Pulmonary masses on PET/CT: Distinguishing benign from malignant

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Authors: J. James, S. higgins; Torquay/UK
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Learning objectives

1. Review the imaging characteristics of benign and malignant pulmonary masses on 18-FDG PETCT.
2. Assess the maximum standard uptake value (SUV max) on 18-FDG PETCT and determine the SUV max ranges for benign and malignant pulmonary masses.
3. Summarize the features that can be used to distinguish benign from malignant pulmonary masses.

Background

• Surgical resection is the recognised treatment of choice for patients with stage I or II non-small cell lung cancer.
• Determining whether a pulmonary mass is benign or malignant with non-invasive imaging techniques remains a challenge, but if successful may help patients avoid unnecessary surgical procedures.
• Benign resection rates have fallen but even with the advent of 18-FDG PETCT remain in the range of 10% for patients with lung cancer.
• 18-FDG PETCT evaluates glucose metabolism in tumours, and because of increased metabolism, malignant tissue typically demonstrates higher uptake than normal tissue or benign lesions.

Imaging findings OR Procedure details

Procedure

• Seventy five patients with suspected lung cancer underwent 18-FDG PETCT between November 2008 and April 2011.
• Obvious cases of multiple lung metastases from a known primary cancer were excluded, however we included cases with known cancer, particularly colorectal cancer, where distinguishing between primary lung cancer and a solitary metastasis was difficult on initial imaging.
• Histopathology from surgery served as reference.
• Of the 75 patients (See Fig. 1 on page 5):
  • 49 cases were of primary lung cancer (65%)
  • 14 were cases of metastases (19%)
  • 12 had benign pathology (16%)
The benign lesions ranged from 15 to 40 mm in diameter. The primary malignant lesions ranged from 13 to 80 mm in diameter, with the metastases ranging 5 to 55 mm.

One quarter of the benign cases had a history of known current or previous malignancy (breast, renal and colorectal cancer). Only 3 (6%) of the primary lung cancer patients had history of a previous or possible malignancy (breast, lung and an epiglottic cyst of unknown nature).

The patients with metastases included 11 colorectal, 1 testicular, 1 anal and 1 melanoma. Imaging features and maximum SUV (SUV max) values were recorded for all patients.

**Imaging Findings**

**Imaging features of benign & malignant pulmonary lesions**

<table>
<thead>
<tr>
<th>Benign features</th>
<th>Malignant features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-defined</td>
<td>Ill-defined / spiculated</td>
</tr>
<tr>
<td>No local invasion</td>
<td>Invasion into adjacent structures</td>
</tr>
<tr>
<td>Associated features of benignity (fat, calcification)</td>
<td>Associated features of malignancy (LNs, mets)</td>
</tr>
<tr>
<td>Lower SUVmax</td>
<td>Higher SUV max</td>
</tr>
<tr>
<td>[Low contrast enhancement]*</td>
<td>[Heterogenous contrast enhancement]*</td>
</tr>
</tbody>
</table>

* Requires diagnostic contrast-enhanced CT, and not available on 18-FDG PETCT images alone.

**Features of the malignant cases:**

- Many of the malignant tumours were ill-defined, often with spiculation and distortion of the surrounding lung parenchyma (See Fig. 2 on page 5).
- The larger tumours had necrotic centres and some displayed cavitation (See Fig. 3 on page 6).
- There were features of local invasion in some tumours - through fissures and into ribs or the mediastinum (see Fig. 4 on page 7, Fig. 5 on page 8, Fig. 6 on page 9 & Fig. 7 on page 10).
- Hilar or mediastinal lymphadenopathy with increased FDG uptake on 18-FDG PETCT was seen with many tumours, increasing confidence in the
diagnosis of a malignant tumour (See Fig. 2 on page 5 & Fig. 3 on page 6).

• SUV max of the malignant tumours is discussed later - the range was 3.1 - 33, with the lowest SUV max seen in an endobronchial tumour that was too small to delineate on CT (See Fig. 8 on page 11).

Features of the benign cases (See Fig. 9 on page 12):

• Some of the benign lesions were very well defined, for example the hamartoma and the typical carcinoids, in combination with low SUV max, giving a high degree of confidence in making a diagnosis of a benign lesion (See Fig. 10 on page 13, Fig. 11 on page 14).
• In addition, the hamartoma had an added benign feature of flecks of internal fat on CT.
• Many of the other benign cases were moderately well defined and were more difficult to definitely distinguish from a malignant tumour.
• Infective/inflammatory lesions were less well-defined on CT and had the highest SUV max of the benign group (See Fig. 12 on page 15).
• The aspergilloma was slightly spiculated with a pleural tag (See Fig. 13 on page 19).
• Several were quite mass-like, such as the chronic abscess, with adjacent atelectasis and ground glass (See Fig. 14 on page 18). One lesion had cavitation and turned out to be organising pneumonia on histology (See Fig. 15 on page 17).
• These lesions did not, however, have any pathologically enlarged lymph nodes, local invasion or distant metastases.
• The cases of TB and granulomatous inflammation were also not particularly well defined, but their shape was somewhat linear rather than rounded (See Fig. 16 on page 16 & Fig. 17 on page 20).

Benign vs malignant SUV

• The average SUV max for the 49 malignant primary lung cancers was 11.8 (range 3.1 - 33), whereas for the 12 benign pulmonary masses it was 4.3 (range 1.7 - 6.7) (See Fig. 18 on page 21).
• The metastases had average SUV max of 7.7 (range 2.3 - 20). Three cases did not have SUV max noted in the report, as 2 cases had nodules that were not avid, and the third case showed multiple avid nodules consistent with metastatic anal carcinoma.
• There is some overlap in the SUV values between benign and malignant processes, especially with small malignant lesions, however 75% of benign
lesions had SUV < 4.5, whereas 88% of the malignant lesions had SUVs >4.5.

- The results found a strong association $X^2 = 30.9$, df = 1, $p < 0.001$.

Images for this section:

Fig. 1
Large RUL/RML adenocarcinoma (SUV 9.8) with nodular pleura & avid LNs (SUV 8.7)

Fig. 2
Cavitating RLL adenocarcinoma with avid hilar lymph node (SUV 11.8)

Fig. 3
Fig. 4

Squamous cell carcinoma with rib destruction (SUV 29.8)
Fig. 5

Apical adenocarcinoma with rib destruction (SUV 12.2)
RLL bronchogenic carcinoma with mediastinal contact (SUV 12.7)

Fig. 6
LLL bronchogenic carcinoma with mediastinal contact (SUV 12.8)

Fig. 7
## Benign cases – imaging features and SUV max

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Lesion Definition</th>
<th>Local invasion</th>
<th>Associations</th>
<th>SUV max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granulomatous inflammation</td>
<td>*</td>
<td>*</td>
<td>Air bronchogram</td>
<td>4.2</td>
</tr>
<tr>
<td>TB</td>
<td>*</td>
<td>*</td>
<td>Not typical of a met</td>
<td>6.2</td>
</tr>
<tr>
<td>Hamartoma</td>
<td>*</td>
<td>*</td>
<td>Internal fat</td>
<td>1.7</td>
</tr>
<tr>
<td>Anthracotic LNs</td>
<td>*</td>
<td>*</td>
<td>7- 9 mm hilar LN</td>
<td>4.1</td>
</tr>
<tr>
<td>Organising pneumonia</td>
<td>*</td>
<td>*</td>
<td>Spiculated, cavity, 11 mm LN</td>
<td>6.4</td>
</tr>
<tr>
<td>Carcinoid</td>
<td>*</td>
<td>*</td>
<td>Known RCC</td>
<td>3.6</td>
</tr>
<tr>
<td>Nodular lymphoid hyperplasia</td>
<td>*</td>
<td>*</td>
<td>Spiculated</td>
<td>2.9</td>
</tr>
<tr>
<td>Chronic abscess</td>
<td>*</td>
<td>*</td>
<td>Previous cancer</td>
<td>3.6</td>
</tr>
<tr>
<td>Aspergilloma</td>
<td>*</td>
<td>*</td>
<td>Previous cancer</td>
<td>4.3</td>
</tr>
<tr>
<td>Benign</td>
<td>*</td>
<td>*</td>
<td>Previous cancer</td>
<td>3.5</td>
</tr>
<tr>
<td>Carcinoid</td>
<td>*</td>
<td>*</td>
<td>Previous cancer</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Fig. 9**
Fig. 10

Typical carcinoids

Example 1 (SUV 3.9):

Example 2 (SUV 2.9):

Example 3 (SUV 3.5):
Chondroid hamartoma (SUV 1.7)

Fig. 11
### SUV in benign cases

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>SUV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic abscess</td>
<td>6.7</td>
</tr>
<tr>
<td>Organising pneumonia</td>
<td>6.4</td>
</tr>
<tr>
<td>TB/granuloma (2)</td>
<td>5.2</td>
</tr>
<tr>
<td>Aspergilloma</td>
<td>3.6</td>
</tr>
<tr>
<td>Typical carcinoids (3)</td>
<td>3.4</td>
</tr>
<tr>
<td>Hamartoma</td>
<td>1.7</td>
</tr>
</tbody>
</table>

![Fig. 12](image-url)
Fig. 16
Fig. 15
Fig. 14
Fig. 13
Fig. 17

Granulomatous inflammation
(SUV 4.2)
Fig. 18
Conclusion

Summary of features distinguishing benign from malignant pulmonary lesions:

- Some features of a pulmonary mass can help differentiate it from a malignant lesion, such as:
  - Being very well-defined.
  - Internal fat.
  - 'Popcorn'/coarse calcification.
  - Absence of malignant features, including absence of evidence of metastatic spread to lymph nodes or distant organs.
  - A low SUV max in a lesion > 2 cm in size is helpful in conjunction with the above features.
- Other pulmonary masses will not have features that definitely allow a diagnosis of a benign lesion on imaging alone, and here histology becomes important.
- Several of the benign lesions included in our study had malignant features on CECT and 18-FDG PETCT, and particularly in the few patients with known or previous cancer, a diagnosis of malignancy had to be excluded first and foremost, which was only possible with histology from surgery.
- It is worthy of note that SUV max values are affected by the size of the lesion as well as how metabolically active a tumour it is, and SUV max is under assessed for lesions less than 2cm in size.
- There is overlap in the range of SUV max values for benign and malignant pulmonary lesions. We found that 75% of benign lesions had SUV max < 4.5, whereas 88% of the malignant lesions had SUV max >4.5.
- If we had used the internationally accepted cut-off of SUV max 2.5, above which a lesion is more likely to be malignant than benign, 100% of our malignant pulmonary lesions would be included, but also 92% of the benign lesions would be included, as only 1 lesion (the hamartoma) had SUV max <2.5 (1.7).

Conclusion:

- Imaging features of pulmonary masses on CECT in conjunction with 18-FDG PETCT help differentiate benign from malignant lesions in conjunction with SUV max and patient history.
- Particular diagnostic difficulty is encountered in patients with a known history of current or previous cancer, especially if there are malignant imaging features of the pulmonary lesion in question.
- Inflammatory lesions tend to have the highest SUV max of the benign pulmonary lesions, and appear the least well-defined, so will always present a diagnostic challenge.
Personal Information

Dr Julia James is a Radiology Registrar on the South West Peninsula Training Rotation in the UK.

Dr Sarah Higgins is a Radiology Consultant at Torbay Hospital, Devon, UK.

References