

Original Research Article

Diagnostic efficacy of FNAC by liquid based technique versus conventional smear in lung and mediastinal masses

Rekha Singh¹, Vani Mittal², Irbinder Kour Bali^{2*}, Sunil Arora², Raj Kumar²

¹Department of Pathology, Strand Life Sciences, Gurugram, Haryana, India

²Department of Pathology, FMHS and SGT Hospital, Gurugram, Haryana, India

Received: 26 May 2020

Accepted: 01 June 2020

*Correspondence:

Dr. Irbinder Kour Bali,

E-mail: irbinderkour@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Fine Needle Aspiration Cytology (FNAC) has proven to be less costly and less invasive procedure than biopsy for diagnosing benign and malignant lesions. Of the two methods liquid based cytology (LBC) and conventional cytology (CC), LBC has been standardized as more efficacious in reporting in Gynaecological cases. But, this is still lacking in non-gynaecological cases and many studies are now focusing on studying LBC due to its proven advantages in Pap smear evaluation.

Methods: An observational study of 72 patients with lung mass and 11 with mediastinal mass was done for a period of six months in a tertiary care hospital in Gurugram to compare the diagnostic efficacy of LBC and CC in fine needle aspirates from lung/mediastinal mass.

Results: Of the 83 cases, reporting of LBC was adequate in 75 cases and CC in only 53 cases. LBC was better when differentiating malignant and benign lesions than CC. CC smears had better cellularity in comparison to LBC smears (36%), but rest cytological features of cytoplasmic detailing, cell architecture, less background debris and blood were all more appreciable in LBC smears than CC preparations.

Conclusions: LBC is a better method than conventional smear for smear preparation and processing of aspirates obtained from lung and mediastinal mass.

Keywords: Conventional cytology, FNAC, Liquid based cytology, Lung mass, Mediastinal mass

INTRODUCTION

The most common cancer around the world is Lung cancer.¹ The key to the effectiveness of its treatment is early detection and diagnosis.² Early diagnosis is also required in order to differentiate the lesions which are benign or malignant, as their course of treatment differs considerably in thoracic lesions be it lung or mediastinal mass.^{3,4} Fine needle aspiration cytology has long been accepted as a quick, effective, low-cost and less traumatic technique for evaluation of lung neoplasm in correlation with clinical and radiological findings.⁵ For deep seated lesions, like those in the thoracic cavity, FNAC can be performed with the help of CT or USG guidance.⁶ The

FNA material can be processed by two methods i.e. conventional smear cytology (CC) and liquid based cytology (LBC). CC is still the majorly used technique in developing nations owing to its low cost, but there are many difficulties faced by pathologists in assessing smears processed by conventional method. These include obscuring elements such as blood, mucus and inflammatory cells overlapping, fixation artifacts, poor cell preservation, and non-uniform cell thickness.^{7,8}

LBC is an emerging method over CC in developed nations due to its established advantages in cervical cytology. LBC was started in 1996 for FNA evaluation and has several advantages like fewer unsatisfactory

smears, less obscuring materials such as blood, mucous, inflammatory cells in smears, less chances of air-drying artifacts, uniform cell thickness, and the use of residual material for cell block preparation for further testing such as immunocytochemistry (ICC), PCR and flow cytometry.⁹⁻¹² Liquid Based Cytology (LBC) has gained interest and popularity among pathologists in developed nations even in non-gynaecological specimens owing to its advantages over CC of increased sensitivity and specificity.^{13,14} Many studies have been reported in the literature on the utility of LBC techniques in FNAC of lymph node, thyroid, breast, salivary gland and abdominal aspirates also, but there is limited data on their role in lung aspirates and no guidelines has been established for the use of LBC in lung / mediastinal aspirates.¹⁵⁻¹⁹

The aim was this study was to assess the diagnostic efficacy of the liquid based cytologic test (LCT) and conventional smear cytology (CC) in fine needle aspirates of lung and mediastinal masses and to compare the cyto-morphological parameters.

METHODS

An observational study was undertaken for a period of 1 year from November 2019 to April 2020 at a tertiary care hospital in Gurugram. Ethical clearance was obtained prior to the study from the Institutional Ethics Committee. Patients who came to Pathology Laboratory and required Fine needle aspiration cytology from lung/mediastinal masses as a part of their management were included in this study after informed consent. Patients' clinical history and demographic data was obtained.

Inclusion criteria

- Patients with lung / mediastinal mass suspected to have neoplasm clinically and/or radiologically.

- Patients requiring CT guided transthoracic fine needle aspiration (TTFNA) and/or Endobronchial ultrasound guided needle aspiration (EBUS – TBNA) were included.

Exclusion criteria

- Patients with history of bleeding disorders, or with pulmonary hypertension.
- Patients already on chemotherapy or radiotherapy
- Patients with recurrence of lung/mediastinal mass.
- Patients with lung mass but were sputum positive for AFB.
- Patients whose corresponding biopsy was not available for histopathological confirmation of diagnosis.

In this study, we intended to compare the efficacy of liquid based cytology with conventional smears in FNA specimens from lung / mediastinal masses. Fine needle aspirates from the lung / mediastinal masses were collected by atleast 2-3 passes for adequate material and direct smears were made on clean glass slides from the first pass material. The second pass aspirate was rinsed into liquid based collection vial with methanol-based preservative solution, then sample was processed in Thin Prep 2000 and smears were made. Smears from both the techniques were fixed in 95% ethanol and stained with papanicolaou stain. The slides prepared from each of the technique were examined and reported by an experienced cytopathologist.

Slides were evaluated on the basis of diagnostic accuracy (benign, suspicious of malignancy, and malignant) and semiquantitative scoring of the cytomorphological features (cellularity, background including presence of blood/stromal material/ debris, monolayer, cellular architecture, nuclear details and cytoplasmic details) was done, which was evaluated by Wilcoxon's signed rank test.

Table 1: Semiquantitative scoring of the cytological features on FNAC smears prepared by LBC and CC method.²⁰

Cytological features	Score 0	Score 1	Score 2	Score 3
Cellularity	Nil	Scant	Adequate	Abundant
Background Debris	Nil	Occasional	Good Amount	Abundant
Blood	Nil	Occasional	Good Amount	Abundant
Monolayer	Absent	Occasional	Good Amount	-
Cell architecture	Non recognised	Moderately recognised	Well recognised	-
Cytoplasmic details	Poor	Fair	Good	Excellent
Nuclear details	Poor	Fair	Good	Excellent

The received corresponding bronchial biopsy was processed and stained with Haematoxylin and Eosin stain and IHC, and the diagnosis was taken as confirmatory. The diagnosis was made on the basis of WHO

Classification of the Tumors of the Lung, Pleura, Thymus and Heart, 2015.²¹ The data was tabulated and analysed using the SPSS software 23.0 for Windows 10. Statistical mean and standard deviation was calculated. Chi square

test was applied to compare the differences in the variables of the two groups and p value was calculated. A p value of less than 0.05 only was considered as statistically significant

RESULTS

In this study we included a total of 83 patients who had required FNAC investigation as a part of their management. Out of 83 patients, 72 had evidence of clinically / radiologically of lung mass and 11 had mediastinal mass. Of the 72 cases of lung mass, 11 were non malignant and rest 61 were malignant (31 adenocarcinoma, 16 squamous cell carcinoma, 5 small cell carcinoma, 4 carcinoid tumour, 2 adenosquamous, 1 large cell carcinoma and 2 poorly differentiated carcinoma) on histopathological diagnosis. Of the 11 mediastinal mass cases, only 1 was benign i.e. diagnosed as Schwannoma, rest 10 were malignant (7 lymphomas and 3 thymomas).

The age group of presenting patients varied from 32 - 76 years of age, with the mean age of 52.72 ± 10.31 years in the study. A majority of patients were in the age group of 41-60 i.e. 65.06%. Male predominance was observed in our study with 84.34% as compared to just 15.66% of female participants (Table 2).

All the patients (72) had the complaint of persistent cough in case of lung mass i.e. 100.00%, which was followed by chest pain in 52 (72.22%) patients and weight loss in 50 (69.44%) patients. Fatigue and hemoptysis were in comparison experienced by less number of patients with lung mass i.e. only 23 and 22 patients respectively. Among the patients who had mediastinal mass, 10 out of 11 patients had radiological evidence of anterior mediastinal mass, whereas only 1 had posterior mediastinal mass. These patients presented mainly with the complaint of retrosternal chest pain (90.91%) and only 1 had compression symptoms (Table 2).

Table 2: Demographic information.

Demographic Information			Patients (N=83)	Percentage
Age (in years)	31-40		09	10.84
	41-50		25	30.12
	51-60		29	34.94
	61-70		16	19.28
	71-80		04	4.82
	Mean \pm SD (age)		52.72 \pm 10.31	
Gender	Female		13	15.66
	Male		70	84.34
Clinical details and chief complaints	Lung mass (n=72)	Chest Pain	52	72.22
		Persistent cough	72	100.00
		Fatigue	23	31.94
		Hemoptysis	22	30.55
		Weight loss	50	69.44
	Mediastinal Mass (n=11)	Ant. Mediastinal mass	10	90.91
		Post. Mediastinal mass	1	9.09
		Retrosternal chest pain	10	90.91
		Compression symptoms	1	9.09

Table 3: Comparison of diagnostic adequacy between Liquid based Cytology (LBC) and Conventional cytology (CC).

Adequacy	LBC		CC		Chi-square value (X ²)	p-value*
	No.	Percentage	No.	Percentage		
Adequate	75	90.36	53	63.86	15.05	<0.001
Inadequate	8	9.64	30	35.14		
Total	83	100	83	100		

*p-value <0.05 considered as significant

Adequacy of the smears was assessed and comparison was done in between the two methods. Table 3 shows that the diagnostic adequacy of liquid based cytology was

more than 90% as compared to only 63.86% in case of conventional smear preparation. This finding was highly significant with $X^2 = 15.05$ and p value <0.001. Table 4

shows the comparison of the FNA diagnosis by LBC and CC in accordance with the histopathological diagnosis. Amongst the benign cases, LBC could diagnose all (100%) cases as correct as compared to only 81.81% by conventional method (p value <0.05). In cases of malignant tumors of lung, adenocarcinomas, squamous cell carcinomas, and poorly differentiated tumours were mostly classified correctly by both the methods, but if comparison is done, significance was found in cases of

adenocarcinomas and squamous cell carcinomas diagnosis by LBC and CC. Another significant finding was that on the LBC preparation less number of cases was typed as 'suspicious for malignancy' criteria i.e. 3.6% only as compared to 21.68% by conventional smear cytology reporting. Wrongly classified cases were also less by LBC reporting, only 3 cases, whereas 9 were wrongly classified in CC reporting.

Table 4: Concordance of FNAC diagnosis on Liquid based Cytology (LBC) and Conventional Cytology (CC) with histopathological diagnosis (n=83).

Histo - pathological diagnosis	No. of cases	LBC		CC		Chi-square value (X ²)	p-value*
		No.	Percentage	No.	Percentage		
Adenocarcinoma	31	30	96.77	25	80.65	17.72	0.001
Squamous cell Carcinoma	16	15	93.75	9	56.25	5.74	0.017
Small cell Carcinoma	5	4	80	2	40	2.04	0.153
Large cell Carcinoma	1	0	0	0	0	0.00	1.000
Carcinoid Tumor	4	2	50	1	50	1.56	0.212
Adenosquamous carcinoma	2	2	100	1	50	0.83	0.361
Poorly differentiated carcinoma	2	2	100	2	100	1.50	0.221
Lymphoma	7	7	100	7	100	3.24	0.072
Thymoma	3	3	100	0	0	5.00	0.254
Schwannoma	1	1	100	0	0	1.00	0.317
Suspicious for malignancy	-	3		18		13.63	0.001
Wrong classified		3		9		7.26	0.007
Non-Malignant/ Benign Lung mass	11	11	100	9	81.82	4.96	0.026

* p-value <0.05 considered as statistically significant

Table 5: Comparison of the conventional and liquid based preparations on the basis of cytomorphological features on the smear.

Cyto-morphological Features	Total	CC = LBC		LBC > CC		CC > LBC		Chi-square value (X ²)	p-value*
		No.	Percentage	No.	Percentage	No.	Percentage		
Cellularity	83	28	33.73	19	22.89	36	43.37	12.23	0.001
Blood	83	1	1.20	3	3.61	79	95.18	0.88	0.348
Background	83	0	0.00	3	3.61	80	96.39	2.84	0.092
Monolayer	83	5	6.02	78	93.98	0	0.00	5.12	0.024
Cell Architecture	83	16	19.28	66	79.52	1	1.20	13.23	0.001
Cytoplasmic details	83	8	9.64	75	90.36	0	0.00	6.44	0.011
Nuclear details	83	6	7.23	75	90.36	2	2.41	2.31	0.129

*p-value <0.05 taken as significant

Table 5 evaluates the cytomorphological features assessed by the pathologist on the smears made by LBC and CC preparation. Wilcoxon Rank test of semiquantitative scoring was done to assess these features. More than 95% of CC smears had blood and debris in their background in comparison to LBC smears. LBC was better than CC in assessing the cell architecture (79.52%), cytoplasmic detailing (90.36%) and monolayer

of cells seen (93.98%) cases. CC was better than LBC in cellularity obtained on the smears i.e. by 43.37%.

DISCUSSION

CT guided transbronchial fine needle aspiration and EBUS-TBNA are well known techniques for diagnosing lesions of the lung and mediastinum. The merits include

minimally invasive nature of these techniques; outpatient based techniques, low cost, provides accurate diagnosis for lung cancers and provides samples for ancillary techniques also.²² The techniques are highly effective only if the sample is processed properly in the laboratory, which can be done by conventional method or by liquid based cytology method.

LBC is an automated cytopreparatory technique whose use has been now widely seen in gynecological specimens as studies have been reported in the literature documenting the benefits LBC over conventional method in tumor diagnoses in gynaecological specimens.^{23,24} For this reason, evaluation of LBC for non-gynae specimens has been on increase for the past decade.¹⁰ Researchers have found Thin prep as better smear preparation method than conventional method in aspirates from breast, salivary gland, endocrine, gastrointestinal, urinary and pulmonary lesions, but it lacks standardization due to only few studies reported in the literature.^{15,25}

The mean age was 52.72 years in our study for patients with lung/mediastinal mass, which is in accordance with the mean age of lung cancers as 52.16 years in India. There was a male predominance seen in ratio of 5.38:1 which was similar to study by Gangopadhyay M et al where it was 10:1. They attributed it to more predisposing factors like smoking, COPD and alcoholism in males.²⁶

The most common symptom in lung cancers was persistent cough (100% cases) followed by chest pain (72.22%), the same attributing to the chief symptoms of almost all the lung cancers in India.²⁷ Amongst the radiologically detected lesions of the mediastinum, mostly were seen in the anterior mediastinum with patients presenting with retrosternal chest pain as their chief complaint. Patient with posterior mediastinal lesion had complaint of compression symptoms also. Similar was observed in the study by Dixit R.⁴ The diagnostic accuracy was 100% and 63.63% by LBC and CC technique of the mediastinal masses. This was well related with the findings of studies by Shaheen et al and Güllüoglu et al.^{28,29}

Thin prep smears were adequate for evaluation in 90.36% (75) cases. Conventional smears made from aspirates of only 53 patients (63.86%) were adequate to make a diagnosis. These findings were in accordance with study by Singh G et al.³⁰ However, in studies by Salhadar et al and Choudhury M et al, 98% and 100% of conventional smears and 64% and 86.7% of Thin Prep slides were found adequate for evaluation from the fine needle aspirates obtained from 50 and 30 patients respectively.^{31,19} There were 61 cases of lung cancers included in our study of which 91.8% were NSCLC which was similar to study by Molina et al with 85% of NSCLC in their study.³² Amongst the NSCLC, majority (55.35%) cases were of adenocarcinoma followed by 28.5 % cases of squamous cell carcinoma, which was similar to other studies.^{26,30}

On comparison of FNAC diagnosis on CC and LBC with respect to corresponding histopathological diagnosis, a significantly better result in case of adenocarcinomas was shown by LBC over CC (p value = 0.001), which correct diagnosis in 30 and 25 cases respectively out of 31 cases. (Table 3) Similarly, there was also a significant difference in the detection rates by conventional smear and LBC smear for squamous cell carcinoma (p value = 0.017), i.e. 56.25% and 93.75%; which was well related to findings by the study of Yang Y et al where detection rates were 41.7% and 72.7%, respectively (p value=0.041).⁷

Majority of the benign lesions were also diagnosed correctly by LBC smears in comparison to CC smears, p value = 0.026 was statistically significant. This was in concordance with the study by Singh G et al.³⁰ LBC smear reporting also showed significant reduction in suspicious for malignant cases as well as were better in tumor typing than CC smears' reporting, p value <0.05 (Figure 1). Diagnostic concordance with histology comparable for techniques as far as lymphomas and poorly differentiated carcinomas were concerned (100% by LBC as well as by CC). Cases of thymoma and schwannoma were correctly identified by LBC but not on CC smear, but difference was not significant, may be owing to the fact that only 3 and 1 case was reported in the study.

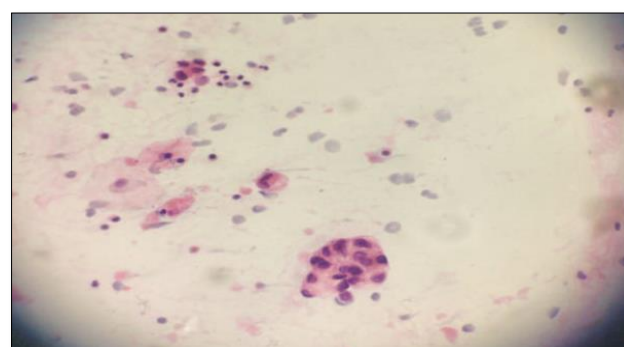


Figure 1: CC preparation smear in a case of squamous cell carcinoma shows? atypical keratinised cells - S/o Suspicious of Malignancy (Pap stain x400).

The cellularity on LBC slides and conventional slides was equivalent in 33.73% (28) cases, significantly better on conventional in 43.37% (36) with p value = 0.001, and better on LBC in 22.89% (19) cases only. These findings were similar with those of Warren et al, wherein cellularity was equivalent on both preparations in 54%, better on conventional in 34%, and better on Thin Prep in 12% cases.¹⁷

The cell architectural pattern observed in the different lesions was equally well recognized on the conventional smears and LBC preparations in 19.28% (16) and was significantly better recognized on LBC smears (Figure 2) in 79.52% (66) cases (p value = 0.001). Conventional cytology was only better in one case than LBC smear

with regards to architecture. These findings were consistent with those of Tripathy K who also observed the Wilcoxon's signed rank test in FNA of different lesions.²⁰

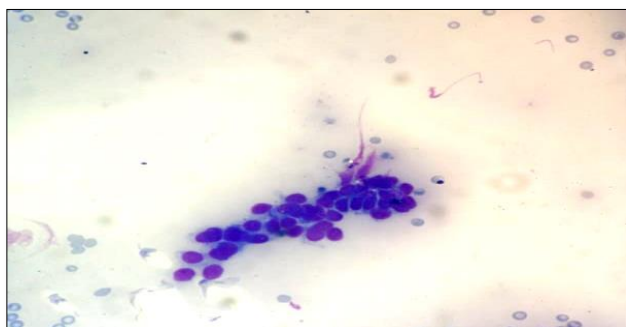


Figure 2: LBC preparation showing malignant cells with high N:C ratio and irregular nuclear contours and well recognized cell architecture, s/o squamous cell carcinoma (Pap stain x600).

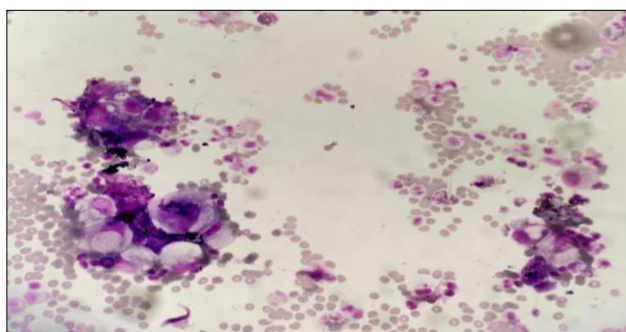


Figure 3: CC preparation of adenocarcinoma, showing clusters of adenocarcinoma admixed in the background of debris and blood (Pap stain x400).

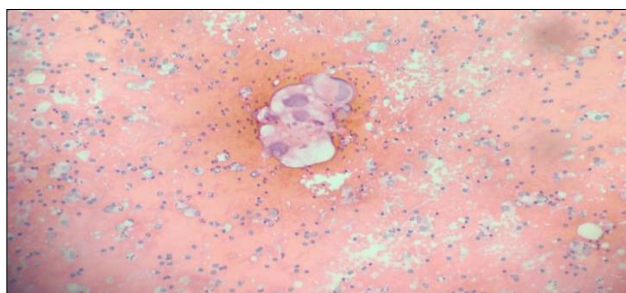


Figure 4: CC preparation of adenocarcinoma, showing a single cluster of adenocarcinoma admixed in the background of inflammation and blood (Pap stain x100).

The background containing debris and smears contaminated with blood was very less on Thin Prep slides in comparison to CC slides (Figure 3, 4) i.e. absent in 96.39% (80) and 95.18% (79) cases of LBC smears respectively and was equivalent on both the preparations in only 1 case (Figure 5). Only 3 of the conventional slides showed a cleaner background than LBC slides. The

difference was although not statistically significant. These findings were in agreement with studies by Leung et al, Choudhury et al who found that background was better on LBC in 75% and 76.6%, equivalent on both the preparations in 21% and 23.3% and was better on conventional smears in only 4% and 0% cases respectively.^{14,19} Studies by Moon SH et al, Li D et al and Els Sheikh TM et al also observed that the background was cleaner on LBC and cellularity was decreased, which is in agreement with our study.³³⁻³⁵

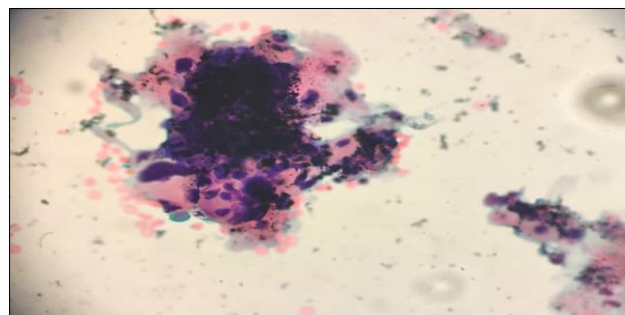


Figure 5: CC preparation of a case of SCC showing atypical keratinised cells entrapped in inflammatory exudates and blood (Pap stain x600).

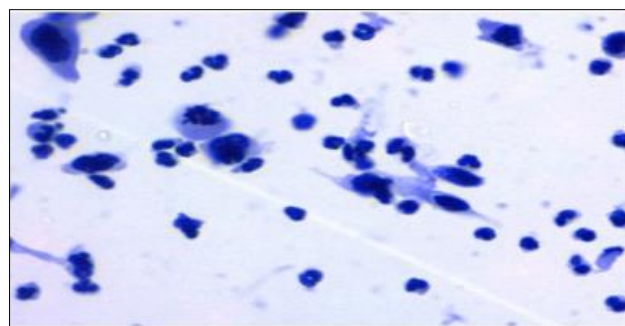


Figure 6: LBC preparation of lung mass in a case of SCC showing malignant cells with marked pleomorphism, high N:C ratio, irregular nuclear contours, dense cytoplasm and prominent nucleoli (Pap stain x600).

The LBC smears showed significantly good amount of monolayered distribution of cells in comparison to CC smears, p value = 0.024. Similar finding was also interpreted by other authors in their studies.^{36,37}

The cytoplasm was significantly better preserved in Thin Prep preparations in 90.36% (75) cases and equally well preserved on both preparations in 9.64% (8) cases. None of the conventional smears showed better cytoplasmic preservation than LBC slides. The nuclear details were better preserved in LBC smears (Figure 6) in 90.36% (75), equally well preserved on both the preparations in 7.23% (6), and better on conventional in 2.41% (2) cases. This difference was not statistically significant though (p value = 0.129). This finding was well versed with the studies by Singh G et al and Imura J et al, where they

attributed the reason behind this to the immediate delivery of material in preservative fluid leading to preservation of nuclear details.^{30,38}

In our study we found that overall cytomorphological features like cell architecture, monolayer, cytoplasmic details and nuclear details were well preserved better on LBC smears than conventional with clearer background in the former, but cellularity was one thing which was better observed in conventional smears. This was also similar to study by Lee et al where the cytological preservation was better on Thin Prep in 76%, better on conventional in 3%, and equivalent on both in 21% cases.³⁹ This observation was however in contradiction with studies like Michael et al and Choudhury et al.^{9,19}

LBC may be is better than CC for reporting of aspirates from lung and mediastinal mass and offers an advantage of carrying out ancillary studies from the left over material for further diagnostic work up, there are limitations to use of LBC owing to it high cost, loss of background during processing and a learning experience needs to be acquired by the pathologist for its interpretation.

CONCLUSION

We concluded that liquid based cytology gives better results in terms of diagnostic accuracy as well as well preservation of cytomorphological parameters, in comparison to conventional smear cytology method. Also, LBC helped reduced the unsatisfactory results and increased the yield of both benign as well as malignant lesions. Although LBC has proven advantages over conventional method in cervical smear cytology, there is still lack of solid evidence of the same in thoracic lesions due to disparity in findings by the researchers. So, there is still an ongoing debate as to which method to be standardized for processing the aspirates from masses in the thoracic cavity and hence, this study will contribute to the literature when these two methods are evaluated for efficacy of FNA diagnosis in lung and mediastinal mass.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Ferlay J, Soerjomataram I, Dixit R, Eser S, Mathers C, Rebelo M, et al. Cancer Incidence and Mortality Worldwide: Sources, Methods and Major Patterns in GLOBOCAN 2012. *Int J Cancer*. 2015;136(5):E359-86
2. Liu C, Wen Z, Li Y, Peng L. Application of Thin Prep bronchial brushing cytology in the early diagnosis of lung cancer: A retrospective study. *Plos One*. 2014;9:e90163
3. Hasanovic A, Rekhtman N, Sigel CS, Moreira AL. Advances in fine needle aspiration cytology for the diagnosis of pulmonary carcinoma. *Pathol Res Int*. 2011;897292
4. Dixit R, Shah NS, Goyal M, Patil CB, Panjabi M, Gupta RC, et al. Diagnostic evaluation of mediastinal lesions: Analysis of 144 cases. *Lung India*. 2017;34:341-8.
5. Kobayashi Y, Uehara T, Ota H. Liquid based thin layer cytology can be routinely used in samples obtained via fiberoptic bronchoscope. *Acta Cytol*. 2011;55:69-78.
6. Beslic S, Zukic F, Milisic S. Percutaneous transthoracic CT guided biopsies of lung lesions; fine needle aspiration biopsy versus core biopsy. *Radiol Oncol*. 2012;46(1):19-2.
7. Yang Y, Zhang X, Lu J, Haidong H. Application of liquid based cytology test of bronchial lavage fluid in lung cancer diagnosis. *Thorac cancer*. 2013;4:318-22.
8. Qiu T, Zhu H, Cai M, Han Q, Shi J, Wang K. Liquid-Based Cytology Preparation Can Improve Cytological Assessment of Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration. *Acta Cytol*. 2015;59:139-43.
9. Michael CW, Hunter B. Interpretation of fine-needle aspirates processed by the Thin Prep® technique: cytologic artifacts and diagnostic pitfalls. *Diagn Cytopathol*. 2000;23:6-13.
10. Gibb RK, Martens MG. The impact of liquid-based cytology in decreasing the incidence of cervical cancer. *Rev Obstet Gynecol*. 2011;4(Suppl 1):S2-S11.
11. Fremont-Smith M, Marino J, Griffin B, Spencer L, Bolick D. Comparison of the Surepath™ Liquid based Papanicolaou smear with the conventional Papanicolaou smear in a multisite direct to vial study. *Cancer*. 2004;104:269-79.
12. Choi YD, Han CW, Kim JH, Oh IJ, Lee JS, Nam JH, et al. Effectiveness of sputum cytology using ThinPrep method for evaluation of lung cancer. *Diagn Cytopathol*. 2008;36:167-71.
13. Hoda RS. Non-gynecologic cytology on liquid-based preparations: A morphologic review of facts and artifacts. *Diagn Cytopathol*. 2007;35:631-4.
14. Leung CS, Chiu B, Bell V. Comparison of ThinPrep and conventional preparations: Nongynecologic cytology evaluation. *Diagn Cytopathol*. 1997;16:368-71.
15. Singh P, Rohilla M, Dey P. Comparison of liquid-based preparation and conventional smear of fine-needle aspiration cytology of lymph node. *J Cytol*. 2016;33(4):187-91.
16. Nasuti JF, Tam D, Gupta PK. Diagnostic value of liquid based (ThinPrep) preparations in nongynecologic cases. *Diagn Cytopathol*. 2001;24:137-41.
17. Warren GP, Gatscha EM, Saigo PE. A comparison of non gynecologic specimens prepared by ThinPrep to conventional methods, direct smears, cytospin

- preparations and cell blocks. *Acta Cytol.* 1994;38:824.
18. Parfitt JR, McLachlin CM, Weir MM. Comparison of ThinPrep and conventional smears in salivary gland fine-needle aspiration biopsies. *Cancer.* 2007;111:123-9.
19. Choudhury M, Pahwa AR. Comparison of liquid-based cytology with conventional cytology in the evaluation of abdominal masses. *Indian J Pathol Microbiol.* 2020;63(1):73-7.
20. Tripathy K, Misra A, Ghosh JK. Efficacy of liquid-based cytology versus conventional smears in FNA samples. *J Cytol.* 2015;32(1):17-20.
21. Travis WD, Brambilla E, Burke AP, Marx A, Nicholson AG, editors. *WHO Classification of Tumours of Lung, Pleura, Thymus and Heart.* 4th edition. Lyon: IARC; 2015
22. Madan K, Dhungana A, Mohan A, Hadda V, Jain D, Arava S, et al. Conventional transbronchial needle aspiration versus endobronchial ultrasound-guided transbronchial needle aspiration, with or without rapid on-site evaluation, for the diagnosis of sarcoidosis: A randomized controlled trial. *J Bronchology Interv Pulmonol.* 2017;24:48-58.
23. Cox JT. Liquid based cytology: Evaluation of effectiveness, cost effectiveness, and application to present practice. *J Natl Compr Canc Netw.* 2004;2:597-611.
24. Akamatsu S, Kodama S, Himeji Y, Ikuta N, Shimagaki N. A comparison of liquid based cytology with conventional cytology in cervical cancer screening. *Acta Cytol.* 2012;56:370-4.
25. Joseph L, Edwards JM, Nicholson CM, Pitt MA, Howat AJ. An audit of the accuracy of fine needle aspiration using a liquid-based cytology system in the setting of a rapid access breast clinic. *Cytopathol.* 2002;13:343-9.
26. Gangopadhyay M, Chakrabarti I, Ghosh N, Giri A. Computed tomography guided fine needle aspiration cytology of mass lesions of lung: Our experience. *Indian J Med Paediatr Oncol.* 2011;32(4):192-6.
27. Noronha V, Pinninti R, Patil VM, Joshi A, Prabhash K. Lung cancer in the Indian subcontinent. *South Asian J Cancer.* 2016;5(3):95-103.
28. Güllüoglu MG, Kiliçaslan Z, Toker A, Kalayci G, Yilmazbayhan D. The diagnostic value of image guided percutaneous fine needle aspiration biopsy in equivocal mediastinal masses. *Langenbecks Arch Surg.* 2006;391:222-7.
29. Shaheen MZ, Sardar K, Murtaza HG, Safdar SS, Hafeez A, Mushtaq MA, et al. CT guided trans-thoracic fine needle aspiration/biopsy of mediastinal and hilar mass lesions: An experience of pulmonology department at a tertiary care teaching hospital. *Pak J Chest Med.* 2008;12:26-38.
30. Singh G, Agarwal P, Goel MM, Kumar M, Singh DP. Conventional vs. Liquid Based Cytology in Fine Needle Aspirates of Lung and Mediastinal Masses. *J Pulm Respir Med.* 2017;7:400.
31. Sallhadar A, Massarini-Wafai R, Wojcik EM. Routine use of Thin Prep® method in fine-needle aspiration material as an adjunct to standard smears. *Diagn Cytopathol* 2001;25:101-3.
32. Molina JR, Yang P, Cassivi SD, Schild SE, Adjei AA. Non-small cell lung cancer: epidemiology, risk factors, treatment, and survivorship. *Mayo Clin Proc.* 2008;83:584-94.
33. Moon SH, Seo DW, Kim JW, Gong G, Eum J, Song TJ, et al. Utility of liquid based cytology in the evaluation of endoscopic ultrasound guided fine needle aspiration: Comparison with the conventional smears. *Gastrointest Endosc.* 2010;71:AB292.
34. Li D, Wan T, Su Y, Ding M, Wu J, Zhao Y. Liquid-based cytological test of samples obtained by catheter aspiration is applicable for the bronchoscopic confirmation of pulmonary malignant tumors. *Int J Clin Exp Pathol.* 2014;7:2508-1.
35. Elsheikh TM, Kirkpatrick JL, Wu HH. Comparison of ThinPrep and Cytospin preparations in the evaluation of exfoliative cytology specimens. *Cancer.* 2006;108:144-9.
36. Rana DN, O'Donnell M, Malkin A, Griffin M. A comparative study: Conventional preparation and ThinPrep 2000 in respiratory cytology. *Cytopathol.* 2001;12:390-8.
37. Astall E, Atkinson C, Morton N, Goddard MJ. The evaluation of liquid based CytoSED cytology of BAL specimens in the diagnosis of pulmonary neoplasia against conventional direct smears. *Cytopathology.* 2003;14:143-9.
38. Imura J, Abe K, Uchida Y, Shibata M, Tsunematsu K, Sathoh M, et al. Introduction and utility of liquid-based cytology on aspiration biopsy of peripheral nodular lesions of the lung. *Oncol Lett.* 2014;7:669-73.
39. Lee KR, Papillo JL, St John T, Eyerer GJ. Evaluation of the ThinPrep processor for fine needle aspiration specimens. *Acta Cytol.* 1996;40:895-9.

Cite this article as: Singh R, Mittal V, Bali IK, Arora S, Kumar R. Diagnostic efficacy of FNAC by liquid based technique versus conventional smear in lung and mediastinal masses. *Int J Res Med Sci* 2020;8:2413-20.