

Transbronchial Biopsy With or Without Fluoroscopy?

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Abstract

The fluoroscopy-guided transbronchial lung biopsy (TBBx) is a useful technique for diagnosis of peripheral lung lesion (PLL). The diagnostic yield of TBBx is limited and variable, ranging in literature from 16 - 70%. The aim of this systematic review was to evaluate the safety and diagnostic yield of fluoroscopy guided TBBx.

Keywords: Transbronchial Lung Biopsy; Fluoroscopy

Abbreviations

AIDS: Acquired Immunodeficiency Syndrome; FB: Flexible Bronchoscopy; FDA: Food Drug Administration; FOB: Fiberoptic Bronchoscopy; F-TBBx: Fluoroscopy Guided TBBx; mSv: Milli-Sieverts; NF-TBBx: Non-Fluoroscopy Guided TBBx; PLL: Peripheral Lung Lesion; TBBx: Transbronchial Lung Biopsy; TBLB: Transbronchial Lung Biopsy

Introduction

Transbronchial lung biopsy (TBBx) also known as “Bronchoscopic Lung Biopsy” is well established technique and is commonly performed by pulmonologists to obtain samples of focal and diffuse lung diseases. This technique has low morbidity and mortality rate. Biopsy of the lung used to be performed by open surgical methods until 1963, when Dr. Anderson carried out bronchoscopic lung biopsy with the help of a rigid bronchoscope. Transbronchial lung biopsy (TBLB or TBBx) via flexible bronchoscopy (FB) was introduced in the early 1970s [1] and has since been widely used by respiratory doctors to assess different diseases of the chest.

There are many modifications of the transbronchial biopsy technique. The most common one is performed by wedging the scope in the segmental bronchus of interest and then by passing the biopsy forceps through the working channel of the scope. The forceps is advanced to the diseased region until a resistance is felt. Afterwards, the forceps is withdrawn about 1 - 2 cm, and the jaws are opened and advanced gently to obtain the sample of the lung parenchyma. Later, when the forceps is advanced to the area where resistance was found jaws are closed. The biopsy forceps must be firmly retracted to obtain the sample. Some physicians ask their patient about shoulder, chest or upper abdomen discomfort to indicate proximity to the pleural space especially if fluoroscopy is not used. Also, closing jaws with expiration is also common.

Fluoroscopy is a type of medical imaging that provides a continuous X-ray image on a monitor. During the fluoroscopy procedure, an X-ray beam is passed through the body and the image of movement of a body part or of an instrument or contrast agent (“X-ray dye”) through the body can be seen detailed in a screen. Fluoroscopy procedures are performed to help diagnose disease, or to guide physicians during certain treatment procedures.

Transbronchial biopsy with or without fluoroscopy is employed in the diagnosis of a variety of lung disease such as peripheral lung masses, focal or diffuse lung infiltrates, suspected fungal and mycobacterial lung infections in immunocompromised hosts and in patients with suspected pulmonary sarcoidosis. This technique is also used in assessment of rejection and infectious complications following lung transplantation.

The diagnosis of peripheral lung lesions is common issue in daily clinical practice. Although new advances in bronchoscopic methods, such as endobronchial ultrasonography guided TBBX [2] and bronchoscopy with an ultrathin bronchoscope coupled with virtual navigation [3] improved ability to target the lesion, these procedures involve complicated methods and are not yet widely used. Transbronchial biopsy under fluoroscopic guidance remains one of the most commonly used procedure for the diagnosis of peripheral pulmonary lesions without visible endobronchial lesions [4,5].

For the last decades, the safety of transbronchial biopsies has been under debate and the necessity of fluoroscopic guidance is still a controversial issue. In the past, the American Thoracic Society recommended that TBBx should be performed only under fluoroscopic control to prevent pneumothorax, although this statement was deleted some years later [6]. British Thoracic Society states that fluoroscopy should be considered for TBBx in patients with localized or focal parenchymal lung disease (Grade D) [7].

Methodology

We have performed a systematic literature review and identified all English retrospective case series and studies covering this topic from January 1974 till January 2016. A MEDLINE and PubMed database search was performed using “transbronchial lung biopsy” and “fluoroscopy” as terms to identify studies. The search was limited to human subjects and to English language studies, non-English language studies were excluded. The reference list of included studies was searched manually.

Review articles, commentaries and case reports were excluded from the analysis. Only retrospective studies were evaluated for inclusion. Studies with fewer than 50 patients were excluded. All included studies had to document technique and indications of TBBx, methodology, lesions definitions, final diagnosis and use of fluoroscopy. We identified series that reported at least one of the following rates of pneumothorax, rate of bleeding and/or diagnostic yield. Clinically significant bleeding was arbitrarily defined as > 100 mL blood present in lavage. No bleeding was defined as the presence of only traces of blood after finishing the biopsies, with no need for continued suctioning.

We had three major areas of interest: 1) Safety and rate of complications of TBBx with and without fluoroscopy, 2) Diagnostic yield of TBBx with and without fluoroscopy, 3) Risk of radiation exposure for patients and staff using fluoroscopy.

Safety

Fiberoptic bronchoscopy (FOB) is a safe procedure. Several surveys worldwide reported low mortality rate and complications rate with 0.01 - 0.04% and 0.08 - 0.12% respectively [8,9]. Main concerns for complications related to transbronchial biopsy are pneumothorax, massive hemorrhage and death. Rate of complications of transbronchial biopsy have been highly variable throughout the literature.

Pneumothorax

In 1972, Andersen and Fontana [10] in their early studies, reported an incidence of 14% of pneumothorax in 450 patients underwent TBBx through a rigid bronchoscopy. They also reported decrease of incidence of pneumothorax with increased number of cases and concluded that it may be related to the operator experience. Many other authors subsequently adapted the flexible fiberoptic bronchoscope technique to the biopsy technique of Andersen and Fontana with good results and reported incidence of complications mostly in small series [11].

In spite of the fact that fluoroscopy has been used for TTBx for several years [12], other studies which included patients with suspected sarcoidosis suggested that the procedure is safe without fluoroscopy [13,14]. Overall, transbronchial biopsy seems to be a safe procedure in hospitalized patients as well as in outpatients. Ahmad., *et al.* [15], compared historical inpatient TBBx series with 148 patients, who underwent this procedure as outpatient under fluoroscopic guidance. They suggested that TBBx has a low incidence of complications, being sufficient one hour in observation for safe discharge [15]. Routine hospitalization for TBBx adds enormous additional expense to the procedure, which can be avoided.

Many retrospective case series reported pneumothorax rate either with use of fluoroscopy (Table 1) or without use of fluoroscopy (Table 2). Only few compared the incidence of complications in both group of patients within one series (Table 3).

Although the rate of pneumothorax ranges between 0.4 - 5.8% in series with use of fluoroscopy (Table 1) and 1.5 - 20.2% in series without use of fluoroscopy one should not conclude fluoroscopy impact on safety of the transbronchial biopsy based just on these ranges.

Author	Year	No	Fluoro	PTX % (No)	PTX_tube% (No)	Bleeding	Death	Reason
Hanson [16]	1976	153	Yes	4.57 (7)	3.26 (5)	1.9 (3)	0 (0)	Mixed
Fletcher [17]	1982	118	Yes	4.23 (5)	2.54 (3)	3.38 (4)	0 (0)	Periph
Ahmad [15]	1986	148	Yes	0.68 (1)	0.68 (1)	2.02 (3)	0 (0)	Mixed
Shiner [18]	1988	71	Yes	1.4 (1)	0 (0)	n/a	0 (0)	Periph
Frazier [19]	1990	305	Yes	0.66 (2)	n/a	n/a	n/a	Mixed
Milman [20]	1994	452	Yes	5.8 (26)	3.8 (17)	0.22 (1)	0 (0)	Mixed
Lai [21]	1996	170	Yes	1.7 (3)	0.58 (1)	0 (0)	0 (0)	Periph
Kawaraya [22]	2003	1372	Yes	0.4 (6)	n/a	0.07 (1)	0 (0)	Periph
Rial [23]	2009	273	Yes	1.4 (4)	0.7 (2)	0 (0)	0 (0)	Periph

Table 1: Complications of fluoroscopy guided transbronchial biopsy.

In the seven years study accomplished by Anders., *et al.* [24], the pneumothorax rate was relatively similar in mixed group of patients who underwent transbronchial biopsy with and without fluoroscopy. In other series published in 1987 by Milligan., *et al.* [25], the difference in the incidence of pneumothorax in patients with lower respiratory tract infection and HIV after transbronchial biopsy with and without fluoroscopy was also not statistically significant (Table 3). On the other hand, Simpson., *et al.* [9], who sent questionnaires to respiratory physicians in the UK, reported rate of pneumothorax to be statically significantly lower when fluoroscopy used in TBBx (1.8% with fluoroscopy vs 1.23% without fluoroscopy). Smyth., *et al.* [26], supported this idea when he sent questionnaires to over 500 pulmonary physicians in the UK almost two decades later. Physicians who used fluoroscopic guidance reported significantly lower incidence of pneumothorax requiring intervention compared to those who did not (2.7/1000 with fluoroscopy vs. 9.2/1000 without fluoroscopy; < 0.03). No difference in the total frequency of pneumothorax was reported.

Author	Year	No of TBBx	Fluoro	PTX % (No)	PTX_tube% (No)	Bleeding	Death	Reason
Broaddus [27]	1985	253	No	9.1 (23)	5.9 (15)	0 (0)	0 (0)	LRTI and HIV
Puar [28]	1985	68	No	1.48 (1)	1.48 (1)	0 (0)	0 (0)	Sarcoidosis
Griffiths [29]	1989	74	No	20.2 (15)	10.8 (8)	2.7 (2)	1.35 (1)	LRTI and HIV
de Fenoyl [30]	1989	174	No	3.44 (6)	2.29 (4)	1.7 (3)	0 (0)	Sarcoidosis, ILD
Suri [31]	1992	65	No	3.07 (2)	0 (0)	3.07 (2)	0 (0)	Mixed

Table 2: Complications of transbronchial biopsy without using fluoroscopy.

Currently there is no strong evidence showing that transbronchial biopsy with fluoroscopy has or has not been associated with a significantly lower incidence of pneumothorax than biopsy performed without fluoroscopy despite all published data.

Author	Year	No of TBBx	Fluoro	PTX % (No)	PTX_tube% (No)	p value	Reason
Simpson [9]	1986	1968	Yes	1.77 (35)	n/a	< 0.05	Mixed
		1234	No	2.9 1(36)	n/a		
Milligan [25]	1987	63	Yes	11.1 (7)	9.52 (6)	> 0.05	LRTI and HIV
		187	No	8.6 (16)	4.27 (8)		
Anders [24]	1988	112	Yes	0.89 (1)	n/a	> 0.05	Mixed
		135	No	0.73 (1)	n/a		
Rittirak [32]	2007	331	Yes	1.2 (4)	n/a	> 0.05	Mixed
		319	No	0.6 (2)	n/a		

Table 3: Comparison of complications of transbronchial biopsy with and without fluoroscopy.

Bleeding and death

TBBx via the flexible bronchoscope is described as a safe, but the potential risk of serious bleeding is always concerning. The first death due to fatal bleeding after TBBx via flexible bronchoscope was reported in 1975 by Flick., *et al* [33]. Clinically significant hemorrhage has been reported in 0.6 to 1.3% in large case series [34,35]. Life threatening bleeding is unusual with transbronchial biopsy. Mechanical ventilation, coagulation disorders, pulmonary hypertension, immunosuppression, and uremia tend to increase the risk of bleeding from transbronchial biopsy [36-38]. A review of TBBx in haemodynamically stable patients on mechanical ventilators reported a 21% incidence of bleeding [36]. A 15% incidence of hemorrhage after TBBx in cardiac-transplant patients with pulmonary artery hypertension was reported by Schulman., *et al* [39]. Zavala [40] pointed out a 4% incidence of clinically significant bleeding in patient without bleeding risk factors.

Overall, risk of bleeding with and without fluoroscopy ranges between 0.2 - 4% in both groups of series. It also doesn't seem that use of fluoroscopy has any impact on mortality of transbronchial biopsy. See table 1 and table 2.

Diagnostic yield

In the literature there is a great debate about the utility of fluoroscopy during TBBx and its impact on the diagnostic yield in different type of lesions. Parenchymatous lung lesions often present as peripheral non-endobronchial lesions, which are not visible through conventional flexible fiberoptic bronchoscopy. Tissue diagnosis from these peripheral lesions is usually obtained by TBBx with or without fluoroscopy. The diagnostic yield of TBBx is limited and variable based on radiologic position, distribution, etiology and size of the lesions.

It also depends on a number of specimens obtained and possibly, the experience of the bronchoscopist. In reality, the diagnostic accuracy (sensitivity and specificity) of TBBx for the most interstitial lung diseases remains undetermined, with some exceptions related to studies in pulmonary infections in patients with AIDS [27] and of acute lung rejection in lung transplant recipients [41]. The diagnostic yield is considered suboptimal in solitary lung nodules smaller than 2 cm in diameter. Its diagnostic accuracy increases when the presence of a bronchus leading to the nodule is found on computed tomography (CT) of the chest (positive bronchus sign) [42], and when the tissue is repeatedly sampled [43]. BTS guidelines recommend 4–6 samples in diffuse lung disease and 7 - 8 samples in focal lung disease [44]. Fluoroscopic guidance is not standard of a procedure at every center at present.

The diagnostic yield might be improved with fluoroscopic guidance to more precisely target the area of interest [45], especially in peripheral lung nodules and masses. We have identified retrospective series which report diagnostic yield of TBBx. Many authors also reported overall diagnostic yield of bronchoscopy with utilization of all available techniques and comparison between them. Some also focus on impact of the different additional techniques as addition to TBBx or independent predicting factors on the diagnostic yield. Kawaraya, *et al.* [22], reported overall diagnostic rate of bronchoscopy 93.4% using forceps, brush, curette and needle. He also reported increased sensitivity of histological examination from TBBx with addition of imprint cytology (increase in 7.9%) and cytology of the rinse fluid of the forceps (increase in 6.9%). Table 4 summarizes reported sensitivities of TBBx in large series.

Author	Year	No of TBBx	Fluoro	Total yield %
Zavala [41]	1975	137	Yes	71
Wallace [47]	1982	133	Yes	65
Lam [48]	1983	155	Yes	60
Shiner [18]	1988	71	Yes	70
Milman [20]	1994	279	Yes	55
Gasparini [49]	1995	404	Yes	54
Lai [21]	1996	170	Yes	62
Baakini [50]	2000	177	Yes	60
Kawaraya [22]	2003	1372	Yes	77
Rial [23]	2010	273	Yes	53

Table 4: Diagnostic yield of fluoroscopy guided transbronchial biopsy.

The use of fluoroscopy during transbronchial biopsy may facilitate target the area of interest especially in solitary pulmonary nodules. There are only two case series comparing the diagnostic yield of fluoroscopy guided TBBx (F-TBBx) vs non-fluoroscopy guided TBBx (NF-TBBx) of peripherally located and endoscopically non-visible lesions (Table 5). Rittirak, *et al.* [50], in a descriptive study from 2007, reported the diagnostic yield of F-TBBx group to be statistically significantly higher than NF-TBBx group for peripheral lung masses (41.4% vs. 29.5%; $p = 0.036$) and focal infiltrative lesions (46.2% vs 29.4% $p = 0.008$). He also noted no difference between the F-Tbbx and NF-TBBx group in diffuse infiltrative lesions. Similar results were reported by Anders, *et al* [24,28]. They performed 52 of F-TBBx and 19 of NF-TBBx in patients with local disease and 22 of F-TBBx and 21 of NF-TBBx in patients with diffuse disease. Statistically significant increased yield was found in group of F-TBBx in patient with focal disease (Table 5).

Author	Year	No of TBBx	Yield F-TBBx %	NF-TBBx %	p
Clark [52]	1977	26	38.5	8	n/a
Anders [24]	1988	71	73	26.3	< 0.001
Rittirak [32]	2007	650	41.4	29.5	< 0.05

Table 5: Comparison of diagnostic yield of transbronchial biopsy with and without fluoroscopy.

Fluoroscopically guided flexible fiberoptic bronchoscopy (FOB) in conjunction with transbronchial biopsy has given physicians an additional procedure for nonsurgical diagnosis of the SPN. The most common bronchoscopic procedure for patients with peripheral nodules is fluoroscopy-guided TBBx [48]. Fluoroscopic localization is most difficult when lesions are small (< 2 cm) and located in the lower lobe basal segments or the upper lobe apical segment [17]. In table 6 we summarize studies that reported different yield based on size of the nodules.

Author	Year	No of TBBx	Fluoro	Total yield %	Yield (%) < 2 cm	Yield (%) 2 - 4 cm	Yield (%) > 4 cm	p
Wallace [47]	1982	133	Yes	65	47	81	n/a	n/a
Lai [21]	1996	170	Yes	62.4	32.3	64.5	68.8	unk
Baaklini [50]	2000	177	Yes	60%	23	57	83	< 0.001
Rial [23]	2010	273	Yes	53.3	20	45	66.7	< 0.001

Table 6: Comparison of diagnostic yield of transbronchial biopsy with fluoroscopy based on size of the nodules.

The question of relative yield is complex. The medical literature has suggested an exponential acceptance of TBBx without fluoroscopy in the diagnosis of sarcoidosis [26]. Diagnosis in sarcoidosis could be made from alveolar tissue as well as bronchial tissue which have been reported to improve diagnostic yield [52].

Despite similar diagnostic yield of TBBx with or without fluoroscopic guidance for diffuse lung infiltrates, fluoroscopy seems to help the bronchoscopist to select different areas for biopsy. Position confirmation of biopsy forceps on fluoroscopy justifies its use while sampling peripheral lung nodule. In a blind biopsy, the tactile sensation is greatly diminished when the tip of the bronchoscope is flexed. In many hospitals the routine use of fluoroscopy with TBBx may be challenging and therefore significant number of transbronchial biopsies is still done without fluoroscopic guidance.

Radiation safety and other inconveniences

The recent developments in X-ray technologies have substantially improved the ability of physicians for performing interventional procedures using fluoroscopy as a guide. Some techniques are long and require considerable time. Because of this, the potential risk of radiation-induced lesions such as dermatitis may be high. In 1994, The Center for Devices and Radiological Health of the United States Food and Drug Administration informed about the potential for radiation-induced burns to patients undergoing fluoroscopic procedures [53]. The FDA has documented more than 100 cases of radiation induced burns, some injuries to both patients and physicians have been described [54,55]. The use of fluoroscopy in the routine practice to some physicians for more than 10 years, has resulted in appearance of cataracts and serious radiation injuries [56].

Moreover, radiation may damage the fiber bundle [57], suggested that the exposure to x-radiation increased optical density of the fiber bundles with a reduction in light transmission in the fiberoptic endoscopes. Exposure of an endoscope to x-irradiation tended to short the life of the fiberoptic bundles, involving an important economic issue due to replace a damaged fibre bundle tends to be expensive.

The main inconvenience of using fluoroscopy for TBBx is its availability in resource-limited settings and radiation exposure to the patient and the room staff [58]. Fluoroscopy carries some risks, as do other X-ray procedures. The radiation dose the patient receives varies depending on the individual procedure. Radiation-related risks associated with fluoroscopy can include injuries to the skin and underlying tissues ("burns"), and rarely radiation-induced cancers. Concerns about radiation-related injuries to patients have increased since the mid-1990s due to the increasing complexity and radiation dose of some fluoroscopically-guided interventions. In 2005, the FDA revised the radiation safety performance standard for diagnostic X-ray systems, including fluoroscopy to improve the display of dose information to the physicians [59]. The probability that a person will experience these effects from a fluoroscopic procedure is statistically very small.

In a recent study, Steinfeld, *et al.* [60], stated that patients and operators are exposed to relatively small amounts of radiation from fluoroscopy during fluoroscopically-guided biopsy of peripheral pulmonary lesions (0.49 - 0.37 and 0.4milli-Sieverts (mSv), respectively). The probability of stochastic risks is dependent on radiation dose. As Goodenough study [61], the magnitude of lifetime risk of fatal cancer for bronchoscopists, is relatively low (1×10^6 per procedure).

Clinically indicated fluoroscopic guidance during bronchoscopy should not be based on radiation safety concerns. Adequate shielding of clinicians should be a rule.

To minimize the radiation risk, fluoroscopy should always be performed with the lowest acceptable exposure for the shortest time necessary. There are no any long-term ill effects known on the patients or the bronchoscopy staff. With an appropriate training and instructions, the fluoroscopy time can be reduced [62]. Fluoroscopically guided transbronchial biopsy is a time-effective, safe, and efficient method for diagnosing focal or diffuse pulmonary lesions.

Conclusion

Despite multiple studies dedicated to fiberoptic bronchoscopy and transbronchial biopsies, fluoroscopy and its utilization during traditional bronchoscopy will remain debatable. It appears that procedure related complications are same with or without fluoroscopy, but it may decrease risk of complication in high risk population of patients.

Patients with high risk of suffering from pneumothorax, such as ones with emphysematous disease or those with positive pressure ventilation [36] may have unsuspected pneumothoraces after TBBx. Also, the unsuspected pneumothorax may be fatal, particularly in patients with underlying lung diseases [63].

Although the overall incidence of pneumothorax seems to be low, fluoroscopically-guided TBBx and/or routine chest roentgenograms after the procedure remains standard of care in many centers.

Diagnostic yield may be improved with fluoroscopy in selected population of patients in which real time guidance of forceps may help operator to guide towards radiographically visible lesion. Also, with increased utilization of modern minimally invasive techniques for diagnosis solitary pulmonary nodules fluoroscopy will remain useful tool in future.

Bibliography

1. Levin DC., *et al.* "Transbronchial lung biopsy via the fiberoptic bronchoscope". *The American Review of Respiratory Disease* 110.1 (1974).
2. Kurimoto N., *et al.* "Endobronchial ultrasonography using a guide sheath increases the ability to diagnose peripheral pulmonary lesions endoscopically". *Chest* 126.3 (2004): 959-965.

3. Asano F, *et al.* "Transbronchial diagnosis of a pulmonary peripheral small lesion using an ultrathin bronchoscope with virtual bronchoscopic navigation". *Journal of Bronchology* 9.2 (2002): 108-111.
4. Mazzone P, *et al.* "Bronchoscopy and needle biopsy techniques for diagnosis and staging of lung cancer". *Clinics in Chest Medicine* 23 (2002): 137-158.
5. Schreiber G and McCrory DC. "Performance characteristics of different modalities for diagnosis of suspected lung cancer: summary of published evidence". *Chest* 123 (2003): 115S-28S.
6. Sokolonski HW BL, *et al.* "ATS Official Position Paper: guidelines for fiberoptic bronchoscopy in adults". *The American Review of Respiratory Disease* 136.4 (1987).
7. I A DU Rand, *et al.* "BTS Guideline for diagnostic flexible bronchoscopy in adults". *British Thoracic Society BTS Flexible Bronchoscopy Guideline* 68 (2013): i1-i44.
8. Credle WF, *et al.* "Complications of fiberoptic bronchoscopy". *The American Review of Respiratory Disease* 109.1 (1974): 67-72.
9. Simpson FG, *et al.* "Postal survey of bronchoscopic practice by physicians in the United Kingdom". *Thorax* 41.4 (1989): 311-317.
10. Andersen HA, *et al.* "Transbronchoscopia Lung Biopsy for Diffuse Pulmonary Diseases: Technique and Results in 450 Cases". *Chest* 62.2 (1972): 125-128.
11. Scheinhorn DJ, *et al.* "Transbronchial forceps lung biopsy through fiberoptic bronchoscope in Pneumocystis carinii pneumonia". *Chest* 66.3 (1974):294-295.
12. Zavala DC. "Methodology in transbronchial lung biopsy [letter]". *Chest* 72.1 (1977): 130-131.
13. Puar HS, *et al.* "Bronchial and transbronchial lung biopsy without fluoroscopy in sarcoidosis". *Chest* 87.3 (1985): 303-306.
14. Prigogine T and Schmerber J. "Transbronchial lung biopsy without fluoroscopy [letter]". *Chest* 92.1 (1987): 187-188.
15. Ahmad M, *et al.* "The safety of outpatient trans bronchial biopsy". *Chest* 90.3 (1986): 403-405.
16. Hanson RR, *et al.* "Transbronchial biopsy via flexible fiberoptic bronchoscope results in 164 patients". *The American Review of Respiratory Disease* 114.1 (1976).
17. Fletcher EC, *et al.* "Flexible Fiberoptic Bronchoscopy and Fluoroscopically Guided Transbronchial Biopsy in the Management of Solitary Pulmonary Nodules". *Journal of Medicinal* 136.6 (1982): 477-483.
18. Shiner RJ, *et al.* "Bronchoscopic evaluation of peripheral lung tumours". *Thorax* 43.11 (1988): 887-889.
19. Frazier WD, *et al.* "Pneumothorax following transbronchial biopsy. Low diagnostic yield with routine chest roentgenograms". *Chest* 97.3 (1990): 539-540.
20. Milman N, *et al.* "Transbronchial lung biopsy through the fibre optic bronchoscope. Results and complications in 452 examinations". *Respiratory Medicine* 88.10 (1994): 749-753.
21. Lai RS, *et al.* "Diagnostic value of transbronchial lung biopsy under fluoroscopic guidance in solitary pulmonary nodule in an endemic area of tuberculosis". *Respiratory Medicine* 90.3 (1996) :139-143.

22. Kawaraya M., *et al.* "Evaluation of various cytological examinations by bronchoscopy in the diagnosis of peripheral lung cancer". *British Journal of Cancer* 89 (2003): 1885-1888.
23. Botana Rial M., *et al.* "Multivariate study of predictive factors for clearly defined lung lesions without visible endobronchial lesions in transbronchial biopsy". *Surgical Endoscopy* 24.12 (2010): 3031-3036.
24. Anders GT., *et al.* "Transbronchial biopsy without fluoroscopy. A seven year perspective". *Chest* 94.3 (1988): 557-560.
25. Milligan SA., *et al.* "Transbronchial biopsy without fluoroscopy in patients with deficiency syndrome". *The American Review of Respiratory Disease* 137.2 (1988): 486-488.
26. Smyth CM and Stead RJ. "Survey of flexible fibreoptic bronchoscopy in the United Kingdom". *European Respiratory Journal* 19.3 (2002): 458-463.
27. Broaddus C., *et al.* "Bronchoalveolar lavage and transbronchial biopsy for the diagnosis of pulmonary infections in the acquired immunodeficiency syndrome". *Annals of Internal Medicine* 102.6 (1985): 747-752.
28. Puar HS., *et al.* "Bronchial and transbronchial lung biopsy without fluoroscopy in sarcoidosis". *Chest* 87.3 (1985): 303-306.
29. Griffiths MH., *et al.* "Diagnosis of pulmonary disease in human immunodeficiency virus infection: role of transbronchial biopsy and bronchoalveolar lavage". *Thorax* 44.7 (1989): 554-558.
30. De Fenoyl O., *et al.* "Transbronchial biopsy without fluoroscopy: a five year experience in outpatients". *Thorax* 44.11 (1989): 956-959.
31. Suri JC., *et al.* "Evaluation of unguided transbronchial biopsy in the diagnosis of pulmonary disease--its safety and efficacy as an outpatient procedure". *Indian Journal of Chest Diseases and Allied Sciences* 34.2 (1992): 57-64.
32. Rittirak W., *et al.* "Diagnostic yield of fluoroscopy-guided transbronchial lung biopsy in non-endobronchial lung lesion". *Journal of the Medical Association of Thailand* 90 (2007): 68-73.
33. Flick MR., *et al.* "Fatal pulmonary hemorrhage after transbronchial lung biopsy through the fiberoptic bronchoscope". *The American Review of Respiratory Disease* 111.6 (1975): 853-856
34. Herf SM and Suratt PM. "Complications of transbronchial lung biopsies". *Chest* 73 (1978): 759-760.
35. Herth FJ., *et al.* "Aspirin does not increase bleeding complications after transbronchial biopsy". *Chest* 122.4 (2002): 1461-1464.
36. Papin TA., *et al.* "Transbronchial biopsy during mechanical ventilation". *Chest* 89.2 (1986): 168-170.
37. Papin TA., *et al.* "Transbronchoscopy in the thrombocytopenic patient". *Chest* 88.4 (1985): 549-552.
38. Zavala DC. "Pulmonary Hemorrhage in Fiberoptic Transbronchial Biopsy". *Chest* 70.5 (1976): 584-588.
39. Schulman LL., *et al.* "Utility of airway endoscopy in the diagnosis of respiratory complications of cardiac transplantation". *Chest* 93.5 (1988): 960-967.
40. Zavala DC. "Diagnostic Fiberoptic Bronchoscopy: Techniques and Results of Biopsy in 600 Patients". *Chest* 68.1 (1975): 12-9.
41. Higenbottam T., *et al.* "Transbronchial lung biopsy for the diagnosis of rejection in heart-lung transplant patients". *Transplantation* 46.4 (1988): 532-539.

42. Gaeta M., *et al.* "Carcinomatous solitary pulmonary nodule: evaluation of tumor bronchi relationship with thin-section CT". *Radiology* 187.2 (1993): 535-539.
43. Descombes E., *et al.* "Transbronchial lung biopsy: an analysis of 530 cases with reference to the number of samples". *Monaldi Archives for Chest Disease* 52.4 (1997): 324-329.
44. I A DU Rand., *et al.* British Thoracic Society Bronchoscopy Guidelines Committee British Thoracic Society guidelines on diagnostic flexible bronchoscopy". *Thorax* 66 (2001): 1-21.
45. Rivera MP., *et al.* "Diagnosis of lung cancer: the guidelines". *Chest* 123 (2003): 129S-136S.
46. Wallace JM and Deutsch AL. "Flexible fiberoptic bronchoscopy and percutaneous needle lung aspiration for evaluating the solitary pulmonary nodule". *Chest* 81.6 (1982): 665-671.
47. Lam WK., *et al.* "Fibreoptic bronchoscopy in the diagnosis of bronchial cancer: comparison of washings, brushings and biopsies in central and peripheral tumours". *Clinical Oncology* 9.1 (1983): 35-42.
48. Gasparini S., *et al.* "Integration of transbronchial and percutaneous approach in the diagnosis of peripheral pulmonary nodules or masses. Experience with 1027 cases". *Chest* 108.1 (1995): 131-137.
49. Baaklini WA., *et al.* "Diagnostic Yield of Fiberoptic Bronchoscopy in Evaluating Solitary Pulmonary Nodule". *Chest* 117.4 (2000):1049-1054.
50. Rittirak W and Sompradeekul S. "Diagnostic yield of fluoroscopy-guided transbronchial lung biopsy in non-endobronchial lung lesion". *Journal of the Medical Association of Thailand* 90.2 (2007): 68-73
51. Clark RA., *et al.* "Transbronchial lung biopsy: a review of 85 cases". *Thorax* 32.5 (1977):546-549.
52. Bilaceroglu S., *et al.* "Combining transbronchial aspiration with endobronchial and transbronchial biopsy in sarcoidosis". *Monaldi Archives for Chest Disease* 54.3 (1999): 217-223.
53. Food and Drug Administration Public Health Advisory: avoidance of serious X-ray induced skin injuries to patients during fluoroscopically guided procedures (September 1994). Center for Devices and Radiological Health, FDA, Rockville (1994).
54. Rosenthal LS., *et al.* "Acute radiation dermatitis following radiofrequency catheter ablation of atrioventricular nodal reentrant tachycardia". *Pacing and Clinical Electrophysiology* 20.7 (1997): 1834-1839.
55. Nahass GT. "Acute radiodermatitis after radiofrequency catheter ablation". *Journal of The American Academy of Dermatology* 36 (1997): 881-884.
56. Vano E., *et al.* "Lens injuries induced by occupational exposure in non-optimized interventional radiology laboratories". *The British Journal of Radiology* 71.847 (1998): 728-733.
57. Ashby BS and Goodman DA. "Effects of x-radiation on fibreoptic endoscopes". *Gut* 21.8 (1980): 717-772.
58. Jain P., *et al.* "Radiation safety for the health care workers in bronchoscopy suite". *Clinics in Chest Medicine* 20.1 (1999): 33-38.
59. Regulations CoF. Food and drugs. "Chapter I--Food and drug administration". Department of health and human services 8 (2013).
60. Steinfort DP., *et al.* "Radiation dose to patients and clinicians during fluoroscopically-guided biopsy of peripheral pulmonary lesions". *Respiratory Care* 55.11 (2010): 1469-1474.

61. Goodenough DJ. "Lessons learned in radiology". In: Radiological protection of patients in diagnostic and interventional radiology, nuclear medicine and radiotherapy: proceedings of an international conference held in Malaga, Spain. Vienna: International Atomic Energy Agency (2001): 145-155.
62. Ernst A., *et al.* "A simple teaching intervention significantly decreases radiation exposure during transbronchial biopsy". *Journal of Bronchology* 11.2 (2004) :109-111.
63. Herf SM., *et al.* "Deaths and complications associated with transbronchial lung biopsy". *The American Review of Respiratory Disease* 115.4 (1977) :708-711.

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