BÖLÜM 6

Toraks Nükleer Tıp Değerlendirmesi

İbrahim Fatih CERAN[1]
Savaş KARYAĞAR[2]

Giriş

Pozitron emisyon tomografisi (PET), pozitron(β^{+}) yayıcı radyoaktif maddeler tarafından oluşturulan anhilasyon(yok olma)fotonlarına dayalı, radyoaktivitenin üç boyutlu dağılımının hesaplandığı bir tomografi tekniğidir. Dokuların fonksiyonel ve metabolik aktivitesinin görüntü ve kantitatif parametreler kullanarak değerlendirilmesini sağlar. PET görüntülemede şu anda en çok kullanılan radyofarmasötik glikoz analoğu olan FDG (Florodeoksiglukoz)'dir (1).

Onkolojide F-18 FDG PET/BT kullanımının temelini ise malign hücrelerin normal hücrelerden farklılaşmasıyla metabolizmalarındaki meydana gelen değişim oluşturur. Malign hücrelerin biyokimyasal karakteristik özellikleri hücre yüzeylerindeki glukoz taşıyıcı proteinlerin (GLUT1, GLUT3 gibi) ve glikolizi yapan hücre için enzimlerin (fosfofruktokinaz ve heksokinaz) artması; buna karşılık glukoz-6-fosfataz aktivitesindeki azalmasına bağlı düşen defosforilasyon hızıdır (2-4). Malign hücrelerin yapısında meydana gelen bu değişiklikler, malign hücrelerde yüksek metabolik aktivite ve tümör dokusundaki yüksek vaskülarite nedeniyle FDG tutulumu çoğu malign hücrede yüksek olmaktadır (5).

SUV (Standart uptake değeri) bir lezyonun artmış FDG aktivitesine sahip olup olmadığını gösteren benign-malign dokuların ayrımını değerlendirmekte kullanılan kantitatif bir parametredir. SUV değerinin belirlenmesinde ilgi alanı (ROİ) içindeki FDG birikimi, hastanın ağırlığı ve hastaya verilen doz ile normalize edilir (6,7) (SUV = ROI'deki ortalama aktivite/enjekte edilen doz/vücut ağırlığı).

[1] Uzm. Dr., Sağlık Bilimleri Üniversitesi, Hamidiye Tıp Fakültesi, Yedikule Göğüs Hastalıkları ve Göğüs Cerrahisi Eğitim ve Araştırma Hastanesi, Nükleer Tıp Kliniği, ficerann@hotmail.com

[2] Doç. Dr., Sağlık Bilimleri Üniversitesi Tıp Fakültesi, İstanbul Prof. Dr. Cemil Taşçıoğlu Şehir Hastanesi, Nükleer Tıp Kliniği, skaryagar@yahoo.com

Malign Kardiyak Lezyonlar

Primer tümörlere göre daha yüksek prevalansları nedeniyle ilk önce metastatik hastalıklar ekarte edilmelidir. Hematojen ve lenfojen yolla en sık kardiyak metastaz yapan iki tümör melanom ve lenfomadır. Bu tümörlerin ardından lokorejyonel toraks maligniteleri (meme, akciğer, yemek borusu),renal hücreli kanserler ve hepatosellüler karsinomlar (vena kava yoluyla) metastaz yaparlar(134). Ekstrakardiyak 2.primer kanser ekarte edildiğinde primer kardiyak neoplazm düşünülmelidir. En sık görülen primer malign kardiyak tümörler başta anjiyosarkomlar ve rabdomyoksarkomlar olmak üzere sarkomlardır. Her ikisi de yoğun artmış FDG tutulumu gösteren invaziv kitleler olarak görülür. Genellikle perikardiyal effüzyon ile birliktedirler.

Posterior Mediasten (Paravertebral Alan)

Periferik Sinir Kılıfı Tümörleri

Nörojenik tümörler paravertebral tümörlerin çoğunluğunu oluşturur. Çoğunlukla maligniteye dönüşme ihtimali olan iyi huylu lezyonlardan (nörorofibromlar, periferik sinir kılıfı tümörleri) oluşurlar. Malign periferik sinir kılıfı tümörleri genellikle hastaları 2. veya 3. dekadda etkiler (138). Sporadik olarak ortaya çıkabilir veya tip 1 nörofibromatozis ile ilişkili olabilirler. Birkaç çalışma, malign periferik sinir kılıfı tümörlerinde 18F-FDG alımının genellikle yüksek olduğunu ve bu durumun iyi huylu ve kötü huylu lezyonları mükemmel bir duyarlılıkla ayırt etmeye izin verdiğini göstermiştir (ortalama SUVmax, maligndе 4.1-12.8, malign olmayanlarda 1.0-2.6 arasında değişmektedir) (139). Literatürde çeşitli SUV eşikleri tanımlanmıştır; genel olarak >2.4-6.1 arasında değişen SUVmax eşikleri için duyarlılık %89-100 ve özgüllük %60-%95'tir. (140).

Kaynaklar

1. Lowe VJ, Delong DM, Hoffman JM et al. Optimum scanning protocol for FDG-PET evaluation of pulmonary malignancy. J Nucl Med. 1995;36:883–7.
2. Delbeke D. Oncological applications of FDG PET imaging: Brain tumors, colorectal cancer, lymphoma and melanoma. *J Nucl Med* 1999; 40: 591-603
3. Avril N, Menzel M, Dose J et al. Glucose metabolism of breast cancer assessed by 18F-FDG PET Histologic and immunohistochemical tissue analysis. *J Nucl Med* 2001; 42: 9-16.
4. Ak I,Stokkel MP, Pauwels EK. Positron emission tomography with 2-18f fluoro-2-deoxy-D-glucose in oncology: Part II: The clinical value in detecting and staging primary tumours. *J Cancer Res Clin Oncol* 2000; 126: 560-574
5. Küçük Ö. Tiroid Kanseri Takibinde PET CT. *Endokrinolojide Diyalog* 2007; 4: 244-246.
6. Kelloff, G.J, Hoffman, J.M, Johnson, B. Progress and promise of FDG-PET imaging for cancer patient management and oncologic drug development, Clinical Cancer Research, 2005, 11, 2785–2808 3.
7. Weber, W.A, Wieder, H. Monitoring chemotherapy and radiotherapy of solid tumors, European Journal Nuclear Medicine Molecular Imaging, 2006, 33, 27–37
8. Boellaard R, O'Doherty MJ, Weber. FDG PET and PET/CT: EANM procedure guidelines for tumour PET imaging: version 1.0. Eur J Nucl Med Mol Imaging. 2010 Jan;37(1):181-200.
9. Austin JH, Müller NL, Friedman PJ, et al. Glossary of terms for CT of the lungs: recommendations of the Nomenclature Committee of the Fleischner Society. Radiology 1996;200:327-31.
10. Detterbeck FC, Mazzone PJ, Naidich DP, et al. Screening for lung cancer: diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2013;143 [e78S—92S].
11. Patel VK, Naik SK, Naidich DP, et al. A practical algorithmic approach to the diagnosis and management of solitary pulmonary nodules: part 1: radiologic characteristics and imaging modalities. Chest 2013;143:825—39.
12. Patel VK, Naik SK, Naidich DP, et al. A practical algorithmic approach to the diagnosis and management of solitary pulmonary nodules: part 2: pretest probability and algorithm. Chest 2013;143:840 — 6
13. Ito M, Miyata Y, Okada M. Management pathways for solitary pulmonary nodules. J Thorac Dis. 2018 Apr;10(Suppl 7):S860-S866.
14. Christensen JA, Nathan MA, Mullan BP, et al. Characterization of the solitary pulmonary nodule: 18F-FDG PET versus nodule-enhancement CT. AJR Am J Roentgenol 2006;187:1361—7.
15. Kim SK, Allen-Auerbach M, Goldin J, et al. Accuracy of PET/CT in characterization of solitary pulmonary lesions. J Nucl Med. 2007;48:214–20.

16. Deppen SA, Blume JD, Kensinger CD, et al. Accuracy of FDG-PET to diagnose lung cancer in areas with infectious lung disease: a meta-analysis. JAMA. 2014;312:1227–36
17. Bakheet SM, Saleem M, Powe J, et al. F-18 fluorodeoxyglucose chest uptake in lung inflammation and infection. Clin Nucl Med. 2000;25:273–8.
18. Erasmus JJ, McAdams HP, Patz EF Jr, et al. PC. Evaluation of primary pulmonary carcinoid tumors using FDG PET. AJR Am J Roentgenol. 1998;170:1369–73.
19. Iwano S, Ito S, Tsuchiya K, et al. What causes false-negative PET findings for solid-type lung cancer? Lung Cancer. 2013;79:132–6.
20. Orlacchio A, Schillaci O, Antonelli L, et al. Solitary pulmonary nodules: morphological and metabolic characterisation by FDG-PET-MDCT. Radiol Med 2007;112:157—73.
21. DeSantis CE, Lin CC, Mariotto AB, et al. Cancer treatment and survivorship statistics, 2014. CA Cancer J Clin. 2014;64:252–71.
22. Chong S, Lee KS, Kim B-T, et al. Integrated PET/CT of pulmonary neuroendocrine tumors: diagnostic and prognostic implications. AJR Am J Roentgenol 2007;188:1223—31.
23. Aquino SL, Halpern EF, Kuester LB, et al. FDG-PET and CT features of non-small cell lung cancer based on tumor type. Int J Mol Med 2007;19:495—9.
24. Erasmus JJ, Macapinlac HA. Low-sensitivity FDG-PET studies: less common lung neoplasms. Semin Nucl Med 2012;42:255—60.
25. Shim SS, Lee KS, Kim BT, et al. Nonsmall cell lung cancer: prospective comparison of integrated FDG PET/CT and CT alone for preoperative staging. Radiology. 2005;236:1011–9.
26. De Wever W, Ceyssens S, Mortelmans L, et al. Additional value of PET-CT in the staging of lung cancer: comparison with CT alone, PET alone and visual correlation of PET and CT. Eur Radiol. 2007;17:23–32.
27. Rodriguez E, Lilenbaum RC. Small cell lung cancer: past, present, and future. Curr Oncol Rep. 2010;12:327–34
28. Kligerman S, Digumarthy S. Staging of non-small cell lung cancer using integrated PET/CT. AJR Am J Roentgenol. 2009;193:1203–11.
29. Gross BH, Glazer GM, Orringer MB, et al. Bronchogenic carcinoma metastatic to normal-sized lymph nodes: frequency and significance. Radiology. 1988;166:71–4.
30. Gould MK, Kuschner WG, Rydzak CE, et al. Test performance of positron emission tomography and computed tomography for mediastinal staging in patients with non-small-cell lung cancer: a meta-analysis. Ann Intern Med. 2003;139:879–92.
31. Zhao L, He ZY, Zhong XN, et al.18FDG-PET/CT for detection of mediastinal nodal metastasis in non-small cell lung cancer: a meta-analysis. Surg Oncol. 2012;21:230–6.
32. Lv YL, Yuan DM, Wang K, et al. Diagnostic performance of integrated positron emission tomography/computed tomography for mediastinal lymph node staging in non-small cell lung cancer: abivariate systematic review and meta-analysis. JThorac Oncol. 2011;6:1350–8.
33. Li X, Zhang H, Xing L, et al. Mediastinal lymph nodes staging by 18F-FDG PET/CT for early stage non-small cell lung cancer: a multicenter study. Radiother Oncol. 2012;102:246–50.
34. Darling GE, Maziak DE, Inculet RI, et al. Positron emission tomography-computed tomography compared with invasive mediastinal staging in non-small cell lung cancer: results of mediastinal staging in the early lung positron emission tomography trial. J Thorac Oncol. 2011;6:1367–72.
35. Silvestri GA, Gonzalez AV, Jantz MA, et al. Methods for staging non-small cell lung cancer: diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2013;143:e211S–50S.
36. Sahiner I, Vural GU. Positron emission tomography/computerized tomography in lung cancer. Quant Imaging Med Surg. 2014;4:195–206
37. Quint LE. Staging non-small cell lung cancer. Cancer Imaging. 2007;7:148–59.
38. Li J, Xu W, Kong F, et al. Meta-analysis: accuracy of 18FDG PET-CT for distant metastasis staging in lung cancer patients. Surg Oncol. 2013;22:151–5.
39. Brady MJ, Thomas J, Wong TZ, et al. Paulson EK. Adrenal nodules at FDG PET/CT in patients known to have or suspected of having lung cancer: a proposal for an efficient diagnostic algorithm. Radiology. 2009;250:523–30.
40. Marom EM, McAdams HP, Erasmus JJ, et al. Staging non-small cell lung cancer with whole-body PET. Radiology. 1999;212:803–9.
41. Qu X, Huang X,Yan W, et al. A meta-analysis of 18FDG-PET-CT, 18FDG-PET, MRI and bone scintigraphy for diagnosis of bone metastases in patients with lung cancer. Eur J Radiol. 2012;81:1007–15.
42. Chang MC, Chen JH, Liang JA, et al. Meta-analysis: comparison of F-18 fluorodeoxyglucosepositron emission tomography and bone scintigraphy in the detection of bone metastasis in patients with lung cancer. Acad Radiol. 2012;19:349–57.
43. Erasmus JJ, McAdams HP, Rossi SE, et al. Patz EF. FDG PET of pleural effusions in patients with nonsmall cell lung cancer. AJR Am J Roentgenol. 2000;175:245–9.
44. Yi CA, Shin KM, Lee KS, et al. Non-small cell lung cancer staging: efficacy comparison of integrated PET/CT versus 3.0-T whole-body MR imaging. Radiology. 2008;248:632–42.
45. Hicks RJ, Kalff V, MacManus MP, et al. 18F-FDG PET provides high-impact and powerful prognostic stratification in staging newly diagnosed non-small cell lung cancer. J Nucl Med. 2001;42:1596–604.
46. Hoekstra CJ, Stroobants SG, Hoekstra OS, et al. The value of [18F]fluoro-2-deoxyd-glucose positron emission tomography in the selection of patients with stage IIIA-N2 non-small cell lung cancer for combined modality treatment. Lung Cancer. 2003;39:151–7.

47. Pommier P, Touboul E, Chabaud S, et al. Impact of 18F-FDG PET on treatment strategy and 3D radiotherapy planning in non-small cell lung cancer: a prospective multicenter study. AJR Am J Roentgenol. 2010;195:350–5.
48. Bradley J, Bae K, Choi N, et al. A phase II comparative study of gross tumor volume definition with or without PET/CT fusion in dosimetric planning for nonsmall cell lung cancer (NSCLC): primary analysis of Radiation Therapy Oncology Group (RTOG) 0515. Int J Radiat Oncol Biol Phys. 2012;82:435–41.
49. Bradley J, Thorstad WL, Mutic S, et al. Impact of FDG-PET on radiation therapy volume delineation in non-small-cell lung cancer. Int J Radiat Oncol Biol Phys. 2004;59:78–86.
50. Van Der Wel A, Nijsten S, Hochstenbag M, et al. Increased therapeutic ratio by 18FDG-PET CT planning in patients with clinical CT stage N2-N3M0 nonsmall-cell lung cancer: a modeling study. Int J Radiat Oncol Biol Phys. 2005;61:649–55.
51. Nestle U, Walter K, Schmidt S, et al. 18F-deoxyglucose positron emission tomography (FDGPET) for the planning of radiotherapy in lung cancer: high Jpn J Radiol 1 3 impact in patients with atelectasis. Int J Radiat Oncol Biol Phys. 1999;44:593–7.
52. Remonnay R, Morelle M, Pommier P, et al. Assessing short-term effects and costs at an early stage of innovation: the use of positron emission tomography on radiotherapy treatment decision making. Int J Technol Assess Health Care. 2008;24:212–20.
53. Hicks RJ. Role of 18F-FDG PET in assessment of response in non-small cell lung cancer. J Nucl Med. 2009;50:31S–42S.
54. Wahl RL, Jacene H, Kasamon Y, et al. From RECIST to PERCIST: evolving considerations for PET response criteria in solid tumors. J Nucl Med. 2009;50(Suppl 1):S122-50. https://doi.org/10.2967/jnumed.108.057307.
55. Ding Q, Cheng X, Yang L, et al. PET/CT evaluation of response to chemotherapy in non-small cell lung cancer: PET response criteria in solid tumors versus response evaluation criteria in solid tumors. J Thorac Dis. 2014;6:677–83.
56. Mac Manus MP, Hicks RJ, Matthews JP, et al. Positron emission tomography is superior to computed tomography scanning for responseassessment after radical radiotherapy or chemoradiotherapy in patients with non-small-cell lung cancer. J Clin Oncol. 2003;21:1285–92.
57. Eschmann SM, Friedel G, Paulsen F, et al. 18F-FDG PET for assessment of therapy response and preoperative re-evaluation after neoadjuvant radiochemotherapy in stage III non-small cell lung cancer. Eur J Nucl Med Mol Imaging. 2007;34:463–71.
58. Usmanij EA, de Geus-Oei LF, Troost EG, et al. 18F-FDG PET early response evaluation of locally advanced non-small cell lung cancer treated with concomitant chemoradiotherapy. J Nucl Med. 2013;54:1528–34.
59. Yossi S, Krhili S, Muratet JP, et al. Early assessment of metabolic response by 18F-FDG PET during concomitant radiochemotherapy of non-small cell lung carcinoma is associated with survival: a retrospective single-center study. Clin Nucl Med. 2015;40:e215–21.
60. Lee DH, Kim SK, Lee HY, et al. Early prediction of response to first-line therapy using integrated 18F-FDG PET/CT for patients with advanced/metastatic nonsmall cell lung cancer. J Thorac Oncol. 2009;7:816–21.
61. Koenig TR, Munden RF, Erasmus JJ, et al. Radiation injury of the lung after threedimensional conformal radiation therapy. AJR Am J Roentgenol. 2002;178:1383–8.
62. Larici AR, del Ciello A, Maggi F, et al. Lung abnormalities at multimodality imaging after radiation therapy for non-small cell lung cancer. Radiographics. 2011;31:771–89.
63. Hellwig D, Gröschel A, Graeter TP, et al. Diagnostic performance and prognostic impact of FDG-PET in suspected recurrence of surgically treated non-small cell lung cancer. Eur J Nucl Med Mol Imaging. 2006;33:13–21.
64. Kanzaki R, Higashiyama M, Maeda J, et al. Clinical value of F18-fluorodeoxyglucose positron emission tomography-computed tomography in patients with non-small cell lung cancer after potentially curative surgery: experience with 241 patients. Interact Cardiovasc Thorac Surg. 2010;10:1009–14.
65. He YQ, Gong HL, Deng YF, et al. Diagnostic efficacy of PET and PET/CT for recurrent lung cancer: a meta-analysis. Acta Radiol. 2014;55:309–17.
66. Yamamoto Y, Nishiyama Y, Ishikawa S, et al. Correlation of 18F-FLT and 18F-FDG uptake on PET with Ki-67 immunohistochemistry in non-small cell lung cancer. Eur J Nucl Med Mol Imaging. 2007;34:1610–6.
67. Sasaki R, Komaki R, Macapinlac H, et al. [18F] fluorodeoxyglucose uptake by positron emission tomography predicts outcome of non-small-cell lung cancer. J Clin Oncol. 2005;23:1136–43.
68. Downey RJ, Akhurst T, Gonen M, et al. Fluorine-18 fluorodeoxyglucose positron emission tomographic maximal standardized uptake value predicts survival independent of clinical but not pathologic TNM staging of resected non-small cell lung cancer.J Thorac Cardiovasc Surg. 2007;133:1419–27
69. Chen HH, Chiu NT, Su WC, et al. Prognostic value of whole-body total lesion glycolysis at pretreatment FDG PET/ CT in non-small cell lung cancer. Radiology. 2012;264:559–66.
70. Im HJ, Pak K, Cheon GJ, et al. Prognostic value of volumetric parameters of 18F-FDG PET in nonsmall-cell lung cancer: a meta-analysis. Eur J Nucl Med Mol Imaging. 2015;42:241–51.
71. Kamel EM, Zwahlen D, Wyss MT, et al. Whole-body 18F-FDG PET improves the management of patients with small cell lung cancer. J Nucl Med. 2003;44:1911–7.
72. Bradley JD, Dehdashti F, Mintun MA, et al. Positron emission tomography in limited-stage small-

cell lung cancer: a prospective study. J Clin Oncol. 2004;22:3248–54.
73. Brink I, Schumacher T, Mix M, et al. Impact of [18F] FDG-PET on the primary staging of small-cell lung cancer. Eur J Nucl Med Mol Imaging. 2004;31:1614–20.
74. Fischer BM, Mortensen J, Langer SW, et al. A prospective study of PET/CT in initial staging of small-cell lung cancer: comparison with CT, bone scintigraphy and bone marrow analysis. Ann Oncol. 2007;18:338–45.
75. Azad A, Chionh F, Scott AM, et al. High impact of 18F-FDG PET on management and prognostic stratification of newly diagnosed small cell lung cancer. Mol Imaging Biol. 2010;12:433–51.
76. Lee YJ, Cho A, Cho BC, et al. High tumor metabolic activity as measured by fluorodeoxyglucose positron emission tomography is associated with poor prognosis in limited and extensive stage small-cell lung cancer. Clin Cancer Res. 2009;15:2426–32.
77. Lanphear BP, Buncher CR. Latent period for malignant mesothelioma of occupational origin. J Occup Med. 1992;34:718–21.
78. Tsao AS, Wistuba I, Roth JA, et al. Malignant pleural mesothelioma. J Clin Oncol. 2009;27:2081–90.
79. Nakano T. Current therapies for malignant pleural mesothelioma. Environ Health Prev Med. 2008;13:75–83.
80. Scherpereel A, Astoul P, Baas P, et al. Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma. Eur Respir J. 2010;35:479–95.
81. Anderson, K., National Comprehensive Cancer Network. NCCN Clinical Practice Guidelines in Oncology™ 2015. Malignant pleural methothelioma v. 2. 2015. , 908-942.
82. Sugarbaker DJ, Garcia JP, Richards WG, et al. Extrapleural pneumonectomy in the multimodality therapy of malignant pleural mesothelioma. Results in 120 consecutive patients. Ann Surg. 1996;224:288–94 (discussion 294–6).
83. Truong MT, Viswanathan C, Godoy MB, et al. Malignant pleural mesothelioma: role of CT, MRI, and PET/CT in staging evaluation and treatment considerations. Semin Roentgenol. 2013;48:323–34.
84. Curran D, Sahmoud T, Therasse P, et al. Prognostic factors in patients with pleural mesothelioma: the European Organization for Research and Treatment of Cancer experience. J Clin Oncol. 1998;16:145–52.
85. Attanoos RL, Gibbs AR. Pathology of malignant mesothelioma. Histopathology. 1997;30:403–18.
86. Truong MT, Viswanathan C, Godoy MB,at al. Malignant pleural mesothelioma: role of CT, MRI, and PET/CT in staging evaluation and treatment considerations. Semin Roentgenol. 2013;48:323–34.
87. Pass HI, Kranda K, Temeck BK, et al. Surgically debulked malignant pleural mesothelioma: results and prognostic factors. Ann Surg Oncol. 1997;4:215–22.
88. Kitajima K, Doi H, Kuribayashi K. Present and future roles of FDG-PET/CT imaging in the management of malignant pleural mesothelioma. Jpn J Radiol. 2016 Aug;34(8):537-47.
89. Roca E, Laroumagne S, Vandemoortele T, et al. 18F-fluoro-2-deoxy-d-glucose positron emission tomography/computed tomography fused imaging in malignant mesothelioma patients: looking from outside is not enough. Lung Cancer. 2013;79:187–90.
90. Nguyen NC, Tran I, Hueser CN, et al. F-18 FDG PET/CT characterization of talc pleurodesis induced pleural changes over time: a retrospective study. Clin Nucl Med. 2009;34:886–90
91. Erasmus JJ, Truong MT, Smythe WR, et al. Integrated computed tomography–positron emission tomography in patients with potentially resectable malignant pleural mesothelioma: staging implications. J Thorac Cardiovasc Surg. 2005;129:1364–70.
92. Wilcox BE, Subramaniam RM, Peller PJ, et al. Utility of integrated computed tomography-positron emission tomography for selection of operable malignant pleural mesothelioma. Clin Lung Cancer. 2009;10:244–8.
93. Ambrosini V, Rubello D, Nanni C,et al. Additional value of hybrid PET/CT fusion imaging vs. conventional CT scan alone in the staging and management of patients with malignant pleural mesothelioma. Nucl Med Rev Cent East Eur. 2005;8:111–5.
94. Tan C, Barrington S, Rankin S, et al. Role of integrated 18-fluorodeoxyglucose position emission tomography-computed tomography in patients' surveillance after multimodality therapy of malignant pleural mesothelioma. J Thorac Oncol. 2010;5:385–8.
95. Niccoli-Asabella A, Notaristefano A, Rubini D, et al. 18F-FDG PET/CT in suspected recurrences of epithelial malignant pleural mesothelioma in asbestos-fibersexposed patients (comparison to standard diagnostic follow-up). Clin Imaging. 2013;37:1098–103.
96. Gerbaudo VH, Mamede M, Trotman-Dickenson B, et al. FDG PET/CT patterns of treatment failure of malignant pleural mesothelioma: relationship to histologic type, treatment algorithm, and survival. Eur J Nucl Med Mol Imaging. 2011;38:810–21.
97. Bénard F, Sterman D, Smith RJ, et al. Prognostic value of FDG PET imaging in malignant pleural mesothelioma. J Nucl Med. 1999;40:1241–5.
98. Flores RM, Akhurst T, Gonen M, et al. Positron emission tomography predicts survival in malignant pleural mesothelioma. J Thorac Cardiovasc Surg. 2006;132:763–8.
99. Kaira K, Serizawa M, Koh Y, Takahashi T, Hanaoka H, Oriuchi N, et al. Relationship between 18F-FDG uptake on positron emission tomography and molecular biology in malignant pleural mesothelioma. Eur J Cancer. 2012;48:1244–54.
100. Kadota K, Kachala SS, Nitadori J, Suzuki K, Dunphy MP, Sima CS, et al. High SUVmax on FDG-PET indicates pleomorphic subtype in epithelioid malignant pleural mesothelioma: supportive evidence to reclassify pleomorphic as nonepithelioid histology. J Thorac Oncol. 2012;7:1192–7.
101. Bille A, Chicklore S, Okiror L, et al. Patterns of disease progression on 18F-fluorodeoxyglucose positron

emission tomography-computed tomography in patients with malignant pleural mesothelioma undergoing multimodality therapy with pleurectomy/decortication. Nucl Med Commun. 2013;34:1075–83.
102. Klabatsa A, Chicklore S, Barrington SF, et al. The association of 18F-FDG PET/CT parameters with survival in malignant pleural mesothelioma. Eur J Nucl Med Mol Imaging. 2014;41:276–82.
103. Lopci E, Zucali PA, Ceresoli GL, et al. Quantitative analyses at baseline and interim PET evaluation for response assessment and outcome definition in patients with malignant pleural mesothelioma. Eur J Nucl Med Mol Imaging. 2015;42:667–75.
104. Ozmen O, Koyuncu A, Koksal D, et al. The potential value of volume-based quantitative PET parameters and increased bone marrow uptake for the prediction of survival in patients with malignant pleural mesothelioma. Nucl Med Commun. 2016;37:43–9.
105. Shields TW. The mediastinum, its compartments, and the mediastinal lymph nodes. In: Shields TW, Lo Cicero III J, Ponn RB, Rusch VW (ed). General Thoracic Surgery. Sixth edition. Philadelphia: Lippincott Williams and Wilkins, 2005: 2
106. Carter BW, Benveniste MF, Madan R, et al. ITMIG Classification of Mediastinal Compartments and Multidisciplinary Approach to Mediastinal Masses. Radio Graphics 2017; 37: 413-36.
107. Rankin S: [(18)F]2-fluoro-2-deoxy-D-glucose PET/CT in mediastinal masses. Cancer Imaging 10:S156-S160, 2010
108. Jerushalmi J, Frenkel A, Bar-Shalom R, et al. Physiologic thymic uptake of 18F-FDG in children and young adults: A PET/CT evaluation of incidence, patterns, and relationship to treatment. J Nucl Med 50:849-853, 2009
109. Benveniste MF, Rosado-de-Christenson ML, Sabloff BS, et al. Role of imaging in the diagnosis, staging, and treatment of thymoma. Radiographics 31:1847-1861, 2011
110. Marx A, Streobel P, Badve SS, et al. ITMIG consensus statement on the use of the WHO histological classification of thymoma and thymic carcinoma: refined definitions, histological criteria, and reporting. J Thorac Oncol 9:596-611, 2014
111. Sadohara J, Fujimoto K, Muller NL, et al. Thymic epithelial tumors: Comparison of CT and MR imaging findings of low-risk thymomas, high-risk thymomas, and thymic carcinomas. Eur J Radiol 60:70-79, 2006
112. Treglia G, Sadeghi R, Giovanella L, et al. Is (18)F-FDG PET useful in predicting the WHO grade of malignancy in thymic epithelial tumors? A meta-analysis. Lung Cancer 86:5-13, 2014
113. Park SY, Cho A, Bae MK, et al. Value of 18F-FDG PET/CT for predicting the World Health Organization malignant grade of thymic epithelial tumors: Focused in volume-dependent parameters. Clin Nucl Med 41:15-20, 2016
114. Eguchi T, Yoshida K, Hamanaka K, et al. Utility of 18F-fluorodeoxyglucose positron emission tomography for distinguishing between the histological types of early stage thymic epithelial tumours. Eur J Cardiothorac Surg 41:1059-1062, 2012
115. Martelli M, Di Rocco A, Russo E, et al: Primary mediastinal lymphoma: Diagnosis and treatment options. Expert Rev Hematol 8:173-186, 2015
116. Tomiyama N, Honda O, Tsubamoto M, et al. Anterior mediastinal tumors: Diagnostic accuracy of CT and MRI. Eur J Radiol 69:280-288, 2009
117. Heron CW, Husband JE, Williams MP: Hodgkin disease: CT of the thymus. Radiology 167:647-651, 1988
118. Barrington SF, Mikhaeel NG, Kostakoglu L, et al. Role of imaging in the staging and response assessment of lymphoma: Consensus of the International Conference on Malignant Lymphomas Imaging Working Group. J Clin Oncol 32:3048-3058, 2014
119. Moran CA, Suster S: Primary germ cell tumors of the mediastinum. Analysis of 322 cases with special emphasis on teratomatous lesions and a proposal for histopathologic classification and clinical staging. Cancer 80:681-690, 1997
120. Strollo DC, Rosado-de-Christenson ML: Primary mediastinal malignant germ cell neoplasms: Imaging features. Chest Surg Clin N Am 12:645- 658, 2002
121. Kubota K, Yamada S, Kondo T, et al. PET imaging of primary mediastinal tumours. Br J Cancer 73:882-886, 1996
122. Terui K, Kohno H, Komatsu S, et al. Mediastinal teratoma with metastatic lymph node: Misleading normal thymic uptake of F-18 FDG. Clin Nucl Med 36:950-951, 2011
123. Kaira K, Abe M, Nakagawa K, et al. 18F-FDG uptake on PET in primary mediastinal non-thymic neoplasm: A clinicopathological study. Eur J Radiol 81:2423-2429, 2012
124. Koizumi T, Katou A, Ikegawa K, et al. Comparative analysis of PET findings and clinical outcome in patients with primary mediastinal seminoma. Thorac Cancer 4:241-248, 2013
125. Macchiarini P: Primary tracheal tumours. Lancet Oncol 7:83-91, 2006
126. Wilson RW, Kirejczyk W. Pathological and radiological correlation of endobronchial neoplasms: Part I, Benign tumors. Ann Diagn Pathol 1:31-46, 1997
127. Khalaf M, Abdel-Nabi H, Baker J, et al. Relation between nodule size and 18F-FDG-PET SUV for malignant and benign pulmonary nodules. J Hematol Oncol 1:13, 2008
128. Elnayal A, Moran CA, Fox PS, et al. Primary salivary gland-type lung cancer: Imaging and clinical predictors of outcome. AJR Am J Roentgenol 201:W57-W63, 2013
129. Kayani I, Conry BG, Groves AM, et al. A comparison of 68Ga-DOTATATE and 18F-FDG PET/CT in pulmonary neuroendocrine tumors. J Nucl Med 50:1927-1932, 2009
130. Ajani JA, D'Amico TA, Almhanna K, et al. Esophageal and esophagogastric junction cancers, version 1.2015. J Natl Compr Canc Netw 13:194- 227, 2015

131. Stagg J, Farukhi I, Lazaga F, et al. Significance of 18F-Fluorodeoxyglucose uptake at the gastroesophageal junction: Comparison of PET to esophagogastroduodenoscopy. Dig Dis Sci 60:1335-1342, 2015
132. Roedl JB, Colen RR, King K, et al. Visual PET/CT scoring for nonspecific 18F-FDG uptake in the differentiation of early malignant and benign esophageal lesions. AJR Am J Roentgenol 191:515-521, 2008
133. Brincker H: Sarcoid reactions in malignant tumours. Cancer Treat Rev 13:147-156, 1986
134. Maleszewski JJ, Anavekar NS, Moynihan TJ, et al. Pathology, imaging, and treatment of cardiac tumours. Nat Rev Cardiol 14:536-549, 2017
135. Harisankar CN, Mittal BR, Agrawal KL, et al. Utility of high fat and low carbohydrate diet in suppressing myocardial FDG uptake. J Nucl Cardiol 18:926-936, 2011
136. Agostini D, Babatasi G, Galateau F, et al. Detection of cardiac myxoma by F-18 FDG PET. Clin Nucl Med 24:159-160, 1999
137. Laura DM, Donnino R, Kim EE, et al. Lipomatous atrial septal hypertrophy: A review of its anatomy, pathophysiology, multimodality imaging, and relevance to percutaneous interventions. J Am Soc Echocardiogr 29:717-723, 2016
138. Valeyrie-Allanore L, Ismaili N, Bastuji-Garin S, et al. Symptoms associated with malignancy of peripheral nerve sheath tumours: A retrospective study of 69 patients with neurofibromatosis 1. Br J Dermatol 153:79-82, 2005
139. Tovmassian D, Abdul Razak M, London K. The role of [18F]FDG-PET/ CT in predicting malignant transformation of plexiform neurofibromas in neurofibromatosis. Int J Surg Oncol 2016. 6162182.
140. Salamon J, Mautner VF, Adam G, et al: Multimodal imaging in neurofibromatosis type 1-associated nerve sheath tumors. Rofo 187:1084- 1092, 2015