scan has two roles, one for anatomical localization of the annihilation process as well as for attenuation correction of the PET data. The combined PET/CT imaging results in highly accurate imaging, where diagnosing, staging, therapy and treatment are endless in the oncology population (Czernin, 2013). The first PET/CT machine began clinical operation in 2001. By 2004, PET/CT was reported as the fastest growing imaging modality, with up to 1,000 systems installed worldwide (Berry & Cook, 2006). The National Oncologic PET Registry (NOPR) was developed in response to the Centers for Medicare and Medicaid to expand coverage for oncologic patients utilizing PET with FDG. Since 2013, there are 979 documented facilities in the United States with at least one registered PET/CT scan using FDG (NOPR, 2013). With the growing number of PET/CT scans in the oncology patient population, more patients are found whose lesions are seen only with PET/CT imaging. In such patients, the best modality for image guided intervention is based on PET/CT guidance. To achieve the best patient outcomes, it is essential for nurses to be adequately educated about the unique nursing considerations involved in PET/CT guided interventions.

Nursing Considerations

Nurses are involved in all aspects of patient care and management throughout the pre, intra and post-procedural course for patients undergoing a PET/CT guided biopsy or ablation. The role of the nurse is essential in providing safe procedural care, while engaging the patient and family in all aspects of care. The nurse acts to facilitate a successful procedure and to provide patient education. Nurses also facilitate educational in-services to other nursing colleagues who provide care to inpatients and outpatients undergoing PET/CT guided procedures. The nurse communicates with the patient to resolve any issues that arise and is the key person for the patient to communicate with during this time. It is important for patients to be met by confident nursing staff in stressful technological environments, as they perceive quality of care with the information provided to them (Brask & Birkelund, 2014). It is important for the nurse to be aware of potential nursing diagnoses while caring for patient undergoing PET/CT guided interventions (See figure 1).

Pre-Procedure

Pre-procedural nursing considerations begin with education about the procedure and fasting. Patients undergoing PET/CT guided procedures are consulted and educated in the Interventional Radiology clinic by both an interventional radiologist and registered nurse. Patients are not permitted to consume solid foods after midnight and are instructed to limit consumption of clear liquids six hours prior to PET injection. Patients should limit strenuous and repetitive exercise activity 24 hours before the PET/CT scan, as this can limit quality of PET images. If the patient engaged in strenuous physical activity, the muscles would take up FDG in a fasting state, interfering with PET scan accuracy. In clinic, medications are reviewed for anticoagulants as well as any medications that require modification due to intervention. For patients on anticoagulants, appropriate bridging or cessation protocols are prescribed. Diabetes medications are among the medications that may require modification

based on the fasting schedule. Education regarding by mouth and injectable diabetic medications is provided and adjustments of long and short acting insulin are explained. The day of the procedure, the patient presents to the pre-operative department, where a nurse conducts a full history and physical assessment, verifies lab values and initiates IV access. A patient's blood glucose is taken and reported to the nuclear medication nurse. Blood glucose levels need to fall between 60mg/dL and 199mg/dL. If blood glucose levels are over 200mg/dL, the hyperglycemic patient may receive insulin or have their procedure rescheduled. Since the FDG tracer works similarly to glucose, it is important to have the patient's blood glucose controlled to limit the increase in metabolic activity interference with FDG uptake. Because it takes 60 to 90 minutes for the FDG isotope to be absorbed, the patient is taken to a shielded room, where FDG is administered by a nuclear medicine nurse and radiation precautions are initiated. For FDG, there is a 10 minute for every 1 millicurie after injection for a patient to be under radiation precautions. Shielded rooms include the pre-procedure room, procedure room and if needed, the post-procedural room. Patients are encouraged to relax and limit movements, as this helps regulate stimulation and unnecessary metabolic activity. For FDG PET/CT therapeutic ablations, medical physics staff is not required to be present because diagnostic dose is below the regulatory threshold. Nursing knowledge of radiation safety precautions is an integral part of education to the patient and family members.

Intra-Procedure

In the procedure room, a patient is generally given moderate sedation for biopsies and general anesthesia for ablations. Patients are educated on sedation expectations and seen by an anesthesiologist before arriving to the procedure room. IV fluids and medications are administered at the discretion of the anesthesia team. Typically, Normosol fluid is used. It is important to keep the patients still, relaxed and warm to prevent an increase uptake of FDG due to regulation in thermogenesis (Ott, 2010). Patients are encouraged to urinate prior to the procedure. Although in some ablation cases, Foley catheters are indicated due to procedure length, every effort is made to avoid catheter placement, if possible. Universal precautions are upheld for body fluid disposal, including proper hand hygiene and glove adherence. It is not necessary to flush urine twice. If spill occurs, the institution's radiation safety department requires the spill to be properly cleaned. If the patient receives a second FDG injection during an ablation procedure (split-dose technique), considerations are made to prepare for a shielded room after the procedure. Radiation safety precautions are upheld with adherence to ALARA (as low as reasonably achievable), while utilizing time, distance and shielding.

Post-Procedure

After the procedure, the patient will typically be in the recovery room for about one hour for biopsies and about two hours for ablations. Chest x-rays are obtained for lung interventions and certain liver and adrenal interventions. Special considerations are taken by the post-anesthesia care nurse to ensure pain management, vital sign stability and bleeding precautions. Patients will have radioactive material in their body for 24 hours and will receive a card stating so. Patients receive educational handouts about the FDG isotope

injection including recommendations to increase water and liquids to help flush out the isotope. Other instructions include limiting close contact with infants or pregnant women for 24 hours and stop breast feeding for 24 hours post-scan. Patients can resume their diet as instructed. Patients are given special instructions warranting notification of the clinical team including excessive pain, fever, difficulty breathing and signs and symptoms indicative of infection.

Radiation Considerations

Radiation exposure is a common concern for both patients and staff who care for patients undergoing ablations and biopsies with PET/CT guidance. Occupation exposure for radiology staff is measured by the Radiation Safety Department and according to the Nuclear Regulatory Commission, should be limited to 5,000 millirems per year and 500 millirems per year for pregnant staff members. Institutions provide staff with radiation badges, also known as dosimeters, which do not protect the staff from radiation exposure, but monitor the amount of exposure. It is important to always wear this badge while working in the radiological environment to ensure accurate documentation and record of exposure and to never wear another employee's badge. ALARA is a widely known term for radiation safety, stressing that the key to radiation safety is ensuring the staff member's exposure is as low as reasonably achievable. The evidence suggests that strategies to limit radiation exposure during PET guided procedures are; minimizing time spent near the patient, increasing distance from the patient and appropriate shielding of staff in the procedure room. The primary factor of radiation exposure to the operator from PET/CT guided procedures is time spent close to the patient (Ryan, Thornton, Sofocleous, Erinjeri, Hsu, Quinn, Dauer & Solomon, 2013). A strategy that could be used to reduce time spent next to the patient and therefore exposure, would be pre-planning tasks needing completion or working with a colleague to complete tasks in a timely manner. It is important to note that commonly used barriers to protect against radiation exposure such as leaded aprons and glasses are not effective in minimizing exposure secondary to PET photons (Ryan et al., 2013). However, the dose from PET/CT guided procedures is not significantly different than typical doses from fluoroscopically guided procedures. Therefore, one could perform up to 2,500 PET/CT guided procedures before reaching the annual exposure limit (Ryan et al., 2013). One strategy to limit exposure during PET guided procedures is encouraging the patient to void prior to entering the procedure room since FDG is largely eliminated via the renal system (Ryan et al., 2013). By upholding proper PET/CT FDG radiation safety understanding, nurses can positively contribute to the education and ease fears of both staff and patients involved.

Discussion

When the target lesion is seen only by PET/CT imaging, PET/CT serves as a vital imaging modality for the interventional radiologist and clinical team caring for the oncology patient. It is important for the radiology nurse to understand the benefit and limitations of PET/CT. PET imaging highlights metabolic components of cancerous lesions and CT imaging allows for the precise visualization of anatomy. If used together, the modalities allow for selection of lesions to target, that previously may have been unattainable with utilizing just one

modality (Ryan et al., 2013). PET/CT allows the interventional radiologist to visualize lesions and perform ablations and biopsies that are not viewable on CT alone. Figures 2 and 3 highlight case studies in which both biopsy and ablation lesions are not seen with CT alone, but are clearly visualized with the fusion of PET/CT (Figures 2&3).

Limitations

For diagnostic CT imaging, intravenous contrast injection is commonly required to best define the target lesion. Although beneficial for imaging and identification of lesions, intravenous contrast injection is of little assistance for procedures due to the short amount of time it enhances the target lesion (Ryan et al., 2013). A restriction of only utilizing PET imaging is that PET imaging has a low spatial resolution meaning it lacks the ability to clearly define anatomic components and boundaries. FDG, utilized for PET, also can concentrate itself in normal tissue. This could pose the problem of deciding if the area is truly of concern or if it correlates with “normal tissue such as the brain, muscles, salivary glands, thyroid gland, myocardium, gastrointestinal tract, and the urinary tract” (Muhammad, Tzannon & Makrilia, 2010). Limitations of PET/CT include claustrophobia since the length of the gantry is comparable to MRI verses CT. Additionally; pregnant patients are advised to avoid having PET/CT imaging with FDG due to the teratogenic effects of the unborn fetus. Finally, positioning can be difficult for certain patients. Patients are commonly positioned supine, prone, right lateral recumbent and left lateral recumbent for PET/CT procedures.

Benefits

The primary benefits of PET/CT are centered towards improved diagnosis, staging, treatment and radiotherapeutic management of cancer treatment (Muhammad, Tzannon & Makrilia, 2010). One of the main benefits of utilizing PET/CT is its capability to identify malignancy before anatomical changes occur. This allows for image guided biopsies to be feasible earlier, leading to early advanced diagnosis and staging of tissue (Kobayashi, Bhargava, Raja, Nasser, Al-Balas, Smith, George, Vij, 2012). The use of PET/CT imaging provides profound accuracy in identifying and characterizing primary and metastatic tumors (Funk, 2012). The staging and restaging of many types of cancer including thoracic, gastrointestinal, lymphoma, head and neck, pancreatic, hepatic, thyroid, gyn, melanoma and unknown primary cancers is significantly impacted by the use of PET/CT image guidance (Berry & Cook, 2006). Additionally, PET/CT aids in isolating prime areas of lesions to biopsy. For example, interventional radiologists can aim to biopsy areas with greater FDG uptake which could improve biopsy accuracy. PET/CT allows for the ability to choose the safest and most attainable FDG avid lesion for biopsy, leading to reduced risk and less procedural related complications. Another benefit of PET/CT is the ability for the interventional radiologist to evaluate for ablation treatment effectiveness while the patient is still under general anesthesia in the procedure room. The early identification of ablation treatment efficacy made possible with PET/CT can in turn prevent patients from having additional ablations in the future (Cornelis, Sotirchos, Violari, Sofocleous, Schoder, Durack, Siegelbaum, Maybody, Humm & Solomon, 2016). This is of benefit to the patient not only physically, but financially (Muhammad, Tzannon, Makrilia, 2010). The NOPR supports

highly significant impact on patient management, including type of treatment (Czernin, 2014). The short half-life of FDG creates for a shorter scan time, leaving room for increased patient use and increased financial outcome to the institution (Muhammad, Tzannon, Makrilia, 2010). Hilner et al., concluded that from 80% of the PET centers in the U.S., PET played an integral part in 36.5% of treatment decisions (Hilner, Siegal & Liu, 2008).

Notable reduction in various use of imaging modalities was identified with the use of PET (Larson, 2008). However, Schoder et al., found that the use of PET/CT altered up to 18% of patient management compared to the use of PET alone (Schoder, Yeung, Gonen, Kraus & Larson, 2008). Furthermore, patients are often inundated with a plethora of appointments for imaging, blood work, treatment and consultation which costs them both time and money. The combination of PET/CT makes it possible for patients to forego additional imaging appointments to follow up on findings from separate PET or CT scans, since it is all done at once. This, in turn, leads to less examinations and therefore lower costs (Muhammad, Tzannon & Makrilia, 2010). For select oncology patient populations whose lesions are seen by PET/CT, the clinically significant benefits of PET/CT can greatly impact one's overall plan of care.

Conclusion

The collaboration of clinical teams including interventional radiologists, nuclear medicine staff and clinical nursing staff are fundamental in achieving successful patient care outcomes for patients undergoing PET/CT guided ablations and biopsies. PET/CT allows for more precise, optimal treatment options, often avoiding unnecessary imaging and procedures, benefitting both the financial resources and clinical benefit of patient care. Nursing impacts patient care for PET/CT patients in many ways. Nurses uphold safe patient practices through ample patient education and support, FDG radiation safety practices and cohesive team collaboration. With the increased growth of PET/CT scans used in select oncology patients, nursing care continues to become more specialized and impact the current growth of the Interventional Radiology imaging modalities.

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Highlights

- Nurses play an integral role in the education of oncology patients receiving PET agents such as FDG, including radiation safety.
- The advantages of PET/CT image guidance for select oncology patients are clinically significant over other imaging modalities.
- Clinical team collaboration is essential for the successful outcome of patients undergoing PET/CT procedures.

Fig. 1.
Nursing Diagnoses

Fig. 2.

A 62-year-old male with history of esophageal cancer post esophagectomy. The left iliac bone lesion for biopsy is FDG avid with no CT correlate (top row). PET imaging is used to localize the lesion and fused PET/CT is used to confirm proper sampling (bottom right). Biopsy sampling revealed metastatic adenocarcinoma, well to moderately differentiated, involving bone.

Fig. 3.

A 53 year old male with history of colon cancer post resection of right hemi-liver. Research protocol required biopsy pre and post-ablation of lesion near resection margin. The lesion is not viewable on CT without contrast (A), but is seen on PET with FDG (B). Pre-ablation biopsy (C), intra-procedural ablation (D), and post-ablation biopsy; status post second FDG injection (E).