

**Radiologic Management of Thoracic Nodules and Masses**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Siegel R, Ma J, Zou Z, Jemal A. Cancer statistics, 2014. <i>CA Cancer J Clin.</i> 2014;64(1):9-29.	Review/Other-Tx	N/A	To provide the expected numbers of new cancer cases and deaths in 2013 nationally and by state, as well as an overview of current cancer statistics using data through 2009, including incidence, mortality, and survival rates and trends. The article also estimate the total number of deaths averted as a result of the decline in cancer death rates since the early 1990s, and provide the actual reported numbers of deaths in 2009 by age for the 10 leading causes of death and the 5 leading cancer types.	In 2009, Americans had a 20% lower risk of death from cancer than in 1991, when cancer death rates peaked. Despite this substantial progress, all demographic groups have not benefitted equally, particularly for cancers such as colorectal and breast, for which mortality declines have been attributed to earlier detection and improvements in treatment. Further progress can be accelerated by applying existing cancer control knowledge across all segments of the population, with an emphasis on those groups in the lowest socioeconomic bracket as well as other disadvantaged populations.	4
2. Howlader N, Noone AM, Krapcho M, et al. SEER Cancer Statistics Review, 1975-2011, National Cancer Institute. Bethesda, MD, <a href="http://seer.cancer.gov/csr/1975_2011/">http://seer.cancer.gov/csr/1975_2011/</a> , based on November 2013 SEER data submission, posted to the SEER web site, April 2014. Accessed September 30, 2015.	Review/Other-Tx	N/A	To present the incidence, mortality, prevalence, and survival statistics of cancer from 1975 through the most recent year for which data are available.	N/A	4
3. Suzuki M, Iwata T, Ando S, et al. Predictors of long-term survival with pulmonary metastasectomy for osteosarcomas and soft tissue sarcomas. <i>J Cardiovasc Surg (Torino).</i> 2006;47(5):603-608.	Observational-Tx	105 cases	To evaluate the efficacy of aggressive pulmonary metastasectomy for patients.	The number of metastases was only the significant risk factor for the curability of the metastasectomy (logistic regression analysis, $P=0.0274$ ). The 5-year and 10-year survival rate were 43.6% and 32%. The curability was only independent prognostic factor on multivariate analysis ( $P=0.0008$ ).	2

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4. Fischer B, Lassen U, Mortensen J, et al. Preoperative staging of lung cancer with combined PET-CT. <i>N Engl J Med.</i> 2009;361(1):32-39.	Experimental-Dx	189 total patients; 98 to PET/CT group and 91 to conventional-staging group	Randomized study to evaluate the clinical effect of combined PET/CT on preoperative staging of NSCLC.	After PET/CT 38 patients were classified as having inoperable NSCLC, and after conventional staging 18 patients were classified thus. 60 patients in the PET/CT group and 73 in the conventional-staging group underwent thoracotomy ( $P=0.004$ ). Among these thoracotomies, 21 in the PET/CT group and 38 in the conventional-staging group were futile ( $P=0.05$ ). Use of PET/CT for preoperative staging of NSCLC reduced both the total number of thoracotomies and the number of futile thoracotomies but did not affect overall mortality.	1
5. Aberle DR, DeMello S, Berg CD, et al. Results of the two incidence screenings in the National Lung Screening Trial. <i>N Engl J Med.</i> 2013;369(10):920-931.	Experimental-Dx	53,454 participants	To determine whether 3 annual screenings (rounds T0, T1, and T2) with low-dose helical CT, as compared with chest radiography, could reduce mortality from lung cancer.	At the T1 and T2 rounds, positive screening results were observed in 27.9% and 16.8% of participants in the low-dose CT group and in 6.2% and 5.0% of participants in the radiography group, respectively. In the low-dose CT group, the sensitivity was 94.4%, the specificity was 72.6%, the PPV was 2.4%, and the NPV was 99.9% at T1; at T2, the PPV increased to 5.2%. In the radiography group, the sensitivity was 59.6%, the specificity was 94.1%, the PPV was 4.4%, and the NPV was 99.8% at T1; both the sensitivity and the PPV increased at T2. Among lung cancers of known stage, 87 (47.5%) were stage IA and 57 (31.1%) were stage III or IV in the low-dose CT group at T1; in the radiography group, 31 (23.5%) were stage IA and 78 (59.1%) were stage III or IV at T1. These differences in stage distribution between groups persisted at T2.	1

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6. McWilliams A, Tammemagi MC, Mayo JR, et al. Probability of cancer in pulmonary nodules detected on first screening CT. <i>N Engl J Med.</i> 2013;369(10):910-919.	Observational-Dx	1,871 persons in PanCan data set; 1,090 persons in BCCA data set	To conduct a population-based prospective study to determine factors predicting the probability that lung nodules detected on the first screening low-dose CT scans are malignant or will be found to be malignant on follow-up.	In the PanCan data set, 1,871 persons had 7,008 nodules, of which 102 were malignant, and in the BCCA data set, 1,090 persons had 5,021 nodules, of which 42 were malignant. Among persons with nodules, the rates of cancer in the 2 data sets were 5.5% and 3.7%, respectively. Predictors of cancer in the model included older age, female sex, and family history of lung cancer, emphysema, and larger nodule size, location of the nodule in the upper lobe, part-solid nodule type, lower nodule count, and spiculation. Our final parsimonious and full models showed excellent discrimination and calibration, with areas under the receiver-operating-characteristic curve of more than 0.90, even for nodules that were 10 mm or smaller in the validation set.	3
7. Lopes Pegna A, Picozzi G, Falaschi F, et al. Four-year results of low-dose CT screening and nodule management in the ITALUNG trial. <i>J Thorac Oncol.</i> 2013;8(7):866-875.	Observational-Dx	3,200 patients	To report subjects' compliance and results of low-dose CT screening and management protocol in the active arm of the ITALUNG trial.	1,406 subjects (87%) underwent baseline low-dose CT and 1,263 (79%) completed 4 screening rounds. Low-dose CT was positive in 30.3% of the subjects at baseline and 15.8% subsequently. 21 lung tumors in 20 subjects (1.5% detection) were found at baseline, and 20 lung tumors in 18 subjects (0.5% detection) in subsequent screening rounds. 10/18 prevalent (55%) and 13/17 incident (76%) non-small-cell cancers were in stage I. Interval growth enabled diagnosis of lung cancer in 16 subjects (42%), but at least 1 follow-up low-dose CT was obtained in 741 subjects (52.7%) over the screening period. FDG-PET obtained in 6.5% of subjects had 84% sensitivity and 90% specificity for malignant lesions. FNAB obtained in 2.4% of subjects showed 90% sensitivity and 88% specificity. Positivity of both FDG-PET and FNAB invariably predicted malignancy. Surgery for benign lesions was performed on 4 subjects (10% of procedures) but followed protocol violations on 3 subjects.	3

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8. MacMahon H, Austin JH, Gamsu G, et al. Guidelines for management of small pulmonary nodules detected on CT scans: a statement from the Fleischner Society. <i>Radiology</i> . 2005;237(2):395-400.	Review/Other-Dx	N/A	To review guidelines for follow-up of small pulmonary nodules.	Nodules $\leq 4$ mm should be followed in 1 year. The current practice in the United States of recommending follow-up studies for all indeterminate opacities is partly related to perceived liability if a cancer should develop. When the medical community has preached the importance of early detection of cancer for so long, it may prove difficult to convince physicians and the public that follow-up CT of every nodule in every patient is unnecessary.	4
9. Adiga S, Athreya S. Safety, efficacy, and feasibility of an ultra-low dose radiation protocol for CT-guided percutaneous needle biopsy of pulmonary lesions: initial experience. <i>Clin Radiol</i> . 2014;69(7):709-714.	Observational-Dx	72 patients	To prospectively determine efficacy and complication rates following an ultra-low dose protocol for CT-guided percutaneous needle biopsy of lung lesions.	The overall technical success rate using the ultra-low dose protocol was 95.8%. There was a statistically significant 57.5% reduction in radiation dose in the ultra-low dose group. There was no significant difference in average length of procedure between the 2 groups. Complication rates between the 2 groups were comparable, with 42% in the standard-dose group and 32% in the ultra-low dose group; no major complications occurred. Within the ultra-low dose group, smaller sized lesions were found to be correlated with higher complication rates, but lesion size had no effect on the total dose of radiation received.	3
10. Cardella JF, Bakal CW, Bertino RE, et al. Quality improvement guidelines for image-guided percutaneous biopsy in adults. <i>J Vasc Interv Radiol</i> . 2003;14(9 Pt 2):S227-230.	Review/Other-Dx	N/A	Guidelines on quality improvement for image-guided percutaneous biopsy in adults.	Guidelines are purposed for quality improvement program that monitors percutaneous biopsy procedures. The most important processes of care in this area are: (a) patient selection, (b) performing the procedure, and (c) monitoring the patient. The outcome measures or indicators for these processes are indications, success rates, and complication rate.	4
11. Godoy MC, Naidich DP. Subsolid pulmonary nodules and the spectrum of peripheral adenocarcinomas of the lung: recommended interim guidelines for assessment and management. <i>Radiology</i> . 2009;253(3):606-622.	Review/Other-Dx	N/A	Review clinical, radiologic, and pathologic aspects of subsolid pulmonary nodules, with the intention to propose new interim management guidelines.	It is anticipated that future developments based on multidisciplinary efforts will result in greater consensus regarding optimal CT classification of subsolid lesions and ultimately more definitive, evidence-based guidelines leading to more rigorous standardization and ultimately improved clinical treatment of patients with subsolid lung nodules.	4

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12. Kim HY, Shim YM, Lee KS, Han J, Yi CA, Kim YK. Persistent pulmonary nodular ground-glass opacity at thin-section CT: histopathologic comparisons. <i>Radiology</i> . 2007;245(1):267-275.	Observational-Dx	53 nodules in 49 patients	To retrospectively compare pure pulmonary GGO nodules observed on thin-section CT images with histopathologic findings.	About 75% of persistent pulmonary GGO nodules are attributed to bronchoalveolar cell carcinoma or adenocarcinoma with predominant bronchoalveolar cell carcinoma component, and at thin-section CT, these nodules do not manifest morphologic features that distinguish them from other GGO nodules with different histopathologic diagnoses.	2
13. Lee HJ, Goo JM, Lee CH, Yoo CG, Kim YT, Im JG. Nodular ground-glass opacities on thin-section CT: size change during follow-up and pathological results. <i>Korean J Radiol</i> . 2007;8(1):22-31.	Review/Other-Dx	96 nodular GGOs in 55 individuals	Retrospective study to evaluate the inter-group differences in growth and the pathological results of nodular GGOs according to their size and focal solid portions.	Mixed nodular GGOs had the potential for growth; most were pathologically adenocarcinoma or bronchoalveolar cell carcinoma. By contrast, pure nodular GGO were stable for several months to years; most were atypical adenomatous hyperplasia, bronchoalveolar cell carcinoma, or focal interstitial fibrosis.	4
14. Fan L, Liu SY, Li QC, Yu H, Xiao XS. Multidetector CT features of pulmonary focal ground-glass opacity: differences between benign and malignant. <i>Br J Radiol</i> . 2012;85(1015):897-904.	Observational-Dx	84 patients	To evaluate different features between benign and malignant pulmonary focal GGO on multidetector CT.	There were 21 benign and 61 malignant lesions. No statistical differences were found between benign and malignant focal GGOs in terms of demographic data, size, location, and attenuation value. The frequency of lobulation ( $P=0.000$ ), spiculation ( $P=0.008$ ), spine-like process ( $P=0.004$ ), well-defined but coarse interface ( $P=0.000$ ), bronchus cut-off ( $P=0.003$ ), other air-containing space ( $P=0.000$ ), pleural indentation ( $P=0.000$ ) and vascular convergence ( $P=0.006$ ) was significantly higher in malignant focal GGOs than that in benign focal GGOs. Binary logistic regression analysis showed that lobulation, interface and pleural indentation were important indicators for malignant diagnosis of focal GGO, with the corresponding odds ratios of 8.122, 3.139 and 9.076, respectively. In addition, a well-defined but coarse interface was the most important indicator of malignancy among all interface types. With all 3 important indicators considered, the diagnostic sensitivity, specificity and accuracy were 93.4%, 66.7% and 86.6%, respectively.	3

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15. Lim HJ, Ahn S, Lee KS, et al. Persistent pure ground-glass opacity lung nodules $\geq$ 10 mm in diameter at CT scan: histopathologic comparisons and prognostic implications. <i>Chest</i> . 2013;144(4):1291-1299.	Review/Other-Dx	46 resected GGNs	To compare the morphologic features of persistent pure GGNs of $\geq$ 10 mm in diameter at thin-section CT scan with histopathology and patient prognosis.	The nodules included 19 adenocarcinoma in situ (41%), 9 minimally invasive adenocarcinomas (20%), and 18 invasive adenocarcinomas (39%). On univariate analysis, the presence of air bronchogram ( $P=.012$ ), size of nodule ( $P=.032$ , cutoff = 16.4 mm in diameter), and mass of nodule ( $P=.040$ , cutoff = 0.472 g) were significant factors that differentiated invasive adenocarcinoma from adenocarcinoma in situ or minimally invasive adenocarcinoma. On multivariate analysis, size ( $P=.010$ ) and mass of nodule ( $P=.016$ ) were significant determinants for invasive adenocarcinoma. There were no cases of recurrence during a follow-up period of $\geq$ 3 years after surgical resection.	4
16. Silva M, Sverzellati N, Manna C, et al. Long-term surveillance of ground-glass nodules: evidence from the MILD trial. <i>J Thorac Oncol</i> . 2012;7(10):1541-1546.	Review/Other-Dx	56 consecutive MILD participants	To evaluate the natural evolution of GGNs in the Multicentric Italian Lung Detection (MILD) trial, which adopted a nonsurgical approach to this subset of lesions.	A total of 15/48 pure GGNs (31.3%) resolved, 4/48 (8.3%) decreased in size, 21/48 (43.8%) remained stable, and 8/48 (16.7%) progressed. Among the part-solid GGNs with a solid component $<$ 5 mm, 3/26 (11.5%) resolved, 11/26 (42.3%) remained stable, and 12/26 (46.2%) progressed. 1 of the 2 part-solid GGNs with a solid component $>$ 5 mm remained stable, and the other decreased in size. 4 lung cancers were detected among the GGN subjects, but only 1 arose from a part-solid GGN, and was resected in stage Ia.	4
17. Jeong YJ, Yi CA, Lee KS. Solitary pulmonary nodules: detection, characterization, and guidance for further diagnostic workup and treatment. <i>AJR Am J Roentgenol</i> . 2007;188(1):57-68.	Review/Other-Dx	N/A	Study to improve understanding of clinical issues involved in making a diagnosis and to guide further diagnostic workup and treatment of solitary pulmonary nodules.	PET/CT is more sensitive at detecting malignancy than dynamic helical CT.	4

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18. Tsutani Y, Miyata Y, Nakayama H, et al. Prognostic significance of using solid versus whole tumor size on high-resolution computed tomography for predicting pathologic malignant grade of tumors in clinical stage IA lung adenocarcinoma: a multicenter study. <i>J Thorac Cardiovasc Surg.</i> 2012;143(3):607-612.	Observational-Dx	502 patients	To compare the usefulness of the solid tumor size with that of the whole tumor size on preoperative high-resolution CT for predicting pathologic high-grade malignancy (positive lymphatic, vascular, or pleural invasion) and the prognosis of clinical stage IA lung adenocarcinoma.	The mean whole and solid tumor size was 1.97 +/- 0.59 cm and 1.20 +/- 0.88 cm, respectively. The receiver operating characteristics area under the curve for the whole and solid tumor sizes used to identify high-grade malignancy were 0.590 and 0.829, respectively. Multiple logistic regression analyses demonstrated solid tumor size ( $P < .001$ ) and $SUV_{max}$ of the tumor ( $P < .001$ ) as independent variables for the prediction of high-grade malignancy. Multivariate Cox analysis of disease-free survival demonstrated the former (hazard ratio, 2.30; 95% CI, 1.46–3.63; $P < .001$ ) and latter (hazard ratio, 1.08; 95% CI, 1.00–1.17; $P = .05$ ) as independent prognostic factors.	3
19. Maataoui A, Vogl TJ, Jacobi V, Khan MF. Diagnostic accuracy of CT readings on coin lesions in the lung as compared with transthoracic CT-guided needle biopsy results. <i>Pneumologie.</i> 2012;66(7):432-436.	Observational-Dx	129 patients	To compare chest CT film reading results with histopathological results after CT-guided TTNB of the lung. In addition, lung lesion morphology was evaluated and compared with the nature of the lesions.	In 129 patients, adequate specimens were obtained. Comparison of CT diagnosis with the histopathological results yielded the following results for chest CT: sensitivity 95%, specificity 43%, PPV 83%, and NPV 75%. Lesions with spiculated margins turned out to be associated with a significantly higher number of malignant lesions than lesions with smooth or blurred margins ( $P < 0.05$ ). Lesions size, lesion shape as well as the presence of necrosis showed no significant relation to nature of the lesions ( $P > 0.05$ ).	3
20. Chandan VS, Zimmerman K, Baker P, Scalzetti E, Khurana KK. Usefulness of core roll preparations in immediate assessment of neoplastic lung lesions: comparison to conventional CT scan-guided lung fine-needle aspiration cytology. <i>Chest.</i> 2004;126(3):739-743.	Observational-Dx	25 cases of neoplastic pulmonary lesions	To compare core roll preparations with aspirate smears and determine whether core roll preparations led to alteration of the histopathology of the core biopsy.	The core roll preparations complement the CT scan-guided lung FNA procedure in the immediate assessment of neoplastic lung lesions without altering the histopathology of core biopsy specimens.	2
21. Mayerhoefer ME, Prosch H, Herold CJ, Weber M, Karanikas G. Assessment of pulmonary melanoma metastases with 18F-FDG PET/CT: which PET-negative patients require additional tests for definitive staging? <i>Eur Radiol.</i> 2012;22(11):2451-2457.	Observational-Dx	183 melanoma patients	To determine, in patients with melanoma, the dependence of PET sensitivity on pulmonary metastasis size, and to determine patients who require further evaluation for definite staging.	A total of 181 pulmonary metastases were analyzed. PET sensitivity was 7.9% for lesions of 4–5 mm; 33.3% for lesions of 6–7 mm; 56.8% for lesions of 8–9 mm; 63.6% for lesions of 10–11 mm; 100% for lesions of 12–14 mm; and 100% for lesions of at least 15 mm. The differences in sensitivity between the size groups were significant ( $P < 0.001$ ).	3

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22. Kim TJ, Park CM, Goo JM, Lee KW. Is there a role for FDG PET in the management of lung cancer manifesting predominantly as ground-glass opacity? <i>AJR Am J Roentgenol.</i> 2012;198(1):83-88.	Observational-Dx	89 patients with 134 ground-glass opacity nodules	To evaluate FDG-PET findings of ground-glass opacity nodules and to determine the value of FDG-PET for the preoperative staging of lung cancer manifesting predominantly as ground-glass opacity.	SUVmax was positively correlated with lesion size (mean, 14.5 mm; range, 5-37 mm) ( $r=0.6705$ ; $P<0.0001$ ) and was negatively correlated with ground-glass opacity percentage (mean, 77%; range, 50%-100%) ( $r=-0.7465$ ; $P<0.0001$ ). Solitary nodules showed higher hypermetabolism rates (73% [41/56]) than did multiple nodules (27% [21/78]) ( $P=0.0001$ ), but SUVmax was not significantly different between solitary and multiple nodules. There was no true-positive interpretation of nodal or distant metastasis from ground-glass opacity nodules by FDG-PET.	3
23. Chang CY, Tzao C, Lee SC, et al. Incremental value of integrated FDG-PET/CT in evaluating indeterminate solitary pulmonary nodule for malignancy. <i>Mol Imaging Biol.</i> 2010;12(2):204-209.	Observational-Dx	117 patients	To evaluate the increased diagnostic benefit of integrated PET/CT interpretation in evaluating solitary pulmonary nodules for malignancy.	PET alone correctly classified 85% of nodules and integrated PET/CT interpretation increased the correct classification to 89%, with similar sensitivity and specificity of 88% and 89%, respectively. False-positive PET results mainly resulted from granulomatous disorders. 4 (50%) of the 7 cases deemed indeterminate on PET alone were resolved with combined PET/CT interpretation.	2
24. Harders SW, Madsen HH, Hjorthaug K, et al. Characterization of pulmonary lesions in patients with suspected lung cancer: computed tomography versus [(1)(8)F] fluorodeoxyglucose-positron emission tomography/computed tomography. <i>Cancer Imaging.</i> 2012;12:437-446.	Observational-Dx	168 patients	To examine the clinical feasibility of CT vs integrated FDG-PET/low-dose CT scan in patients with suspected lung cancer and pulmonary lesions on CT.	When used early in the workup of the lesions, CT raised the prevalence of lung cancer in the population to the point where further diagnostic imaging examination could be considered futile. We also found that the overall diagnostic accuracy, as well as the classification probabilities and predictive values of the 2 modalities were not significantly different; the reproducibility of these results was substantial.	2



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25. Sim YT, Goh YG, Dempsey MF, Han S, Poon FW. PET-CT evaluation of solitary pulmonary nodules: correlation with maximum standardized uptake value and pathology. <i>Lung</i> . 2013;191(6):625-632.	Observational-Dx	186 patients	To perform a retrospective review of PET/CT scans for solitary pulmonary nodules characterization between April 2008 and June 2011.	A total of 641 PET/CTs were performed for solitary pulmonary nodules characterization and staging; 186 patients (77 males, 109 females) with pathological confirmation were included, and 158 (85%) nodules were malignant: adenocarcinomas (n = 66), squamous cell carcinomas (n = 40), and metastases (n = 20) were the commonest. 28 lesions (15%) were benign, including granuloma/chronic inflammation (n = 8), infection (n = 7), and hamartomas (n = 5). Using cutoff SUV <sub>max</sub> of 2.5, the accuracy of PET/CT in diagnosing malignant solitary pulmonary nodules is 81.2%, with sensitivity 86.7%, specificity 50%, PPV 90.7%, and NPV 40%. The likelihood of malignancy increases with SUV <sub>max</sub> . Nevertheless, even with SUV <sub>max</sub> <2.5, there is a 62% chance that a nodule is malignant.	3
26. Takeda A, Kunieda E, Fujii H, et al. Evaluation for local failure by 18F-FDG PET/CT in comparison with CT findings after stereotactic body radiotherapy (SBRT) for localized non-small-cell lung cancer. <i>Lung Cancer</i> . 2013;79(3):248-253.	Observational-Dx	257 patients	To assess FDG-PET/CT to detect local recurrence after stereotactic body radiotherapy for NSCLC.	A total of 214 FDG-PET/CT scans were obtained for 164 localized NSCLC tumors in 154 patients. The median follow-up period was 24.9 months (range: 6.3–72.1). Among these, 21 scans of 17 tumors were diagnosed as local recurrence. The median SUV <sub>max</sub> on early and late images of recurrence and their resistive index were 5.0 (range: 3.2–10.7), 6.3 (range: 4.2–13.4), and 0.20 (range; 0–0.41), respectively. These were significantly higher than the respective values of nonrecurrence images of 1.8 (range: 0.5–4.6), 1.7 (range: 0.5–6.1), and 0.00 (range: -0.37–0.41) (all <i>P</i> <0.05). For SUV <sub>max</sub> s on early and late images, optimal thresholds were identified as 3.2 and 4.2. Using each threshold, the sensitivity and specificity were 100% and 96%–98%, respectively. CT findings were classified into GGO (N=9), scar or fibrotic change (n=96), consolidation with air-bronchogram (n=34), consolidation only (n=22), and nodule (n=17); the respective numbers of recurrence were 0, 0, 1, 3, and 17.	3

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27. Chen CM, Chang JW, Cheung YC, et al. Computed tomography-guided core-needle biopsy specimens demonstrate epidermal growth factor receptor mutations in patients with non-small-cell lung cancer. <i>Acta Radiol.</i> 2008;49(9):991-994.	Review/Other-Dx	17 patients	To evaluate the use of CT-guided CNB specimens for the assessment of epidermal growth factor receptor gene mutation in NSCLC.	There were 12 (70.6%) epidermal growth factor receptor gene mutants and 5 (29.4%) nonmutants. The objective response rate to gefitinib therapy was 73.3% (11/15 patients), with 91.7% (11/12 mutants) for the mutant group and 0% for the nonmutant group. CT-guided CNB of advanced NSCLC enables the acquisition of sufficient tissue for epidermal growth factor receptor gene mutation analysis.	4
28. Avritscher R, Krishnamurthy S, Ensor J, et al. Accuracy and sensitivity of computed tomography-guided percutaneous needle biopsy of pulmonary hilar lymph nodes. <i>Cancer.</i> 2010;116(8):1974-1980.	Observational-Dx	80 patients	To retrospectively evaluate the sensitivity and accuracy of CT-guided percutaneous needle biopsy in patients with hilar adenopathy.	Percutaneous needle biopsy included FNAB and CNB in 81 (100%) and 14 (17%) procedures, respectively. Data on 69 percutaneous needle biopsy specimens (67 FNAB specimens and 13 CNB specimens) were available for statistical analysis. Overall, percutaneous needle biopsy had a sensitivity of 91.4% (95% CI, 81.0%–97.1%) and an accuracy rate of 92.8% (95% CI, 83.9%–97.1%). Pneumothorax occurred in 39 patients (48%), 26 (32%) of whom required thoracostomy tube insertion.	3
29. Solomon SB, Zakowski MF, Pao W, et al. Core needle lung biopsy specimens: adequacy for EGFR and KRAS mutational analysis. <i>AJR Am J Roentgenol.</i> 2010;194(1):266-269.	Review/Other-Dx	18 patients	To prospectively compare the adequacy of CNB specimens with the adequacy of specimens from resected tissue, the histologic reference standard, for mutational analysis of malignant tumors of the lung.	2 specimens were unsatisfactory for mutational analysis. The results of mutational assay results of the other 16 specimens were the same as those of analysis of the surgical specimens obtained an average of 31 days after biopsy.	4
30. Diacon AH, Schuurmans MM, Theron J, et al. Transbronchial needle aspirates: comparison of two preparation methods. <i>Chest.</i> 2005;127(6):2015-2018.	Observational-Dx	86 patients; 282 pairs of samples	Prospective comparison of 2 preparation methods for transbronchial needle aspirates.	The direct technique is superior to the fluid technique for the preparation of transbronchial needle aspirates.	2

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31. Kucuk CU, Yilmaz A, Akkaya E. Computed tomography-guided transthoracic fine-needle aspiration in diagnosis of lung cancer: a comparison of single-pass needle and multiple-pass coaxial needle systems and the value of immediate cytological assessment. <i>Respirology</i> . 2004;9(3):392-396.	Observational-Dx	143 consecutive patients	To compare single-pass needle and multiple-pass coaxial needle systems and to evaluate the value of immediate cytological assessment during the procedure in the diagnosis of lung cancer with CT-guided transthoracic FNA.	The mean number of FNAs was 1.25 in group A, 1.39 in group B and 1.34 in group C (group A vs group B, $P=0.08$ ). The diagnostic accuracy was 83.3%, 97.9% and 100.0%, respectively (group A vs group B, $P=0.03$ ; group B vs group C, $P>0.05$ ). Although immediate cytological assessment resulted in adequate samples being obtained from all patients in groups B and C, adequate samples were obtained in 41/48 patients (85.4%) in group A ( $P=0.004$ ). There was no statistically significant difference among the groups with respect to the rate of pneumothorax.	3
32. Mazza E, Maddau C, Ricciardi A, Falchini M, Matucci M, Ciarpallini T. On-site evaluation of percutaneous CT-guided fine needle aspiration of pulmonary lesions. A study of 321 cases. <i>Radiol Med</i> . 2005;110(3):141-148.	Observational-Dx	312 patients	To determine the importance of having a cytopathologist present during percutaneous CT-guided FNA of pulmonary lesions.	CT guided aspiration cytology can be a safe and fast procedure for lung nodule characterization.	3
33. Yamagami T, Iida S, Kato T, Tanaka O, Nishimura T. Combining fine-needle aspiration and core biopsy under CT fluoroscopy guidance: a better way to treat patients with lung nodules? <i>AJR Am J Roentgenol</i> . 2003;180(3):811-815.	Observational-Dx	138 samples	To evaluate the value of the combined use of FNA and tissue core biopsy under real-time CT fluoroscopy guidance.	Combined use of FNA and core biopsy improves the diagnostic ability of CT fluoroscopy-guided lung biopsy.	3
34. Ko JP, Shepard JO, Drucker EA, et al. Factors influencing pneumothorax rate at lung biopsy: are dwell time and angle of pleural puncture contributing factors? <i>Radiology</i> . 2001;218(2):491-496.	Observational-Dx	159 patients; 160 coaxial CT-guided lung biopsies	To study factors (needle dwell time and plural puncture) influencing pneumothorax and chest tube placement rate.	Longer dwell times do not correlate with pneumothorax and should not influence the decision to obtain more biopsy samples. A shallow pleural puncture angle may increase the pneumothorax rate.	3

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35. Nakamura M, Yoshizako T, Koyama S, Kitagaki H. Risk factors influencing chest tube placement among patients with pneumothorax because of CT-guided needle biopsy of the lung. <i>J Med Imaging Radiat Oncol.</i> 2011;55(5):474-478.	Review/Other-Tx	150 patients	To evaluate the risk factors for developing a pneumothorax requiring chest tube placement in patients undergoing CT-guided needle biopsy of the lung.	Pneumothorax occurred in 93/156 procedures (59.6%), and chest tube placement was required in 12 cases (7.7% of all biopsies, 12.9% of all pneumothoraces). Among patients with a pneumothorax, the proportion of cases biopsied in the supine position was significantly greater in the chest tube placement group (58.3%; 7/12) than in the nonchest tube placement group (28.4%; 23/81) ( $P=0.026$ ). Patient age, presence of emphysema, lesion size, needle path length, location of pulmonary lesions, number of pleural punctures and the smallest angle between the pleura and the needle showed no significant differences between the 2 groups.	4
36. Geraghty PR, Kee ST, McFarlane G, Razavi MK, Sze DY, Dake MD. CT-guided transthoracic needle aspiration biopsy of pulmonary nodules: needle size and pneumothorax rate. <i>Radiology.</i> 2003;229(2):475-481.	Observational-Dx	846 consecutive CT-guided TTNB procedures	To retrospectively evaluate the effect of needle size of pneumothorax rate and the diagnostic accuracy of CT-guided needle aspiration biopsy.	Pneumothorax occurred in 226/846 patients. Coaxial needle size and patient age had a significant effect on pneumothorax rate. Pneumothorax occurred in 124 (38%) of 324 patients who underwent procedures with 18-gauge needles and in 121 (23%) of 522 patients who underwent procedures with 19-gauge needles ( $P<.001$ ). The overall diagnostic accuracy was 96% for procedures performed with 18-gauge needles and 92% for procedures performed with 19-gauge needles, with a sensitivity of 95% and 89% and a specificity of 100% and 99%, respectively. Pneumothorax occurred in 153 patients older than 60 years, in 99 patients 60 years and younger ( $P<.02$ ), in 90 patients older than 70 years, and in 162 patients younger than 70 years ( $P<.01$ ). The relationship between pneumothorax rate and age as a continuous distribution was not significant ( $P<.07$ ), nor were the 50- or 75-year age cutoffs ( $P<.06$ and $P<.9$ , respectively). Use of a smaller coaxial stabilizing needle produces a substantially decreased risk of pneumothorax with comparable diagnostic accuracy, sensitivity, and specificity for histopathologic diagnosis of pulmonary nodules.	3

\* See Last Page for Key

**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
37. Kothary N, Bartos JA, Hwang GL, Dua R, Kuo WT, Hofmann LV. Computed tomography-guided percutaneous needle biopsy of indeterminate pulmonary pathology: efficacy of obtaining a diagnostic sample in immunocompetent and immunocompromised patients. <i>Clin Lung Cancer</i> . 2010;11(4):251-256.	Observational-Dx	262 patients	To evaluate the efficacy of CT-guided percutaneous lung biopsy of pulmonary nodules with indeterminate radiologic characteristics in patients at risk for malignant and nonmalignant processes such as infection or inflammation.	Of the entire cohort, 166 patients (63.4%) had a nonmalignant process, and 96 patients (36.6%) had a malignancy. CT-guided percutaneous lung biopsy established a diagnosis in 166 patients (63.4%). Of the 166 patients with a nonmalignant etiology and 96 patients with malignancy, it provided a definitive diagnosis in 91 patients (54.8%) and 75 patients (78.1%), respectively, a difference that was statistically significant ( $P=.0001$ ). Overall diagnostic efficacy between immunocompetent and immunocompromised patients was comparable ( $P=.2$ ); however, detection of infection or inflammation in individual groups was lower compared with detection of malignancy ( $P=.002$ and $P=.06$ , respectively). CT-guided percutaneous lung biopsy in patients who are clinically at risk for both nonmalignant and malignant processes continues to be a challenge. Although CT-guided percutaneous biopsy can establish an accurate diagnosis in a large majority of patients with malignancy, it is significantly less sensitive for infectious or inflammatory processes.	3

**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
38. Aviram G, Greif J, Man A, et al. Diagnosis of intrathoracic lesions: are sequential fine-needle aspiration (FNA) and core needle biopsy (CNB) combined better than either investigation alone? <i>Clin Radiol.</i> 2007;62(3):221-226.	Observational-Dx	582 patients	To assess the diagnostic accuracy of sequential CT-guided percutaneous FNA and CNB in comparison with FNA and CNB performed separately for diagnosing intrathoracic lesions.	Adequate samples were obtained in 541 (93%) of FNAs and 513 (88%) of CNBs. Of 582 lesions, 419 (72%) were malignant and 163 (28%) were benign. For malignant lesions, the sensitivity, specificity and accuracy of the procedures were: 376/419 (89.7%), 136/163 (83.4%), and 88% for FNA; 317/419 (75.6%), 138/163 (84.7%), and 78% for CNB; 400/419 (95.5%), 154/163 (94.5%), and 95% for FNA+CNB. The sequential procedures showed significantly better sensitivity, specificity and accuracy compared with either FNA or CNB separately ( $P<0.003$ ). For the 163 benign lesions, 76 (47%) had a specific benign pathological diagnosis. The diagnosis was obtained in 16/76 (21%) by FNA, in 54/76 (71%) by CNB, and in 60/76 (79%) by FNA+CNB. There was no significant difference between the results of the sequential procedures and CNB alone ( $P>0.05$ ).	3
39. Doxtader EE, Mukhopadhyay S, Katzenstein AL. Core needle biopsy in benign lung lesions: pathologic findings in 159 cases. <i>Hum Pathol.</i> 2010;41(11):1530-1535.	Review/Other-Dx	155 patients; 159 CNBs	Review pathologic findings in CNBs showing benign changes in order to determine the types of processes that can be diagnosed by this technique and the factors that influence accuracy and specificity.	Specific diagnoses were established in 122 (77%) of 159 CNBs, while 24 (15%) were nonspecific and 13 (8%) were nonrepresentative. The most common specific diagnoses were necrotizing granulomatous inflammation (45), scar (28), organizing pneumonia (13), and benign neoplasms (11). A mixture of interstitial fibrosis and chronic inflammation (16) was the most common nonspecific diagnosis. A specific diagnosis was significantly more likely in biopsies with 3 or more cores or with a core length of more than 1 cm. Malignancy was diagnosed on a subsequent biopsy in only 1 case, and the initial biopsy in that case showed nonspecific chronic inflammation and fibrosis. Findings confirm that CNB is an accurate method of diagnosing benign lung lesions, yielding specific diagnoses in the majority.	4

**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
40. Kahn N, Meister M, Eberhardt R, et al. Early detection of lung cancer by molecular markers in endobronchial epithelial-lining fluid. <i>J Thorac Oncol.</i> 2012;7(6):1001-1008.	Review/Other-Dx	142 epithelial-lining fluid samples from 51 NSCLC patients and 20 benign cases	To investigate whether biomarker analysis in endobronchial epithelial-lining fluid collected by bronchoscopic microsampling may be useful for a definitive preoperative diagnosis.	All patients underwent bronchoscopic microsampling without complications. Gene-expression analyses by microarrays and quantitative real-time polymerases chain reaction could be reliably applied to epithelial-lining fluid samples, and resulted in potential biomarkers for malignant pulmonary nodules. Four genes (tenascin-C, [C-X-C motif] ligand 14, S100 calcium binding protein A9, and keratin 17) were found to be upregulated in epithelial-lining fluid of NSCLC patients with adenocarcinoma or squamous cell carcinoma. Combined analysis of tenascin-C expression and the nodule size improved the prediction of malignancy in this patient cohort.	4
41. Fielding DI, Chia C, Nguyen P, et al. Prospective randomised trial of endobronchial ultrasound-guide sheath versus computed tomography-guided percutaneous core biopsies for peripheral lung lesions. <i>Intern Med J.</i> 2012;42(8):894-900.	Experimental-Dx	57 patients	To determine diagnostic rate, complications and patient tolerability of EBUS-guide sheath and CT-guided percutaneous core biopsy for peripheral lung lesions.	Of 64 participants (mean lesion size 29 +/- 16 mm), 57 completed the study. Diagnostic sensitivity was 67% for EBUS-guide sheath and 78% for CT-guided biopsy ( <i>P</i> =not significant). In those with negative results, in the EBUS group, 9 had a CT-guided biopsy as a cross-over, 7 of which were positive. In the CT group, 4 had cross-over EBUS-guide sheath of which 3 were diagnostic. Sensitivity for malignancy was 17/23 for EBUS-guide sheath (74%) and 23/26 (88%, <i>P</i> =not significant). For lesions <2 cm, CT-guided biopsy had a significantly better diagnostic yield (80% vs 50%, <i>P</i> =0.05). In EBUS-guide sheath cases, for lesions with an air bronchogram, sensitivity was 89%. Pneumothorax and intercostal catheter insertion occurred in 3 and 2 cases, respectively, for EBUS, and 10 and 3 cases for CT-guided biopsy ( <i>P</i> =0.02 for pneumothorax). 9 unexpected admissions occurred after CT-guided biopsy compared with 3 after EBUS-guide sheath. Overall, tolerability was high for both groups; however 3 patients had moderate-to-severe pain after CT-guided biopsy.	1

**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
42. Covey AM, Gandhi R, Brody LA, Getrajdman G, Thaler HT, Brown KT. Factors associated with pneumothorax and pneumothorax requiring treatment after percutaneous lung biopsy in 443 consecutive patients. <i>J Vasc Interv Radiol.</i> 2004;15(5):479-483.	Observational-Dx	443 consecutive patients	Prospective study to describe patient- and procedure-related factors associated with post-biopsy pneumothorax and those that require intervention.	Prior surgery and prone positioning during biopsy seem to provide a “protective effect” against clinically significant post-biopsy pneumothorax.	3
43. Hiraki T, Mimura H, Gobara H, et al. Incidence of and risk factors for pneumothorax and chest tube placement after CT fluoroscopy-guided percutaneous lung biopsy: retrospective analysis of the procedures conducted over a 9-year period. <i>AJR Am J Roentgenol.</i> 2010;194(3):809-814.	Review/Other-Dx	1,033 patients	To retrospectively evaluate the incidence of and the risk factors for pneumothorax and chest tube placement after CT fluoroscopy-guided lung biopsy.	The overall incidence of pneumothorax was 42.3% (464/1,098). Chest tube placement was required for 11.9% (55/464) of pneumothoraces (5.0% [55/1,098] of the total number of procedures). The significant independent risk factors for pneumothorax were no prior pulmonary surgery ( $P=0.001$ ), lesions in the lower lobe ( $P<0.001$ ), greater lesion depth ( $P<0.001$ ), and a needle trajectory angle of $<45$ degrees ( $P=0.014$ ); those for chest tube placement for pneumothorax were pulmonary emphysema ( $P<0.001$ ) and greater lesion depth ( $P<0.001$ ).	4
44. Yaffe D, Shitrit D, Gottfried M, Bartal G, Sosna J. Ipsilateral opposite-side aspiration in resistant pneumothorax after CT image guided lung biopsy: complementary role after simple needle aspiration. <i>Chest.</i> 2013;144(3):947-951.	Observational-Dx	127 patients	To evaluate the efficacy of ipsilateral opposite-side aspiration, a new method to overcome resistant pneumothorax after failure of a simple aspiration. The patient position is reversed (from prone to supine or vice versa) and the aspiration repeated.	Among 129 CT image-guided biopsies, pneumothorax was detected by CT scan in 54 (42%); 51 (39%) were detected during the biopsy. Delayed pneumothorax occurred in 2 patients (1.55%). Manual aspiration to treat pneumothorax was performed in 27/129 procedures (21%). Simple aspiration was successful in 20/27 cases (74%). Ipsilateral opposite-side aspiration was accomplished in the remaining 7 cases (26%) and was successful in 6 cases (86%). 2/129 procedures (1.55%) required chest tube placement.	4



**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Malone LJ, Stanfill RM, Wang H, Fahey KM, Bertino RE. Effect of intraparenchymal blood patch on rates of pneumothorax and pneumothorax requiring chest tube placement after percutaneous lung biopsy. <i>AJR Am J Roentgenol.</i> 2013;200(6):1238-1243.	Experimental-Dx	242 patients	To determine whether an autologous intraparenchymal blood patch reduces the rate of pneumothorax and the rate of pneumothorax requiring chest tube placement after percutaneous lung biopsy.	The rate of pneumothorax was reduced from 35% to 26% ( $P=0.12$ ) with the use of the blood patch, but the reduction was not significant. The rate of pneumothorax requiring chest tube placement was significantly reduced from 18% to 9% ( $P=0.048$ ). There was a greater benefit in the blood patch group when a 19-gauge guiding needle was used: Pneumothorax requiring chest tube placement was reduced from 19% to 3% whereas an increase from 16% to 20% was seen with a 17-gauge needle ( $P=0.029$ ).	1
46. Wagner JM, Hinshaw JL, Lubner MG, et al. CT-guided lung biopsies: pleural blood patching reduces the rate of chest tube placement for postbiopsy pneumothorax. <i>AJR Am J Roentgenol.</i> 2011;197(4):783-788.	Observational-Dx	463 patients	To determine whether pleural blood patching reduces the need for chest tube placement and hospital admission for pneumothorax complicating CT-guided percutaneous lung biopsy.	Intervention for pneumothorax was necessary in 45/463 patients (9.7%) and 19/463 patients (4.1%) required chest tube placement. Pleural blood patching as a method to treat a postbiopsy pneumothorax and avoid further intervention was associated with a significantly higher success rate than simple aspiration: 19/22 (86.4%) vs 7/15 (46.7%) (odds ratio = 7.2, $P=0.03$ ), respectively.	4
47. Tran AA, Brown SB, Rosenberg J, Hovsepian DM. Tract embolization with gelatin sponge slurry for prevention of pneumothorax after percutaneous computed tomography-guided lung biopsy. <i>Cardiovasc Intervent Radiol.</i> 2014;37(6):1546-1553.	Observational-Dx	145 patients	To determine the effect of embolization with absorbable gelatin sponge slurry on the incidence of pneumothorax and need for chest tube placement after percutaneous lung biopsy.	Although tract embolization did not significantly decrease the chances of developing pneumothorax ( $P=0.06$ ), it did decrease the likelihood of progressing to requiring chest tube insertion. Without tract embolization, 10.7% of cases required a chest tube, whereas only 6.9% of the patients whose tract was embolized needed a chest tube ( $P=0.01$ ). A history of emphysema was associated with 151% increased odds of pneumothorax requiring chest tube placement after lung biopsy ( $P=0.009$ ). Tract length >24 mm was associated with a 262% increase in the odds of requiring chest tube placement ( $P=0.003$ ).	4
48. Petsas T, Siambli D, Giannakenas C, et al. Fibrin glue for sealing the needle track in fine-needle percutaneous lung biopsy using a coaxial system: Part II--Clinical study. <i>Cardiovasc Intervent Radiol.</i> 1995;18(6):378-382.	Observational-Dx	26 group A; 32 group B	Comparative study to determine the effectiveness of fibrin glue as a sealant.	Fibrin glue is a safe sealing material for percutaneous lung biopsy and serves to decrease the frequency.	3

**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
49. Billich C, Muche R, Brenner G, et al. CT-guided lung biopsy: incidence of pneumothorax after instillation of NaCl into the biopsy track. <i>Eur Radiol.</i> 2008;18(6):1146-1152.	Review/Other-Dx	140 patients	To evaluate whether instillation of NaCl 0.9% solution into the biopsy track reduces the incidence of pneumothoraces after CT-guided lung biopsy.	All patients were alternately assigned to 1 of 2 groups: group A in whom the puncture access was sealed by instillation of NaCl 0.9% solution during extraction of the guide needle (n = 70) or group B for whom no sealing was performed (n = 70). CT-guided biopsy was performed with a 18-G coaxial system. Localization of lesion (pleural, peripheral, central), lesion size, needle-pleural angle, rate of pneumothorax and alveolar hemorrhage were evaluated. In group A, the incidence of pneumothorax was lower compared to group B (8%, 6/70 patients vs 34%, 24/70 patients; $P < 0.001$ ). All pneumothoraces occurred directly post puncture after extraction of the guide needle. 1 patient in group A and 8 patients in group B developed large pneumothoraces requiring chest tube placement ( $P = 0.01$ ). The frequency of pneumothorax was independent of other variables. After CT-guided biopsy, instillation of NaCl 0.9% solution into the puncture access during extraction of the needle significantly reduces the incidence of pneumothorax.	4
50. Matsuguma H, Nakahara R, Kondo T, Kamiyama Y, Mori K, Yokoi K. Risk of pleural recurrence after needle biopsy in patients with resected early stage lung cancer. <i>Ann Thorac Surg.</i> 2005;80(6):2026-2031.	Review/Other-Dx	335 patients	Retrospective study to elucidate the real risk of pleural recurrence after needle biopsy in patients with resected early stage lung cancer.	Preoperative diagnoses were obtained for 290 patients; 220 were diagnosed by bronchoscopy and 66 by percutaneous needle biopsy. Pleural recurrence or needle track implantation was observed for 8.6% of the patients who underwent a needle biopsy, whereas it was 0.9% for patients who were examined using other diagnostic modalities ( $P = 0.0009$ ). Needle biopsy especially using a cutting-type biopsy needle can cause a pleural recurrence in addition to needle track implantation.	4

**Radiologic Management of Thoracic Nodules and Masses  
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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
51. Sano Y, Date H, Toyooka S, et al. Percutaneous computed tomography-guided lung biopsy and pleural dissemination: an assessment by intraoperative pleural lavage cytology. <i>Cancer</i> . 2009;115(23):5526-5533.	Observational-Dx	491 patients	To assess role of percutaneous CT-guided lung biopsy in pleural dissemination.	No significant association was observed between percutaneous CT-guided lung biopsy and intraoperative pleural lavage cytology results, even in patients with stage IA disease. Percutaneous CT-guided lung biopsy with a coaxial needle does not seem to cause pleural dissemination.	3
52. Zwischenberger JB, Savage C, Alpard SK, Anderson CM, Marroquin S, Goodacre BW. Mediastinal transthoracic needle and core lymph node biopsy: should it replace mediastinoscopy? <i>Chest</i> . 2002;121(4):1165-1170.	Review/Other-Dx	89 patients	Retrospective study to assess mediastinal lymph nodes for staging lung cancer by transthoracic needle with or without core biopsy.	Transthoracic FNA with or without core biopsy is diagnostic in 78% of cases with mediastinal adenopathy.	4
53. Lin ZY, Li YG. Artificial pneumothorax with position adjustment for computed tomography-guided percutaneous core biopsy of mediastinum lesions. <i>Ann Thorac Surg</i> . 2009;87(3):920-924.	Review/Other-Dx	11 patients	To assess the use of artificial pneumothorax with position adjustment to gain a pleural space approach in CT-guided core biopsy of mediastinal masses.	Artificial pneumothorax with position adjustment is a safe and effective method that provides access for CT-guided biopsy of mediastinal lesions without the risks of traversing aerated lung tissue and with a relatively low volume of injected air.	4
54. Lu Y, Fritz J, Li C, et al. Magnetic resonance imaging-guided percutaneous biopsy of mediastinal masses: diagnostic performance and safety. <i>Invest Radiol</i> . 2013;48(6):452-457.	Observational-Dx	59 participants	To evaluate the diagnostic performance and safety of magnetic resonance imaging-guided percutaneous mediastinal biopsy procedures using a 0.23-T open magnetic resonance system with optical tracking navigation.	Technical success was achieved in 57/59 procedures (96.6%). For the FNA, a mean of 3 passes (range, 2–4 passes) was performed. For the CNB, a mean of 4 passes (range, 3–6 passes) was performed. Pathological and cytological analysis of biopsy specimens showed 41/57 malignant lesions (71.9%) and 16/57 benign lesions (28.1%), with a sensitivity, specificity, PPV, NPV, and accuracy of 93.2% (41/44), 100% (13/13), 100% (41/41), 81.2% (13/16), and 94.7% (54/57), respectively. Procedure time was 30 minutes (range, 20–50 minutes). Mild hemoptysis occurred in 3 cases, and in 2 cases, a small pneumothorax occurred.	3
55. Shah PL, Singh S, Bower M, Livni N, Padley S, Nicholson AG. The role of transbronchial fine needle aspiration in an integrated care pathway for the assessment of patients with suspected lung cancer. <i>J Thorac Oncol</i> . 2006;1(4):324-327.	Observational-Dx	129 patients	Prospective study to evaluate the value of TBNA for the assessment of patients with suspected lung cancer.	TBNA improves the diagnostic yield and staging of patients with lung cancer.	3

**Radiologic Management of Thoracic Nodules and Masses**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
56. Annema JT, Versteegh MI, Veselic M, Voigt P, Rabe KF. Endoscopic ultrasound-guided fine-needle aspiration in the diagnosis and staging of lung cancer and its impact on surgical staging. <i>J Clin Oncol.</i> 2005;23(33):8357-8361.	Observational-Dx	242 consecutive patients with suspected (n=142) or proven (n=100) lung cancer	To assess the extent EUS-FNA could prevent surgical interventions.	Sensitivity, specificity, and accuracy for EUS in mediastinal analysis were 91%, 100% and 93%, respectively. EUS-FNA qualifies as the initial staging procedure.	3
57. Cerfolio RJ, Bryant AS, Eloubeidi MA. Routine mediastinoscopy and esophageal ultrasound fine-needle aspiration in patients with non-small cell lung cancer who are clinically N2 negative: a prospective study. <i>Chest.</i> 2006;130(6):1791-1795.	Observational-Dx	153 total patients (136 clinically staged N0 and 17 clinically staged N1)	A prospective study to determine the necessity of routine mediastinoscopy and/or EUS-FNA in patients with NSCLC who are clinically N2 negative.	Routine mediastinoscopy or EUS-FNA is not recommended in patients who are clinically staged as N0 but may be considered in patients clinically staged as N1 and/or in those with adenocarcinoma, upper-lobe tumors, or tumors with a $SUV_{max} \geq 10$ .	3
58. Herth FJ, Ernst A, Eberhardt R, Vilman P, Dienemann H, Krasnik M. Endobronchial ultrasound-guided transbronchial needle aspiration of lymph nodes in the radiologically normal mediastinum. <i>Eur Respir J.</i> 2006;28(5):910-914.	Observational-Dx	100 patients	To determine the accuracy of EBUS-TBNA in sampling nodes $\leq 1$ cm in diameter.	EBUS-TBNA can accurately sample small mediastinal nodes.	3
59. Singh P, Camazine B, Jadhav Y, et al. Endoscopic ultrasound as a first test for diagnosis and staging of lung cancer: a prospective study. <i>Am J Respir Crit Care Med.</i> 2007;175(4):345-354.	Observational-Dx	113 patients	Prospective study to evaluate EUS-FNA as a single test for diagnosing and staging of lung cancer.	EUS-FNA has a high diagnostic yield and accuracy for detecting lung cancer.	3
60. Herth FJ, Becker HD, Ernst A. Ultrasound-guided transbronchial needle aspiration: an experience in 242 patients. <i>Chest.</i> 2003;123(2):604-607.	Observational-Dx	242 patients	Prospective study to examine the possibility of EBUS in providing imaging support for TBNA.	EBUS affords an excellent yield independent of lymph node location.	3

**Radiologic Management of Thoracic Nodules and Masses**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
61. Navani N, Lawrence DR, Kolvekar S, et al. Endobronchial ultrasound-guided transbronchial needle aspiration prevents mediastinoscopies in the diagnosis of isolated mediastinal lymphadenopathy: a prospective trial. <i>Am J Respir Crit Care Med.</i> 2012;186(3):255-260.	Experimental-Dx	77 patients	To determine the efficacy and health care costs of EBUS-TBNA as an alternative initial investigation to mediastinoscopy in patients with isolated isolated mediastinal lymphadenopathy.	EBUS-TBNA prevented 87% of mediastinoscopies (95% CI, 77%–94%; $P<0.001$ ) but failed to provide a diagnosis in 10 patients (13%), all of whom underwent mediastinoscopy. The sensitivity and NPV of EBUS-TBNA in patients with isolated mediastinal lymphadenopathy were 92% (95% CI, 83%–95%) and 40% (95% CI, 12%–74%), respectively. 1 patient developed a lower respiratory tract infection after EBUS-TBNA, requiring inpatient admission. The cost of the EBUS-TBNA procedure per patient was pound 1,382 (\$2,190). The mean cost of the EBUS-TBNA strategy was pound 1,892 (\$2,998) per patient, whereas a strategy of mediastinoscopy alone was significantly more costly at pound 3,228 (\$5,115) per patient ( $P<0.001$ ). The EBUS-TBNA strategy is less costly than mediastinoscopy if the cost per EBUS-TBNA procedure is less than pound 2,718 (\$4,307) per patient.	2
62. Minnich DJ, Bryant AS, Cerfolio RJ. Thoracoscopic and robotic dissection of mediastinal lymph nodes. <i>Thorac Surg Clin.</i> 2012;22(2):215-218.	Review/Other-Dx	N/A	A review of the anatomy of the mediastinal lymph nodes.	Understanding the anatomy of the lymphatic channels and lymph nodes in the mediastinum is relevant to many disease processes as well as therapeutic interventions for thoracic malignancies.	4

**Radiologic Management of Thoracic Nodules and Masses  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
63. Kang HJ, Hwangbo B, Lee GK, et al. EBUS-centred versus EUS-centred mediastinal staging in lung cancer: a randomised controlled trial. <i>Thorax</i> . 2014;69(3):261-268.	Experimental-Dx	148 patients	To assess diagnostic values, change of diagnostic values by adding secondary procedures and procedure-related parameters such as cardiorespiratory parameters, complications and satisfaction scores between groups.	Diagnostic values were evaluated in 148 patients (74 in each group). In Groups A and B the diagnostic accuracy (93.2% (95% CI, 87.5% to 99.0%) vs 97.3% (95% CI, 93.6% to 101.0%), $P=0.245$ ) and sensitivity (85.3% (95% CI, 68.9% to 95.0%) vs 92.0% (95% CI, 74.0% to 99.0%), $P=0.431$ ) in detecting mediastinal metastasis were not statistically different. In Group A, adding EUS-FNA to EBUS-TBNA did not significantly increase the accuracy (from 91.9% to 93.2%, $P=0.754$ ) or sensitivity (from 82.4% to 85.3%, $P=0.742$ ). In group B, adding EBUS-TBNA to EUS-FNA increased the accuracy (from 86.5% to 97.3%, $P=0.016$ ) and sensitivity (from 60.0% to 92.0%, $P=0.008$ ). There were no intergroup differences in procedure time, cardiorespiratory parameters during procedures, complications or patient satisfaction.	2
64. Sconfienza LM, Mauri G, Grossi F, et al. Pleural and peripheral lung lesions: comparison of US- and CT-guided biopsy. <i>Radiology</i> . 2013;266(3):930-935.	Observational-Dx	273 patients	To retrospectively compare the outcome of CT and US guidance when sampling a consecutive series of peripheral lung or pleural lesions.	No significant difference was found for patient age ( $P=.741$ ), sex ( $P=.900$ ), lesion size ( $P=.206$ ), or lesion origin ( $P=.788$ ). Median time was 556 seconds for CT-guided biopsy (25th percentile, 408 seconds; 75th percentile, 704 seconds) and 321 seconds for US-guided biopsy (25th percentile, 157 seconds; 75th percentile, 485 seconds) ( $P<.001$ ). Postprocedural pneumothorax was observed in 25/170 (14.7%) CT-guided procedures and in 6/103 (5.8%) US-guided procedures ( $P=.025$ ); hemorrhage occurred in 2/170 (1.2%) CT-guided procedures and in 1/103 (1.0%) US-guided procedures ( $P=.875$ ). Technical success was achieved in 100/103 US-guided procedures (97.1%) and in 164/170 CT-guided procedures (96.5%) ( $P=.999$ ).	3

## Evidence Table Key

### Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  - c) the study is an expert opinion or consensus document.
- M = Meta-analysis

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Dx = Diagnostic

Tx = Treatment

## Abbreviations Key

CI= Confidence interval

CNB = Core-needle biopsy

CT = Computed tomography

EBUS-TBNA = Endobronchial ultrasound-guided transbronchial needle aspiration

EUS-FNA = Endoscopic ultrasound guided fine-needle aspiration

FDG-PET = Fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography

FNA = Fine-needle aspiration

FNAB = Fine-needle aspiration biopsy

GGNs = Ground-glass nodules

GGO = Ground-glass opacity

NPV = Negative predictive value

NSCLC = Non-small-cell lung cancer

PPV = Positive predictive value

SUV<sub>max</sub> = Maximum standardized uptake value

TBNA = Transbronchial fine needle aspiration

TTNB = Transthoracic needle biopsy

US = Ultrasound