The Effectiveness of Halifax-Produced ^{18}FDG-PET/CT in the Evaluation of Patients with Solitary Pulmonary Nodule or Suspected Lung Cancer and the Impact on Patient Management

By
Shane A. Rajaraman

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Approved:	Dr. Genlou Sun Supervisor
Approved:	Dr. Tom Rand Reader
Approved:	Dr. Susan Bjornson Reader
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Abstract

Integrated Positron Emission Tomography and Computerized Tomography (PET/CT) is a powerful imaging technique that combines functional and anatomical information for early and accurate detection of cancer. Limited availability and cost necessitate appropriate case selection based on its impact on patient management. The Halifax-based Lung Cancer Site Team (LCST) oncologists request PET/CT scans using online requisitions that prospectively capture pre-PET/CT case information including cancer indication, stage, management intent (curative or palliative) and treatment modality (surgery,chemotherapy,radiotherapy,multimodality therapy,or observation) in a database. Using the database we identified 77 scans completed on patients with suspected lung cancer (SLC, including solitary pulmonary nodule, SPN) during July 3rd,2010 to November 30th,2010. After considering PET/CT results and subsequent follow up medical records, with the aid of oncologists we determined similar post-PET/CT information to assess for changes in these parameters as well as confirmation of the nature of the suspected lung lesion. When used to diagnose a SLC or SPN, the PET/CT showed 88.6% sensitivity, 83.3% specificity,86.5% accuracy,88.6% positive predictive value, and 88.3% negative predictive value. PET/CT established a different diagnosis (usually benign) in 41.6%, and changed stage in 58.4% of cases. PET/CT changed management intent in 7.8% of cases (usually to palliative) and altered treatment modality in 59.7%. If the lung nodule size measured above 30mm, then 61% of the cases were confirmed as malignant. The Halifax PET/CT protocol is effective in correctly diagnosing malignancy in cases of suspected lung cancer at rates similar to that reported in literature. As utilized by the LCST oncologists, the impact of PET/CT on expected management (59.7%) is higher than that reported in literature (26%) suggesting a widening of the case selection criteria. In those cases where nodule size was>30mm, where an unexpectedly low number of malignant cases were confirmed, further analysis is planned to investigate pre-PET imaging criteria of malignancy.

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Dr. H. Hollenhorst, Dr. M. Rajaraman, Dr. L. Mulroy:
Department of Radiation Oncology, Capital District Health Authority, Dalhousie University

M. Abdolell (M.Sc):
Department of Diagnostic Imaging, Capital District Health Authority, Dalhousie University

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LIST OF ABBREVIATIONS USED IN THIS DOCUMENT

CDHA	Capital District Health Authority
CT	Computerized Tomography
FDG	Fluorodeoxyglucose
LCST	Lung Cancer Site Team
NPV	Negative Predictive Value
PET	Positron Emission Tomography
PPV	Positive Predictive Value
QEIIHSC	Queen Elizabeth II Health Science Centre
REB	Research Ethics Board
SLC	Suspected Lung Cancer
SPN	Solitary Pulmonary Lung Nodule
US	United States
VG	Victoria General

INTRODUCTION

Positron Emission Tomography (PET) is a powerful functional, non-invasive imaging procedure used for the early and accurate detection of cancer. It uses very small amounts of radioactive drugs, most commonly the glucose analog ^{18}F-fluorodeoxyglucose (^{18}FDG), to image cancerous tumours which have increased glucose requirements due to their high metabolic activity. Therefore, PET detects cancer cells based on differences in glucose metabolism and function rather than structural or anatomical variations detected by conventional diagnostic imaging like computed tomography (CT) (Slegelman et al.1986). The more sensitive and specific detection of malignancy by PET before the onset of significant structural changes is offset by its poor anatomical localization. The integration of PET and CT into one unit capable of simultaneous imaging and image co-registration has allowed for improved interpretation based on both functional and anatomical information. Thus, all modern PET units have integrated CT capabilities (Von Schulthess et al. 2006).

With advances in technology, a combined PET/CT unit has become a powerful functional and anatomical imaging tool for cancer. This integrated imaging procedure has increasingly contributed toward the detection and management of cancer and has been useful for many indications (i.e. purposes or reasons to use PET/CT) such as to (PETNET Solutions, 2012):

- Locate the site of cancer
- Determine the size of the tumor
- Differentiate benign from malignant growths
- Discover if the cancer has spread or upstaged
- Select and/or modify appropriate treatment options

- Monitor the success of the treatment
- Detect and recurrent tumors

PET/CT scans are used in a wide variety of cancers including lung cancer, lymphoma and Hodgkin's lymphoma, pancreatic cancer, ovarian and cervical cancer. PET/CT imaging is especially useful for detecting head and neck cancer or melanoma which had previously been classified as "hard to spot" cancers. With an increase in the availability of PET/CT imaging, the indications for oncologic PET continue to expand in a variety of cancer types. Additionally, the publication of large datasets for purposes of quality assurance, such as the US National Oncology PET Registry, has provided baseline data for comparison with data from institutions and jurisdictions where this technology is still emerging. Electronic PET/CT databases, such as the one developed and used in Halifax, are proving useful to validate and optimize the usefulness of PET/CT scans to help cancer patients. Despite the great potential of oncologic PET/CT imaging, it remains a limited resource due to the relatively high operational and capital costs (about $2000 per study) (Eggertson, 2005). Availability should continue to improve as costs decrease with the local production of radioisotopes and as new PET/CT facilities are constructed, including the possibility of mobile units in the future (UPMC Cancer Center, 2012).

Utility of Oncologic PET/CT in Diagnosis of Lung Cancer

Lung cancer remains one of the most common and lethal cancers in both men and women with over one quarter (27%) of all cancer deaths attributable to this disease (Canadian Cancer Society Steering Committee on Cancer Statistics, 2012). Early diagnosis of lung cancer improves operability and curability (Henschke et al. 1999). Accurate methods to evaluate lung lesions suspected of being malignant will facilitate early diagnosis and should improve outcomes for lung cancer patients.

The impact of PET/CT scans in oncology has been significant. One of the first applications of PET scanners in oncology was for the investigation of pulmonary nodules. Over all, PET has distinct advantages and some notable limitations compared with serial conventional imaging techniques (Rohren et al. 2004). PET and integrated PET/CT have relatively high sensitivities and specificities in the evaluation of SLC and SPN (SPN is defined as a solitary pulmonary nodule that is less than or equal to 30 mm in size). In 2001, a published meta-analysis on the use of PET in the diagnosis of pulmonary nodules and mass lesions reviewed forty eligible studies with a total of 1,909 patients and reported sensitivity and specificity rates of 94% and 83%, respectively (Gould et al. 2001). Faryniuk et al (2006) conducted a literature review on the clinical utility of integrated PET/CT scans which included three studies on patients who were suspected of having lung cancer with an overall sensitivity, specificity, and accuracy of 94%, 89%, and 92%, respectively. Limitations of using PET/CT to evaluate SLC include low spatial resolution, paucity of published data in small lung nodules (< 1 cm) and the occurrence of false positives (eg. infection, sarcoidosis) and false negatives (eg. well differentiated or slow growing cancers)

(Rohren et al. 2004). The US-based National Oncology PET Registry maintains one of the largest PET databases. In an analysis of data from 8240 patients with confirmed or suspected cancers of several different types (10,497 PET scans performed for various indications), PET scans altered intended patient management in about 50% of cases (Hillner et al. 2008). More specifically, when PET is used to evaluate SLC, the apparent beneficial change in patient management is limited to 26% of cases (Herder et al. 2003). Although PET/CT scanners have been consistently shown to be useful in detecting cancer, its usefulness in clinical practice must be evaluated in the context of the individual patient's specific situation, cancer type, the precise indication, and institutional cancer management guidelines. Therefore, it is critical to evaluate utilization of PET/CT at the institutional level to confirm proper radioisotope production, delivery, imaging technique and evidence-based, efficient clinical application in order to optimize the impact on patient management.

PET/CT in Nova Scotia

In July 2008, an integrated PET/CT scan unit (GE Discovery^{TM} PET/CT) was installed for clinical use at the VG site of the QEIIHSC of the CDHA in Halifax. Concurrently, a unique online requisition system and database was developed and implemented for oncologists to request clinical PET/CT services. Using this, specific pre-PET/CT case information has been prospectively collected including cancer site, staging information, indication for PET/CT and intended management.

Radionuclides used in PET scanning have short physical half lives. However, time is required for safe radioisotope production and transfer, patient injection, tumour uptake and for conducting the

scan with the integrated PET/CT unit. ^{18}Fluorodeoxyglucose (^{18}FDG) is the most common radioisotope used for oncologic PET mainly because of its relatively large half life of 110 min (Radiation Protection of Patients, 2012). For the first two years of operating the Halifax PET/CT scanner, this isotope was produced in Ontario and shipped to Halifax every work day following a tight flight schedule. Isotope shipment was associated with high operational costs and irregular supply due to disruption of transport related to inclement weather and other challenges.

In July 2010, a cyclotron was installed for clinical use at the VG site of the QEIIHSC which produced a regular supply of local ^{18}FDG in Halifax. This eliminated a number of challenges and increased PET/CT scanner capacity. Additionally, patients who previously had to drive to Halifax early in the morning on a specific day to undergo testing gained more flexibility. Within Atlantic Canada, and outside Halifax, the only clinical PET/CT facility is in Saint John, New Brunswick and there is no other cyclotron producing ^{18}FDG for clinical use.

The majority of lung cancers diagnosed in Nova Scotia are managed within the Lung Cancer Site Team (LCST) in a multidisciplinary fashion. Using existing management guidelines and case conferences, the QEIIHSC LCST oncologists request PET/CT to aid in the diagnosis and management of lung cancer patients.

GOALS

The primary goal of this study is to review and assess the usefulness of PET/CT scanning in patients with SLC as conducted at the QEIIHSC and compare this with that reported in the literature. If the Halifax-produced ^{18}FDG and the QEIIHSC PET/CT scan protocol are effective, then the calculated sensitivity and specificity should be comparable to published results. If the overall impact of PET/CT on intended management differs significantly than that published in the literature, it would suggest that the indications of QEII HSC LCST for using PET/CT scans in patients with SLC should be reassessed as they may be too restrictive or too broad.

To achieve this goal, the study has two objectives. First, data will be acquired from the online PET/CT requisition database and from review of electronic patient records to create a confusion matrix in order to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy (Moses et al. 1993). Second, LCST oncologists will assess how often PET/CT study results changed the pre-PET/CT diagnosis, stage and intended patient management.

METHODS

The online requisition system used by clinicians to request clinical PET/CT services required the submission of pre-PET patient information which was collected in a prospective database with previously obtained full approval of the Capital Health Research Ethics Board (REB). For all patients who completed PET/CT scans between July 3 to November 30, 2010 with the intention of evaluating SLC or SPN, the database provided the following:

- Patient identifiers
- Age
- Gender
- Cancer Site
- Indication for PET/CT
- Pre-PET stage of suspected lung cancer
- Size of Lung Nodule
- Pre-PET Treatment Plan

With the aid of QEIIHSC LCST oncologists, I conducted electronic chart reviews to tabulate further information and the results of the PET/CT study and how this changed diagnosis, stage and intended treatment plan as well as follow-up information to determine the true nature of the lung nodule or lesion. Lung lesions were confirmed as malignant or cancerous if biopsy or surgical excision provided this histopathologic diagnosis or if subsequent serial imaging revealed progressive changes consistent with malignancy (e.g. steady growth). Oncologist and patient confidentiality was strictly maintained at all times.

Inclusion and Exclusion Criteria

Inclusion Criteria

For this study, all PET/CT studies that were requested by QEIIHSC LCST Oncologists on patients with SPN or SLC completed between July 3 to November 30, 2010 were included.

Exclusion Criteria

Patients were excluded from the final analysis if there was a previous diagnosis of cancer or if data were not available to determine the true malignant or benign nature of the lung

nodule (i.e. lost to follow-up or deceased without further investigations). The final number of patients eligible for analysis was $n = 77$.

Statistical Definitions and Analysis

To address the first objective of assessing the effectives of PET/CT in SLC and SPN, a confusion matrix (Table 1) was constructed to calculate the following (Epidemiological Research Methods 2012, Evidence-Based Diagnosis, 2012).

Sensitivity = a/(a+c)

This quantifies the percent of patients suspected of having lung cancer by PET/CT results that are actually confirmed to have lung cancer.

Specificity = d/(b+d)

This quantifies the percent of patients who have a negative PET/CT do not have cancer given that the patient is confirmed not have cancer.

Accuracy= (a+d)/(a+b+c+d)

This refers to the probability of a positive PET/CT given that the patient has confirmed cancer or the probability of a negative PET/CT given that the patient is confirmed not to have cancer.

Positive predictive value (PPV) = a/(a+b)

This is the probability of confirming cancer among patients with a positive PET/CT scan.

Negative predictive value (NPV) = d/(c+d)

This is the probability of confirming no cancer among patients with a negative PET/CT scan.

Table 1. Confusion matrix format for PET/CT detection of cancer

	Cancer Present	No Cancer
PET/CT Positive	a	b
PET/CT Negative	c	d

To address the second objective to assess how PET/CT scan results changed diagnosis, stage and intended management plan, the percentage of cases where these changed was calculated. A subset analysis was completed to compare the confirmed malignancy rate for cases where nodule size was less than or equal to 30 mm or greater than 30 mm.

RESULTS AND DISCUSSION

Cohort characteristics

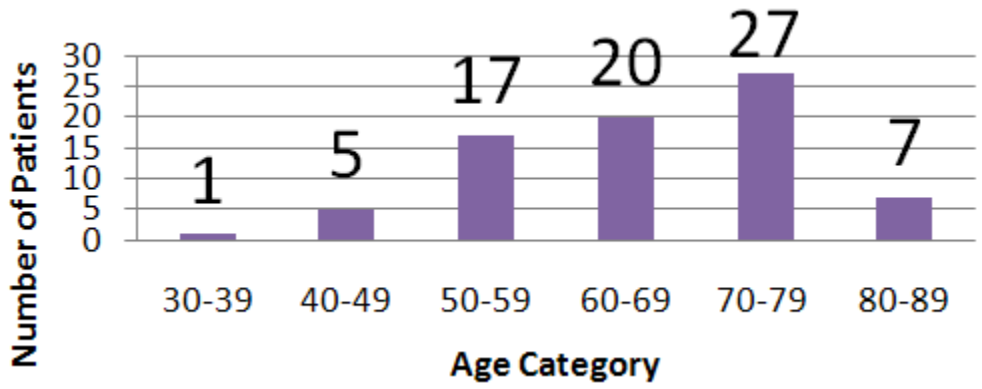
There was no significant difference between the number of males and the number of females in the study cohort (Table 2). This result is similar to the relatively equal distribution of lung cancer diagnosed among male and female Canadians as reported in the Canadian Cancer Statistics 2012 publication (Canadian Cancer Society Steering Committee on Cancer Statistics, 2012).

Table 2: Age characteristics and gender distribution of study cohort (n=77)

Age (Years)	Gender
Mean: 66	Female: 40 (52%)
Range: 38-83	Male: 37 (48%)

As expected for cancer in general, older patients in this cohort were more likely to have cancer than younger patients with a mean age of 66 and over half the patients being between the age of 60-79 (Table 2 and Figure 1).

Figure 1: Age distribution of study cohort (n=77)



Confusion Matrix Calculations

The study data was used to create a confusion matrix as shown below in Table 3.

Table 3: Confusion matrix results for current study (n=74)

	Cancer Present	No Cancer	
PET/CT Positive	39	5	44
PET/CT Negative	5	25	30
	44	30	74

Table 4: Study confusion matrix calculations from table 3 with comparisons to published literature (n=74) and published literature (Faryniuk et al. 2006).

	Current Study	Published Literature
Sensitivity = 100% * a/(a+c)	88.6%	94.2%
Specificity = 100% * d/(b+d)	83.3%	89.2%
Accuracy = 100% * (a+d)/(a+b+c+d)	86.5%	92.4%
Positive Predictive Value = 100% * a/(a+b)	88.6%	n/a
Negative Predictive Value = 100% * d/(c+d)	88.3%	n/a

n/a = not available.

Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value calculations are comparable to the results in published literature and shown in Table 4. These high values suggest that the Halifax-produced ^{18}FDG was effective in collecting in lung cancer cells and visible on the PET/CT scans if cancer was indeed present. It is important to note that in three cases, the PET/CT scan results, as interpreted by the radiologist, were inconclusive and these cases were not analyzed in the confusion matrix. These three cases were recommended for further testing, including a biopsy of the tissue to determine the nature of the cells. Interestingly, the PPV and NPV are very similar figures at 88.6% and 88.3% respectively suggesting that the PET/CT scan has a similar chance of predicting true positive cancers as it does true negative cancers in patients with suspected lung cancer.

Proportion of Instances Where the PET/CT Results Altered Diagnosis, Stage, and Intended Management

1. Diagnosis

Diagnosing cancer can be difficult especially when the cancer is internal, as is the case for lung cancer. Sampling for tissue determination requires invasive procedures which have some associated risks and discomfort for the patient. Signs and symptoms of lung cancer include (Sign and Symptoms of Lung Cancer, 2012):

- An un-resolving cough
- Shortness of breath of wheezing
- Constant chest pain
- Development of a hoarse voice
- Continuous chest infections
- Continuous fatigue
- Unexplained weight loss
- Loss of appetite

However, these symptoms are not specific for cancer and may also be caused by non-malignant diseases such as lung infection or chronic obstructive lung disease. In some cases, a PET/CT is required to see if the radio isotope (^{18}FDG) collects in the lung cancer cells in high risk patients who are defined as those with any of these symptoms in combination with a lesion detected on lung imaging.

This study reviewed all of the *n* = 77 cases that were requested to be evaluated with PET/CT for SLC in the given time frame and determined the percentage of cases where the PET/CT results changed the clinicians perspective of the diagnosis of cancer. After reviewing the scans, the diagnosis was changed from SLC to benign (i.e. PET scan was negative) in 32 of the 77 patients (41.6%). Considering the fairly high NPV of 88.3%, the oncologist may recommend close follow-up only when the PET/CT suggests the lesion is 'not cancer' rather than to subject the patient to risky and uncomfortable invasive biopsy or surgical procedures.

2. Stage

The stage of cancer indicates the burden of disease and the extent to which it has spread throughout the body. Many factors are involved in staging a particular cancer including size of the nodule, penetration in surrounding tissue, indication that the cancer has spread to the lymph nodes, and evidence that the disease has become even more metastatic and spread to other distant areas of the body through the bloodstream. Cancer staging is very important in determining the overall outlook or prognosis and aids in deciding on appropriate treatment methods. Advanced stage cancers generally have a worse survival outcome (MedicineNet 2012).

An outline of the stages of cancer we used in this study is:

Stage 0: No invasive cancer

Stage I&II (Local): Cancer limited to the lungs

Stage III (Local & Regional): Cancer has spread to structure surrounding the lungs or regional lymph nodes

Stage IV (Metastatic): Cancer has spread to a distance site in the body via the blood stream. The three most common areas for this disease to spread are to the bones, liver, and the brain.

This study concluded that in 45 of the 77 cases (58.4%), the stage of cancer was reassessed following the assessment of the PET/CT scan results. Although most of these cases were "down staged" from suspected cancer (Stage I & II) to benign (Stage 0), some were upstaged when cancer was confirmed from local (Stage I & II) to local regional (Stage III) or metastatic disease (Stage IV). When upstaged, there were often important changes in the intended treatment management plan for the patient. This study found approximately 15% of the cases were upstaged due to the PET/CT. This number is higher compared to Bradley et al. in 2004 who found only 8% of cases were upstaged due to PET results. Stage 0 (no cancer) patients were usually followed up with additional imaging to ensure the lesion is indeed non-cancerous. Stage I & II patients are often considered for surgical removal aimed at cure. Select patients who have Stage III may still be considered for a curative management with surgery and or radiotherapy with chemotherapy. Stage IV patients are not usually eligible for curative management options and the intent of treatment changes to palliative.

3. Management

a. Curative vs. Palliative

"Curative intent" suggests that the clinician's plans are to treat the patient with intent to eradicate all cancer. "Palliative intent" suggests that the disease has progressed uncontrollably and the aim of the treatment is not to cure the patient of cancer but to focus on quality of life and supportive

care. The clinician will advise the best treatment plan for the patient to either cure them of their cancer, extend the patient's life, and/or make life more comfortable for the patient.

In this study the PET/CT scan results changed the clinician's management goal (curative or palliative) in 7.8 % of the cases. In all of these cases, the management goals were changed from curative to palliative but not vice versa. In essence, this means the patient would be spared risky and aggressive treatment options which would likely have a detrimental affect rather than beneficial. Instead, the patient would be offered palliative treatment options aimed at optimizing comfort and supportive care.

b. Avoided Tests

If a single non evasive evaluation procedure helps avoid subsequent testing, this can be extremely useful for the clinician and especially the patient and may even reduce health care costs. The biggest impact is that the patient will not need to undergo unnecessary procedures that put the patient at further risk such as surgery or biopsies.

For the purpose of this study, we evaluated whether the patient was able to avoid test (biopsies or additional imaging) based on the PET/CT results. It was found that the PET/CT results allowed the clinician to avoid further tests in 49.3% of the cases.

c. Management Strategy

Similar to Part b, the proportion of instances where the PET/CT results changed the management strategy was determined. Management strategy was evaluated in four different categories: observation, additional imaging, tissue biopsy, and treatment (such as surgery, radiation therapy, or chemotherapy). It was found that in 54.5 % of cases the management strategy changed based

on the results of the PET/CT scan. This percentage of cases is high and shows the importance of the PET/CT scan results as it further guides and helps the clinician to an appropriate management strategy for the individual patient.

d. Treatment Change

The treatment plan is optimized when using the best available information regarding the patient's specific case, including specific diagnosis and stage of the disease (Cummings et al. 1986). Treatment can be costly, time consuming, and if not done for the correct reasons, may create side effects that do more harm than good to the patient. For the purpose of this study, any change in intended management amongst various treatment options (or combinations thereof) of surgery, chemotherapy, and radiation therapy was tallied.

When the results were analyzed, it was found that the PET/CT scan altered treatment in 46 of the 77 patients or 59.7 % of the cases for suspected lung cancer. This percentage is high compared to the literature (Herder et al. 2003) which showed PET/CT scans altered treatment in 26% of cases. This percentage may be relatively high in this study because the treatment options were divided into many alternatives including combinations of various treatments. Nevertheless, this study found that some form of treatment change occurred in approximately 6 out of 10 patients which underlines the significance of PET/CT scan results when used in patients with SLC or SPN.

Impact of Nodule Size on Malignancy

The nodule size can affect the pre-test probability of malignancy being present which in turn may affect the confusion matrix calculations. In this study, nodule size was available in all but 2 cases for an n=75. Out of this sample, the largest nodule measured 80 mm and the smallest measured 6 mm with an average size of 24.6 mm (Figure 2)

A solitary pulmonary nodule (SPN) is defined as one that is less than or equal to 30 mm in size. These 75 cases were divided into two subsets: those that were true SPN (less than or equal to 30 mm, n=57) and those that were not (greater than 30 mm, n=18). The malignancy rates were similar for both groups (56% and 61% respectively). This suggests that the pre-test probability of cancer in each subset was similar in this study and that nodule size should not affect the confusion matrix calculations (Figure 3).

Figure 2: Malignancy status (cancer vs. not cancer) and lung nodule size of each study patient (n=75)

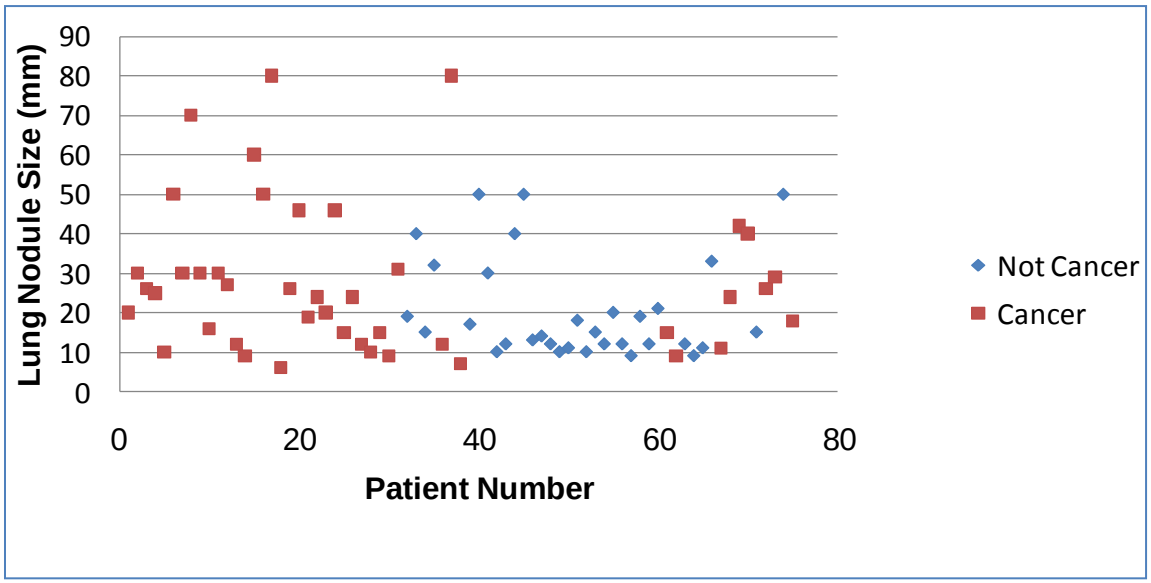
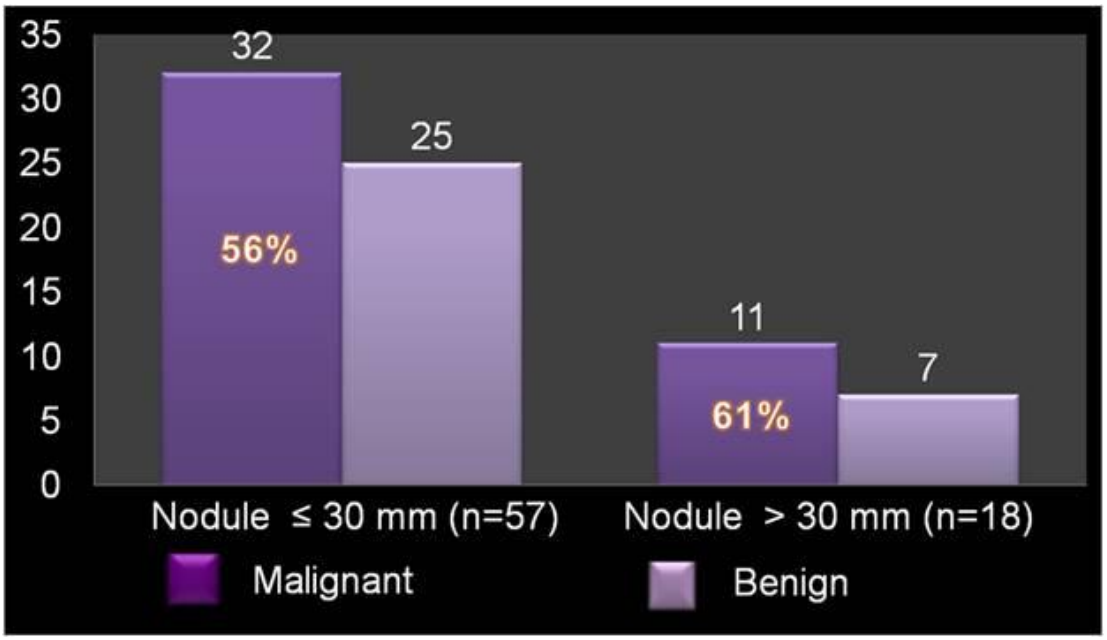


Figure 3: Nodule size subset and malignancy rate (n=75) Range = 6-80mm, Mean = 25mm



The chance of having cancer if the nodule size is greater than 30mm increases from 56% to 61%. Most guidelines recommend that larger masses (greater than 30mm) be managed with biopsy or surgery rather than diagnostic imaging such as the PET/CT scan (Kanne et al. 2012). However, in these situations of large lung nodules where diagnosis may not be significantly aided by PET/CT, PET/CT may still be useful for determining cancer stage information that is important with respect to determining the appropriate treatment options.

EXAMPLE CASE WHERE PET/CT ALTERED RESULTS

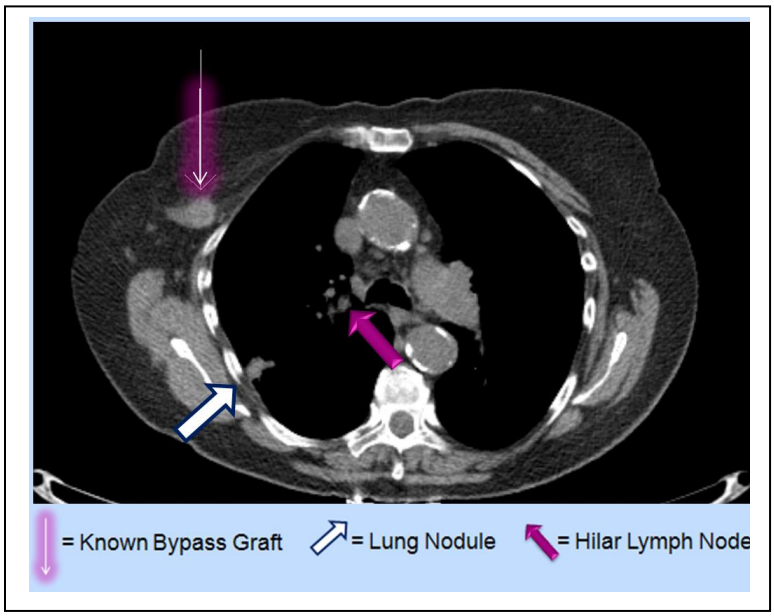
Many cases in this study revealed how the PET/CT scan altered the clinician's initial diagnosis and stage of the suspected lung nodule. Below is an example of one such case that demonstrates the value of using PET/CT scans in evaluating SLC.

Case #29

Case #29 presented as a 77 year old female. She was an ex-smoker with a history of previous lung nodules that were stable on serial CT imaging but now presents with a new solitary right upper lobe spiculated lung nodule, 15 mm in size suspicious for lung cancer. The following steps were taken:

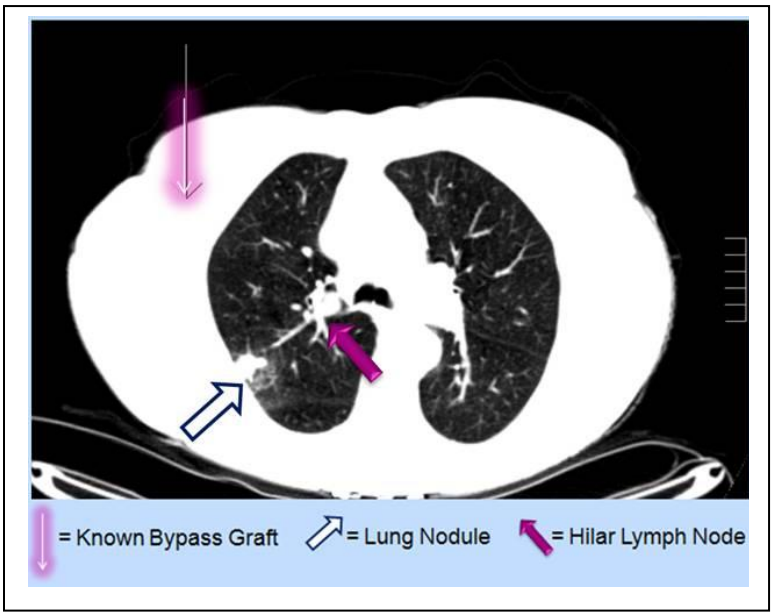
1. CT Scan (Figure 4)*:* Soft tissue window showed a right upper lobe solitary lung nodule (SPN). There were no obvious enlarged hilar lymph nodes. However, there was a known bypass graft noted but is irrelevant to the SPN. Small lymph hilar lymph nodes were seen which by CT criteria were not thought to be malignant.

Figure 4: CT scan of case #29 showing new lung nodule in right upper lobe (thick white arrow)



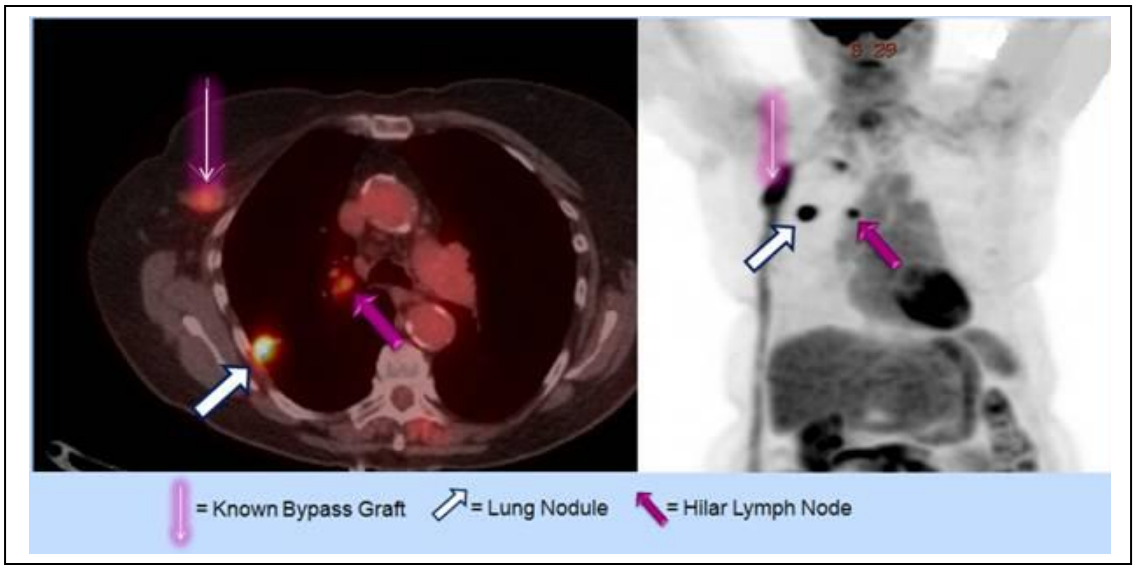
2. CT scan (figure 5)*:* Lung window showed a more detailed picture of the lung nodule and a descriptive view of the surrounding bronchioles

Figure 5: CT scan of case#29 in lung window view showing details of lung nodule



3. PET/CT scan (figure 6)*:* Intense ^{18}FDG uptake is shown in lung nodule and moderate uptake in hilar lymph node suggesting cancer in both areas. Stage is now changed from local only to local and regional disease. This stage change alters the treatment plan in terms of the specific type of surgery required (a common treatment for primary solitary lung nodules) and possibly from surgery to radiation therapy. This PET/CT scan allowed the patient to avoid further tests (biopsy on the site) and changed the treatment plan significantly.

Figure 6: PET/CT scan axial view and full body scan of case#29 showing lung nodule (thick white arrow) and hilar lymph node (thick purple arrow) ^{18}FDG uptake confirming their malignant nature



CONCLUSION

This study confirms a relatively high sensitivity (88.6%), specificity (83.3%), accuracy (86.5%), positive predictive value (88.6%), and negative predictive value (88.3%) of PET/CT scans for evaluating SLC or SPN and is in consistent with data reported from recent literature. From this, it can be inferred that the cyclotron built in Halifax in June 2010 is producing ^{18}FDG which is being administered effectively and is collecting in metabolically active areas that allow the correct identification of cancer in patients with SLC and SPN in most cases.

The PET/CT scan also had a significant impact on the diagnosis, staging, and management of the suspected lung cancer. The diagnosis changed in 41.6% of the cases whereby all cases went from initially being suspected as lung cancer to being diagnosed as benign. Although this number is high, this study was conducted primarily on suspected lung cancer patients; therefore, all cases that required a PET/CT scan were suspected as being positively diagnosed for cancer. The PET/CT scan suggested a stage change in 58.4% of cases which is significant because cancer stage can affect the treatment options given to an individual patient. In 7.8% of the cases, the PET/CT scan resulted in the altered management: from curative to palliative due to upstaging. This information allowed the clinician to avoid unnecessary tests in these patients who would otherwise have had to undergo uncomfortable and invasive procedures. In total, the PET/CT scans avoided unnecessary tests in 49.3% of the cases and changed the treatment strategy (i.e. observation, additional imaging, biopsy, or treatment) in 54.5% of the cases. Finally the PET/CT altered treatment modality (i.e. surgery, radiation, chemotherapy, observation, or any combination) in 59.7% of cases. In other words, 6 out of 10 patients in this study had their treatment plan changed because of the PET/CT scan results.

FUTURE PLANS

The literature suggests (Rohren et al. 2004) that a PET/CT can be avoided when nodule sizes exceed 30 mm, due to the high pre-test probability of malignancy. This was not supported by the results of the current study which indicated that there is a minimal difference in the malignancy rate when nodule size is greater than 30 mm as opposed to when nodules are smaller (56% and 61%, respectively). Further analysis of the subset of patients with nodules greater than 30 mm is being planned. Also, some studies suggest that there may be some concern about the effectiveness of PET for characterisation of nodules smaller than 1.5 cm (National Collaborating Centre for Acute Care, 2012). Studying this subset would also be recommended in the future to determine the effectiveness of PET on these small pulmonary nodules.

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