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Original Article

Modified Technique for Obtaining Mediastinal Samples With Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration: Results From a Prospective Observational Study☆

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ABSTRACT

Background: Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) is a widely-accepted method for obtaining both benign and malignant mediastinal lymph node samples. We present the results obtained with a modification that simplifies sampling, known as fine-needle capillary sampling or EBUS-FNC.
Methods: A prospective observational study with 44 consecutive patients who underwent EBUS at the University of Navarra Clinic in Pamplona, Spain. All samples were obtained by EBUS-FNC instead of by conventional EBUS-TBNA. No suction was used, and the internal stylus was not completely withdrawn at any time.
Results: The examination of the mediastinum by means of EBUS identified the presence of lymphadenopathies or mediastinal masses in 38 patients (86.4%). Samples were taken from more than one lymph node in 23 patients (52.3%). EBUS-FNC provided adequate and representative material for interpretation in all patients, and diagnostic performance was 87%. Sensitivity for the detection of lung cancer with EBUS-FNC was 84%. Mild complications were only recorded in two patients (4.5%).
Conclusions: Our study suggests that EBUS-FNC is a safe technique, comparable to EBUS-TBNA in efficacy, and is able to obtain adequate samples.

Técnica modificada de obtención de muestras del mediastino mediante punción transbronquial bajo guía de ecografía endobronquial: resultados de un estudio prospectivo observacional

Palabras clave:
Broncoscopia
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Biopsias por punción
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Cáncer de pulmón

RESUMEN

Antecedentes: La aspiración mediante punción transbronquial bajo guía de ecografía transbronquial (EBUS-TBNA) es un método ampliamente aceptado para la obtención de muestras de ganglios linfáticos mediastínicos tanto benignos como malignos. Se presentan los resultados obtenidos con una modificación que simplifica la técnica de obtención de muestras a la que se denomina capilaridad con aguja fina o EBUS-FNC.
Métodos: Estudio prospectivo observacional de 44 pacientes consecutivos a los que se practicó una EBUS en la Clínica de la Universidad de Navarra de Pamplona, España. Todas las muestras se obtuvieron mediante EBUS-FNC en vez de con la EBUS-TBNA convencional. No se aplicó aspiración y no se retiró en ningún momento por completo el estilete interno.
Resultados: La exploración del mediastino mediante EBUS identificó la presencia de adenopatías o masas mediastínicas en 38 pacientes (86,4%). Se obtuvieron muestras de más de un ganglio linfático en 23 pacientes (52,3%). La EBUS-FNC proporcionó un material adecuado y representativo para realizar la interpretación en todos los pacientes y el rendimiento diagnóstico fue del 87%. La sensibilidad para la detección del cáncer de pulmón con la EBUS-FNC fue del 84%. Se registraron complicaciones menores (%) tan solo en dos pacientes (4,5%).

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Conclusiones: Nuestro estudio sugiere que la EBUS-FNC es una técnica segura y comparable a la EBUS-TBNA en cuanto a su eficacia y obtención de muestras adecuadas.

Introduction

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) has become widely accepted as one of the various methods currently in existence for obtaining mediastinal samples in a range of pathological states.[1–7] It is regarded as a minimally invasive technique and is not associated with serious complication.[3,5,7] EBUS-TBNA is particularly useful in the mediastinal staging of non-microcytic lung-cancer (NMLC), for which its sensitivity has been estimated at between 89% and 98%, and its specificity 100%, with a negative predictive value (NPV) in excess of 92%.[2,8–13] The EBUS-TBNA has proven useful in diagnosing malignancy in lymph nodes, with a sensitivity of 91% and a NPV of 93%.[14] Benign tumours, especially sarcoidosis, can also be easily diagnosed by means of EBUS-TBNA.[15–17]

The success of EBUS-TBNA depends on the adequate training of the endoscopy team, the availability of an experienced cytopathologist to carry out a rapid evaluation (ROSE), and the use of an appropriate technique during the procedure.[18–20] The conventional sampling technique for EBUS-TBNA is based on the application of negative pressure or aspiration with a syringe.[20] It has been suggested that continuous aspiration optimises the amount of tissue obtained for diagnostic purposes, and keeps the needle in the target lesion.[21,22] All the studies presented so far are based on EBUS-TBNA as the preferable procedure for obtaining samples.

Biffod was the first researcher to describe an alternative sampling technique, with the use of a needle and without the application of external pressure, for breast lesions.[23] This simplified sampling technique is based on the physical properties of the liquids, which allows a smooth extraction of the material with no need for aspiration. The technique, which is known as fine needle capillary sampling or FNC has also been tried on other organs[24–26] and on lymph nodes. FNC can provide cytology samples of a higher quality, and it may be associated with a lesser degree of contamination of the sample due to haemorrhage than is the case with TBNA. In different studies, it has been described as the technique of choice for sampling in endoscopic ultrasound-guided (EBUS). EBUS-FNC is a simplified technique which obviates the need to withdraw the stylet or to aspirate with a syringe. The aims of the present study are to describe this technique and determine its performance capacity in a random group of patients on whom EBUS mediastinal examination is carried out.

Material and Methods

The study included a total of 44 consecutive patients, on whom a EBUS examination of the mediastinum was performed in the Clinic of the University of Navarre in Pamplona, Spain, between 1 January and 31 August 2011. All the patients concerned had been sent for EBUS following the results obtained in image diagnoses in which mediastinal adenopathies were identified or because they were eligible for mediastinal staging, due to the presence of lung cancer. A medical evaluation was carried out by an endoscopist on all the participants in the scheme, with the aim of recording the relevant demographic data, confirming the advisability of such an intervention, obtaining the informed consent of the patients, and excluding any other possible contraindication. In the same way, the researchers reviewed the existing diagnostic images (CT and or PET-TC) before the intervention, with the aim of identifying the presence of mediastinal lesions that could be aspirated, and planning the procedures to be applied.

Technique for Obtaining Samples by Endobronchial Ultrasound-Guided Transbronchial Aspiration

All the EBUSs were carried out in the endoscopy room with the patient in supine decubitus position, under conscious sedation, by means of a combination of midazolam and fentanyl, and topic anaesthesia (lidocaine 2%). The vital constants and arterial oxygen saturation were monitored continuously. A special bronchoscope was used, with an external diameter of 6.9 mm and a work channel of 2 mm (BF-UC260F-OL8; Olympus Ltd., Tokyo, Japan), inserted orally and passed though the orfarynx and vocal chords until it reached the main carina. The probe (frequency MHz) was connected to another image processor (UE-C60; Olympus Ltd., Tokyo, Japan). The EBUS was carried out with the balloon partially inflated with a saline solution for obtaining a B mode image, and the mediastinal lymph nodes were examined systematically, following the lymph node map proposed by Mountain.[32,33] Once a target lymph node or mediastinal mass was clearly identified by means of the EBUS, the colour Doppler ultrasound was activated in order that the best possible location for the aspiration could be identified, and large blood vessels avoided. The diameter of the lymph node was measured at the short axis and its morphological features recorded. Aspirations were carried out on all the nodes larger than 5 mm that could be visualised, using a special calibre 22 needle (NA-201SX-4022; Olympus Ltd., Tokyo, Japan), making sure that the first aspirations were carried on N3 nodes, if there were any, followed by 2 and then N1, until a diagnosis was achieved, or until a large number of lymphocytes could be observed in at least one sample from each node.

EBUS-FNC was carried out after the point of the needle had been inserted into the interior of the lesion or the lymph node. A stylet was used to clean the residue, cartilage, bronchial epithelium or blood clots out of the needle channels in the usual manner. Subsequently, instead of removing the stylet altogether and performing aspiration with a Vaclok syringe in the usual way (TBNA), the stylet was partially and continuously withdrawn while the lymph node or mediastinal mass was being probed with the needle with a gentle penetration movement, under direct ultrasonic visualisation. Aspiration was not performed and nor was the internal stylet ever completely removed. Subsequently, the material was collected by means of a capillary action rather than aspiration (FNC). The needle was then removed from the bronchoscope's work channel, and the stylet was pressed in order to remove the material contained in its interior and place it on a glass microscope slide for immediate staining. The stylet was then completely removed and a syringe was connected to the needle in order to remove the remaining material, which was then placed on a slide, or so that the cellular material could be placed in a test tube with ethanol. Finally, the stylet was once again inserted into the needle and, if necessary, a new sample was obtained in exactly the same way. All the procedures were carried out by means of ROSE.

ROSE

For each aspiration, at least one glass slide was examined by means of fast-stain, using the Diff-Quik method, by a suitably skilled cytology technician. The preparation was immediately examined

Table 1
Clinical and Demographic Characteristics of the Patients (No.=44).

Tobacco-related antecedents	79.5% (35)
Packets-years, mean	51.8±28.4
Malignant illness antecedents	33.3% (14)
Kidney	4
Urinary bladder	3
Lung	2
Prostate	1
Breast	1
Others	3
Examination recommended	
Suspicion of malignant disease	82%(36)
Examination of panenchymal/mediastinal anomalies	18%(8)
Obvious primary tumour	90.9% (40)
Upper right lobule	5
Central lobule	5
Lower right lobule	5
Upper left lobule	6
Lower left lobule	5
Hilar	5
Mediastinum	2
Other location	7

under a microscope and classified as diagnostic and/or adequate. The remaining preparations were fixed in ethanol (96%) for later examination. The criteria for classifying a sample as adequate were established by Davenport.[34] A sample was considered adequate when the presence of malignant cells or, alternatively, of a benign diagnosis, was evident to the cytopathologist, or when the lymphocytes constituted at least 30% of the total number of cells. The acellular samples or those that showed an abundance of red blood corpuscles or respiratory epithelium cells, were considered inadequate. The number of needle passes required depended on the examination carried out by the cytopathologist of the available material; as well particular care was being taken to ensure that an amply sufficient number of cells could be obtained for analysis of genetic mutation, including analyses of ALK, EGFR and KRAS, which are carried out systematically in our centre when NMLC is confirmed.

Statistical Analysis

All the variables were recorded and analysed using the data processing programme SPSS 15.0 for Windows, version 15.0.1, November 2006, created by LEAD Technologies Inc. The means are presented together with standard deviation, and a confidence interval of 95%. The frequencies are expressed as percentages.

Results

The study included 44 patients (75% male) with an average age of 62.2 (±9.8) years. The characteristics of the patient are shown in Table 1.

All patients presented mediasinal lymph node damage, visible in the CT or PET-CT scan images. In total, the clinical suspicion of malignant mediasinal damage was 82% (36/44) prior to the EBUS, in a population in which the incidence of malignant disease was 31.8% (14/44). The most prevalent malignancies, in decreasing order of frequency, were in renal neoplasms, cancer of the urinary bladder and of the lung. 18% of the patients presented mediastinal disease whose aetiology was uncertain. The endobronchial ultrasound-guided examination of the mediastinum revealed lymph nodes or mediastinal mass with a diameter of more than 5 mm in 38 patients (86.4%). Four patients presented an apparently normal mediastinum, despite indications to the contrary in the CT scan, 1 patient had a lymph node that was too small for aspiration and 1 patient had a lesion which could not be clearly identified for technical reasons, and from which samples could therefore not be obtained. Samples were obtained from more than one lymph node in 23 patients (52.3%). The lymph nodes from which most samples were obtained are shown in Table 2, with a total of 192 FNC passes and an average of 5 passes per patient.

Table 2
Technical Features of the EBUS-FNC.

Puncture of lymph gland	86.4% (38)
Sampling stations	
4R	18.5%
4L	6.2%
5	15.4%
7	29.2%
10R	10.8%
10L	9.2%
Endobronchial lesion	10.7%
Number of puncture sites	
No puncture	4.5% (2)
Only one site	43.2% (19)
2 or more sties	52.3% (23)
Total number of FNC applications	192
Average number of applications	5
Complications associated with the technique	4.5% (2)

In those cases in which aspiration was not carried out on any of the lymph glands, the sample was obtained by means of conventional bronchoscopy (bronchial biopsy, TBNA, broncial brushing and/or bronchoalveolar lavage) in the same intervention.

In only 2 patients (4.5%) were any complications recorded, including a light to moderate haemorrhage at the location of the aspiration. The bleeding could be brought under control locally with an ice-cold saline solution and aspiration, and neither further invasive measure nor intubation was required. In one of the patients with bleeding, uncontrolled hypertension occurred, which was attributable to failure to comply with the habitual antihypertensive treatment prior to the intervention. No more sever complications, and no deaths, occurred during the study period.

The analysis of the samples by the Cytopathology Department confirmed that all the aspirations carried out on lymph glands using the capillary technique provided sufficient representative material for an interpretation (Table 3), with a diagnostic result of 86.8%. The diagnostic sensitivity of the EBUS-FNC was 88% for interventions which produced sufficient samples, and 84.1% for the total number of interventions.

The final diagnosis was lung cancer in 61.4% (27/44) of the patients, with a greater incidence in men (81.5%), and in patients with tobacco-related antecedents (89.9%). Other diagnoses were metastasis in the lymph nodes, renal, skin and breast neoplasm, nontuberculosis mediastinal granulotamous lymphadenitis (2 cases), plasmocytoid cell tumour (1 case) and reactive lymphadenopathy with an obvious focus of infection (2 cases).

In 4 of the 7 cases in which EBUS-FNC did not permit a definitive diagnosis, the procedure applied to establish diagnosis was correlation with clinical antecedents, diagnostic image examination

Table 3
Analysis of Samples by Cytopathology Department.

Adequate sample	95.5% (42/44)
Puncture of lymph gland	38
Puncture in different location	4
EBUS-FNC diagnosis	84.1% (37/44)
Non microcytic lung cancer	24
Microcytic lung cancer	3
Lymph node metastases	5
Other diagnosis	5

and reports from the Cytopathology Department in relation to the samples.

Discussion

The diagnostic performance of the EBUS-TBNA depends on a number of factors, including the following: the availability of recent diagnostic images for an adequate planning of the intervention, adequate experience on the part of the staff involved, the availability of ROSE, obtaining an adequate representative sample from the lymph gland.[18–20,35–38] The conventional technique for obtaining samples using EBUS or TBNA requires the application of negative pressure.[20] The sample is obtained primarily by means of aspiration. It has been said that this method reduces the presence of inadequate samples by 5% or more.[22,38] Concerns about the influence of FNA on the quality of the sample were first voiced by Zajdela et al.[24] This author described contamination of the sample resulting from bleeding attribute to the wounding of the neighbouring tissue, which complicated the cytopathological evaluation of mammary samples obtained by means of FNA. FNC was recommended as an alternative means of obtaining samples. This method was introduced by Bradford in 1982 in a study of mammary carcinoma samples. This key study highlighted the fact that there is a good correlation between cytological samples obtained by means of FNC and histology.[23]

FNC is based on capillarity, a physical property of liquid and semi-liquid media which permits the surface of a liquid to flow spontaneously towards the interior of a capillary tube. This effect is the result of the cohesion forces, known as surface tension, which are present between the molecules of the liquid. The analysis of the liquid is directly proportional to the surface tension, and inversely proportional to the calibre of the tube.[39] FNC can be useful as a means of obtaining lymph node samples, as the cells are not bonded in a compact ultrastructure, which means that material can rise through the interior of the needle by capillarity as the stylet is withdrawn.[25] FNC can provide cellular material and its diagnostic usefulness is comparable to that of conventional FNA, according to data obtained in patients with breast cancer in the Curie Institute in France.[24] In comparative studies carried out on thyroid glands and the liver, a distortion of the cellular architecture of the samples obtained by conventional FNA has been described,[25,26] although no significant differences were observed in the diagnostic usefulness of FNC as opposed to FNA (sensitivity of 90% compared with 80%–90%).[25,40] FNC can be considered superior to FNA as contamination resulting from blood is minimal, and the cellular morphology is better preserved.[41,42] This serves to explain the greater diagnostic usefulness compared with FNA.[24,26,41–43]

The question of whether FNC is more advantageous than conventional FNA in EUS remains to be answered. Wallace and Storch did not observe any significant differences in terms of the quality or diagnostic usefulness of the samples obtained by means of EUS-FNA compared with FNC.[28,29] In Wallace's study, FNA was more likely to produce sanguineous samples, but it also produced more cellular samples than FNC.[28] The authors arrived at the conclusion that FNC results in a greater overall sample quality as less blood is present, although there were no differences in terms of the diagnostic usefulness. Puri et al., by contrast, described a greater sensitivity and negative predictive value in samples obtained by means of EUS-FNA than in those obtained by EUS-FNC (85.7% as opposed to 66.7%).[30]

One of the advantages of EUS-FNC compared with EUS-FNA could be the need for fewer needle passes. It has been pointed out that the optimal number of needle passes with conventional FNA is 5 for lymph glands and 7 for solid tumours, with an overall sensitivity of 77% and 83%, respectively, and a specificity of 100%.[44,45] Wallace, by contrast, suggests that 3 is the optimal necessary number for a diagnosis based on samples obtained by means of EUS-FNC.[28] Given that each needle pass takes between 3 and 5 min from beginning to end, fewer passes would substantially reduce the length of time required for the intervention and therefore the length of the sedation required, which could result in a smaller number of possible EUS complications.

Our study supports the use of FNC as a viable alternative to TBNA in the samples obtained by means of EBUS. Comparisons with historical data published so far suggest that the techniques are, to say the least, comparable, as regards their effectiveness in obtaining adequate samples and as regards diagnostic accuracy, given that 77%–100% of the samples obtained with EBUS-TBNA form, are adequate and/or diagnostic.[13,27,46] It is possible to argue that FNC is easier to as it avoids the need for needle aspiration, which simplifies the process of obtaining lymph gland samples in the mediastinum. There is a consensus among practitioners with experience in EBUS and conventional TBNA that EBUS-TBNA is a laborious technique which often requires at least two specialists in order to obtain a single sample, although there are some bronchoscopists who are used to applying the aspiration while they hold the needle and the bronchoscope with one hand. Simplifying the technique could be useful in EBUS examination of the mediastinum in an overburdened working environment in which the endoscopist has to deal with sedation, bronchoscopy, monitoring of the patient and the obtaining of tissue all at the same time.

To the best of our knowledge, this is the first study which systematically focuses on the obtaining of mediastinal samples with EBUS using FNC as opposed to conventional TBNA. One of the limitations of our study is the lack of comparisons between EBUS-FNC with conventional EBUS-TBNA. In this respect it should be seen as a hypothesis-generating study and proof of concept. Another serious limitation is the prevailing uncertainty regarding what constitutes an adequate sample. It should be pointed out that there are no established criteria in this regard. Consequently, the evaluation of a given sample as adequate or inadequate can be considered subjective; in that it depends on the criteria of the specialist, and may not be reproducible. By and large, little coincidence among observers appears to be the order of the day.[31]

Conclusions

Our study indicates that EBUS-FNC is a viable alternative to conventional EBUS-TBNA for obtaining mediastinal samples. The modified technique is safe and comparable, in terms of its effectiveness and its success in obtaining adequate samples, to everything that has been published in relation to the performance of EBUS-TBNA. It is arguable that EBUS-FNC is simpler than EBUS-TBNA and can be better in the sense that it can reduce the amount of time required for obtaining samples, and in terms of the complexity of the procedure. Whether EBUS-FNC provides better quality samples remains to be demonstrated by means of a prospective and randomised study.

Conflict of Interest

The authors have no conflict of interest to declare.

References

1. Herth F, Becker HD, Ernst A. Ultrasound-guided transbronchial needle aspiration. An experience in 242 patients. Chest. 2003;123:604–7.
2. Herth F, Becker HD, Ernst A. Conventional vs endobronchial ultrasound-guided transbronchial needle aspiration: a randomized trial. Chest. 2004;125:322–5.
3. Yasufuku K, Chiyo M, Sekine Y, Chhajed PN, Shibuya K, Iizasa T, et al. Real-time endobronchial ultrasound-guided transbronchial needle aspiration of mediastinal and hilar lymph nodes. Chest. 2004;126:122–8.
4. Rintoul RC, Skwarski KM, Murchison JT, Wallace WA, Walker WS, Penman ID. Endobronchial and endoscopic ultrasound-guided real-time fine needle aspiration for mediastinal staging. Eur Respir J. 2005;25:416–21.

5. Plat G, Pierard P, Haller A, Hutsebaut J, Faber J, Dusart M, et al. Endobronchial ultrasound and positron emission tomography positive mediastinal lymph nodes. Eur Respir J. 2006;27:276–81.
6. Herth FJ, Eberhardt R, Vilmann P, Krasnik M, Ernst A. Real-time endobronchial ultrasound-guided transbronchial needle aspiration for sampling mediastinal lymph nodes. Thorax. 2006;61:795–8.
7. Bauwens O, Dusart M, Pierard P, Faber J, Priqoqine T, Duysinx B, et al. Endobronchial ultrasound and value of PET for prediction of pathological results of mediastinal hot spots in lung cancer patients. Lung Cancer. 2008;61:356–61.
8. Yasufuku K, Nakajima T, Motoori K, Sekine Y, Shibuya K, Hiroshima K, et al. Comparison of endobronchial ultrasound, positron emission tomography, and CT for lymph node staging of lung cancer. Chest. 2006;130:710–8.
9. Detterbeck FC, Jantz MA, Wallace M, Vansteenkiste J, Silvestri GA. Invasive mediastinal staging of lung cancer: ACCP evidence-based clinical practice guidelines (2nd ed.). Chest. 2007;132 Suppl. 3:202s–20s.
10. Herth FJ, Eberhardt R, Krasnik M, Ernst A. Endobronchial ultrasound-guided transbronchial needle aspiration of lymph nodes in the radiologically and positron emission tomography-normal mediastinum in patients with lung cancer. Chest. 2008;133:887–91.
11. Gu P, Zhao Y, Jiang L, Zhang W, Xin Y, Han BH. Endobronchial ultrasound-guided transbronchial needle aspiration for staging of lung cancer: a systematic review and meta-analysis. Eur J Cancer. 2009;45:1389–96.
12. Adams K, Shah PL, Edmonds L, Lim E. Test performance of endobronchial ultrasound and transbronchial needle aspiration biopsy for mediastinal staging in patients with lung cancer: systematic review and meta-analysis. Thorax. 2009;64:757–62.
13. Varela-Lema L, Fernández-Villar A, Ruano-Rivano A. Effectiveness and safety of endobronchial ultrasound-transbronchial needle aspiration: a systematic review. Eur Respir J. 2009;33:1156–64.
14. Kennedy MP, Jimenez CA, Bruzzi JF, Mhatre AD, Lei X, Giles FJ, et al. Endobronchial ultrasound-guided transbronchial needle aspiration in the diagnosis of lymphoma. Thorax. 2008;63:360–5.
15. Garwood S, Judson MA, Silvestri G, Hoda R, Fraig M, Doelken P. Endobronchial ultrasound for the diagnosis of pulmonary sarcoidosis. Chest. 2007;132:1298–304.
16. Wong M, Yasufuku K, Nakajima T, Herth FJ, Sekine Y, Shibuya K, et al. Endobronchial ultrasound: new insight for the diagnosis of sarcoidosis. Eur Respir J. 2007;29:1182–6.
17. Oki M, Saka H, Kitagawa C, Tanaka S, Shimokata T, Kawata Y, et al. Real-time endobronchial ultrasound-guided transbronchial needle aspiration is useful for diagnosing sarcoidosis. Respirology. 2007;12:863–8.
18. Diette GB, White P, Terry P, Jenckes M, Rosenthal D, Rubin HR. Utility of on-site cytopathology assessment for bronchoscopic evaluation of lung masses and adenopathy. Chest. 2000;117:1186–90.
19. Diacon AH, Schuurmans MM, Theron J, Louw M, Wright CA, Brundyn K, et al. Utility of rapid on-site evaluation of transbronchial needle aspirates. Respiration. 2005;72:182–8.
20. Bolliger CT, Herth FJF, May PH, Miyasawa T, Beamis JF. Clinical chest ultrasound: from the ICU to the bronchoscopy suite. Progress in respiratory research, vol. 37. Basel, Switzerland: Karger AG; 2009. p. 147–59.
21. Thompson HD. Thin needle aspiration biopsy. Acta Cytol. 1982;26:262–3.
22. Das DK. Fine-needle aspiration cytology: its origin, development, and present status with special reference to a developing country, India. Diagn Cytopathol. 2003;28:345–51.
23. Briffod M, Gentile A, Hebert H. Cytopuncture in the follow-up of breast carcinoma. Acta Cytol. 1982;26:195–200.
24. Zajdela A, Zillhardt P, Voillemot N. Cytological diagnosis by fine needle sampling without aspiration. Cancer. 1987;59:1201–5.
25. Fagelman D, Chess Q. Non-aspiration fine needle cytology of liver: a new technique for obtaining diagnostic samples. AJR Am J Roentgenol. 1990;155: 1217–9.
26. Rizvi SA, Husain M, Khan S, Mohsin M. A comparative study of fine needle aspiration cytology versus non-aspiration technique in thyroid lesions. Surgeon. 2005;3:273–6.
27. Diaz J, Chawla M, Simoff M. Endobronchial ultrasound-guided transbronchial needle aspiration in the diagnosis of metastatic thyroid cancer. J Bronchol Intervent Pulmonol. 2009;16:70–1.
28. Wallace MB, Kennedy T, Durkalski V, Eloubeidi MA, Etamad R, Matsuda K, et al. Randomized controlled trial of EUS-guided fine needle aspiration techniques for the detection of malignant lymphadenopathy. Gastrointest Endosc. 2001;54:441–7.
29. Storch IM, Sussman DA, Jorda M, Ribeiro A. Evaluation of fine needle aspiration vs fine needle capillary sampling on specimen quality and diagnostic accuracy in endoscopic ultrasound-guided biopsy. Acta Cytol. 2007;51:837–42.
30. Puri R, Vilmann P, Săftoiu A, Skov BG, Linnemann D, Hassan H, et al. Randomized controlled trial of endoscopic ultrasound-guided fine-needle sampling with or without suction for better cytological diagnosis. Scand J Gastroenterol. 2009;44:499–504.
31. Skov BG, Baandrup U, Jakobsen GK, Kiss K, Krasnik M, Rossen K, et al. Cytopathologic diagnoses of fine needle aspirations from endoscopic ultrasound of the mediastinum: reproducibility of the diagnoses and representativeness of aspirates from lymph nodes. Cancer. 2007;111:234–41.
32. Mountain CF. A new international system for staging lung cancer. Chest. 1986;89 Suppl. 4:225s–33s.
33. Mountain C. Revisions in the international system for staging lung cancer. Chest. 1997;111:1710–7.
34. Davenport RD. Rapid on-site evaluation of transbronchial aspirates. Chest. 1990;98:59–61.
35. Fritscher-Ravens A. Endoscopic ultrasound evaluation in the diagnosis and staging of lung cancer. Lung Cancer. 2003;41:259–67.
36. Micames CG, McCrory DC, Pavey DA, Jowell PS, Gress FG. Endoscopic ultrasound-guided fine needle aspiration for non-small cell lung cancer staging. Chest. 2007;131:539–48.
37. Medford ARL, Bennett JA, Free CM, Agrawal S. Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA): applications in chest medicine. Respirology. 2010;15:71–9.
38. Cameron SEH, Andrade RS, Pambuccian SE. Endobronchial ultrasound-guided transbronchial needle aspiration citology: a state of the art review. Cytopathology. 2010;21:6–26.
39. Santos JEC, Leiman G. Non-aspiration fine needle cytology-application of a new technique to nodular thyroid disease. Acta Cytol. 1988;32:353–6.
40. Mair S, Dunbar F, Becker PJ, du Plessis W. Fine needle cytology: is aspiration suction necessary? A study of 100 masses in various sites. Acta Cytol. 1989;33:809–13.
41. Ghosh A, Misra RK, Sharma SP, Singh HN, Chaturvedi AK. Aspiration vs nonaspiration technique of cytodiagnosis—a critical evaluation in 160 cases. Indian J Pathol Microbiol. 2000;43:107–12.
42. Kate MS, Kamal MM, Bobhate SK, Kher AV. Evaluation of fine needle capillary sampling in superficial and deep-seated lesions. An analysis of 670 cases. Acta Cytol. 1998;42:679–84.
43. Baksh S, Masih K, Singh S, Das S. Diagnostic utility of fine needle non-aspiration cytology versus fine needle aspiration cytology in breast masses. Indian J Pathol Microbiol. 2004;47:319–21.
44. Ciaccia D, McGrath K, Kim I. Prospective evaluation of the increment sensitivity for diagnostic EUS-guided FNAB [abstract]. Gastrointest Endosc. 2002;56 Suppl.:S100–47.
45. LeBlanc JK, Ciaccia D, Al-Assi MT, McGrath K, Imperiale T, Tao LC, et al. Optimal number of EUS-guided fine needle passes needed to obtain a correct diagnosis. Gastrointest Endosc. 2004;59:475–81.
46. Jacob-Ampuero MP, Haas AR, Ciocca V, Bibbo M. Cytologic accuracy of samples obtained by endobronchial ultrasound-guided transbronchial needle aspiration at Thomas Jefferson University Hospital. Acta Cytol. 2008;52:687–90.