

Comparative Study of Conventional Cytological Smear and Liquid Based Cytology in Thyroid Lesions

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Abstract:

Objective: To study and compare conventional pap smear and liquid based cytology according to Bethesda System in thyroid lesion.[By aspiration and non-aspiration techniques.]

Methods: The present study was conducted as an observational cross-sectional study on total of 102 cases presented with thyroid swelling to study and compare conventional pap smear and liquid based cytology by aspiration technique according to Bethesda System in thyroid lesion and to study and compare conventional cytological smear by non- aspiration technique and Liquid Based Cytology by aspiration technique in Thyroid Lesions.

Results: All the Bethesda category I smear were found to be acellular. Only follicular cells were observed in majority of smears belonging to Bethesda category II (53.9%). Majority of swellings belonged to Bethesda category II (84.3%) and the most common diagnosis was colloid goitre (54.9%) with FC singly and in clusters on CS. On LBC smears, majority of swellings belonged to Bethesda category II (92.2%) and the most common diagnosis was colloid goitre (69.6%) with FC singly and in clusters. LBC could identify benign follicular lesion, hyperplastic nodule, follicular neoplasm and papillary carcinoma in 100% cases. LBC could identify colloid goitre in 98.2% cases, Hashimoto's thyroiditis in 88.9% cases. However, 36.4% smears were correctly identified by LBC which were unsatisfactory on CS.

Conclusion: To conclude, LBC can be used as complementary to Conventional smear rather than replacing it. The residual material in LBC can be used for immunocytochemistry in suspected cases of malignancy.

Keywords: Bethesda System, Thyroid lesion, Follicular lesion, Hyperplastic nodule, Follicular neoplasm and Papillary carcinoma

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Introduction

As per Globocan 2020, thyroid cancers are ninth most common cancers in both sexes worldwide with incidence rate of 0.68 in both sexes i.e. 1.02 in women and 0.33 in men globally. [1-3] Thyroid cancers are 19th most common cause of cancer in India and its incidence was documented to be 1.5%. [4,5]. Thyroid cancers are associated with multiple risk factors such as female gender, radiation exposure during childhood, family history of thyroid cancer, etc. The most common presentation of thyroid cancer is nodule or lump in the neck. [6] Depending upon the size of thyroid nodule, patient may present with difficulty in breathing, dysphagia, hoarseness of voice, Horner's Syndrome or non-specific symptoms such as anorexia, fatigue, weight loss, fever etc. [7,8]

The initial diagnostic workup of thyroid malignancy include evaluation of thyroid functions. A nuclear medicine imaging examination (thyroid uptake and

scan) should be done if a TSH is subnormal (hyperactive thyroid), to determine if the nodule itself is hyperfunctioning (hot), isofunctioning (warm), or nonfunctioning (cold) relative to the surrounding thyroid tissue. [9,10] Fine-needle aspiration (FNA) will be required for the cytologic assessment of non-functioning nodules. The result of FNAC is reported according to Bethesda criteria for reporting thyroid cytology, which helps in classifying the biopsy results and recommends further course of action. [11] However, the FNAC has certain limitations. The diagnosis of FTC may thus only be determined from the final pathology following surgical resection, despite the fact that FNA might classify some results as suspicious for FTC. [12,13]

Conventional smears have been used as the gold standard method in cytology for diagnosis of malignant lesions. The aspirated material is used to

create variable number smears. Screening of the prepared smears slides is often time consuming and laborious task for cytologists. Technical factors, such as incorrect smear preparation and fixation that results in poor retention of cellular features, contribute to the issue. The reporting of the smears is hampered by thick smears, cellular overlapping, and concealing inflammatory infiltration. [14] To overcome the limitations of conventional smears, Liquid-based cytology (LBC) was introduced. Though LBC was introduced initially for gynaecological cervical smears, but recently its utility have been reported in both non gynecological smears and FNAC obtained material. [15] In this technique, cells are suspended in a preservative liquid. SurePath and ThinPrep are two FDA-approved procedures. The cells obtained from liquid based preparations are devoid of any obscuring elements and are dispersed evenly. [16]

For the examination of thyroid fine needle aspirations, there is debate regarding the relative worth of liquid-based preparations (LBPs) against conventional smears (CS). The simplicity, low cost, and retention of crucial background information that might be lost in LBPs are all points of emphasis for CS proponents. However, due to inconsistent slide preparation and fixation, CS is laborious and time-consuming to screen. The benefits of LBC include increased sensitivity and specificity due to greater fixation and the preservation of nuclear features. Other epithelial or inflammatory cells do not obscure or dilute abnormal cells. Remaining material in the fixative solution enables the performance of ancillary studies, such as immuno-histochemistry. [17]

With the above background, the present study was conducted at tertiary care centre to study and compare conventional pap smear and liquid based cytology by aspiration technique according to Bethesda System in thyroid lesion and to study and compare conventional cytological smear by non-aspiration technique and Liquid Based Cytology by aspiration technique in Thyroid Lesions.

Materials and methods

Study design: Cross sectional (observational study)

Study area: Department of Pathology, Gandhi Medical College, & associated Hospitals (Hamidia Hospital) Bhopal

Study population: new patients with thyroid swelling presenting at the study area during the study period.

Study duration: 1 year i.e. 1st August 2022 to 31st July 2023.

Sample size: All patients with thyroid swellings presenting at the study area during the study period.

Inclusion Criteria

- All the patients presented to the cytology section, pathology department, GMC, Bhopal.

Exclusion Criteria

- Patient not willing to give consent for the study.

Methodology

After obtaining ethical clearance from Institute's ethical committee, all the patients presenting at the study area fulfilling the inclusion criteria were enrolled and consent was obtained. Patients' files were reviewed for age, sex, size and duration of the lesions, imaging data if available. Data regarding thyroid function test and thyroid ultrasonography was documented in proforma. FNAC of the thyroid nodule was done using aseptic precautions and lesions was aspirated in the cytology unit. A minimum of two passes were taken from each lesion.

The material for LBC was submerged in solution Eziprep preservative solution for LBC. Finally, the conventional smears and LBC preparation were evaluated. The following cytomorphologic features were evaluated, scored, and recorded in each case for both the LBC and CS slides according to the Bethesda system.

Observation Chart

Table 1: Distribution according to diagnosis on conventional smear by aspiration biopsy

Diagnosis	Frequency (n=102)	Percentage
Unsatisfactory	11	10.8
Benign follicular lesion	2	2.0
Colloid cyst	12	11.8
Colloid Goitre	56	54.9
Hashimoto's Thyroiditis	9	8.8
Hyperplastic nodule	6	5.9
Subacute granulomatous thyroiditis	1	1.0
AUS	1	1.0
Follicular Neoplasm	3	2.9
Papillary Carcinoma	1	1.0

Majority of cases with thyroid swelling were diagnosed as colloid goitre (54.9%), whereas about

11.8% swellings were due to colloid cyst and 10.8% smears were unsatisfactory. About 8.8% cases were

Hashimoto's thyroiditis, 5.9% were hyperplastic nodule, 2.9% were follicular neoplasm and 2% cases were benign follicular lesion. 1 case each was due to

Subacute granulomatous thyroiditis, AUS and Papillary carcinoma.

Table 2: Distribution according to cellularity on LBC smears

Cellularity	Frequency (n=102)	Percentage
Acellular	4	3.9
Benign follicular cell in microfollicles	1	1.0
Follicular cells in microfollicles and 3D clusters, nuclear overlapping, irregular nuclear membrane	3	2.9
Follicular Cells in sheets and clusters, anisonucleosis, Oxyphilic cells and lymphocytes	8	7.8
Follicular Cells in sheets, hypercellular, anisonucleosis	7	6.9
Follicular cells singly and in clusters	71	69.6
Follicular cells seen	3	2.9
Macrophages	4	3.9
Papillary fragment seen with intranuclear pseudoinclusion	1	1.0

In majority of smears, follicular cells were seen singly and in clusters (69.6%). In about 7.8% cases, follicular Cells in sheets and clusters with anisonucleosis, Oxyphilic cells and lymphocytes were observed. 6.9% smears showed follicular cells in sheets, hypercellular and anisonucleosis whereas

macrophages were observed in 3.9% cases. However, Follicular cells in microfollicles and 3D clusters, nuclear overlapping, irregular nuclear membrane were observed in 2.9% cases. Papillary fragment seen with intranuclear pseudoinclusion was observed in 1 case.

Table 3: Distribution according to the Bethesda system for reporting thyroid cytopathology (TBSRTC) and cellularity of smear based upon non aspiration cytology

Bethesda Category	Cellularity	Frequency (n=102)	Percentage
I	Acellular	43	42.1
II	Follicular cells with anisonucleosis, Oxyphilic cells	2	2.0
	Follicular cells with Lymphocytes	2	2.0
	Follicular cells seen	55	53.9

All the Bethesda category I smear were found to be acellular. Only follicular cells were observed in majority of smears belonging to Bethesda category II (53.9%). In about 2% cases each belonging to Bethesda category II, Follicular cells with anisonucleosis, Oxyphilic cells and Follicular cells with Lymphocytes were observed.

Table 4: Distribution according to the Bethesda system for reporting thyroid cytopathology (TBSRTC), diagnosis and cellularity of smear based upon aspiration cytology

Bethesda Category	CS aspiration cellularity	CS diagnosis	Frequency (n=102)	Percentage
I	Acellular	Unsatisfactory	11	10.8
II	Benign follicular cells singly and in microfollicles	Benign follicular lesion	2	2.0
	FC singly and in clusters	Colloid cyst	12	11.8
	FC singly and in clusters	Colloid Goitre	56	54.9
	FC in sheets and clusters, anisonucleosis, Oxyphilic cells and lymphocytes	Hashimoto's Thyroiditis	9	8.8
	FC in sheets, hypercellular, anisonucleosis	Hyperplastic nodule	6	5.9
	FC in sheets, epitheloid cells, granuloma, giant cells	Subacute granulomatous thyroiditis	1	1.0
III	FC in 3-d clusters, mild anisonucleosis	AUS	1	1.0
IV	FC in microfollicles and 3D clusters, nuclear overlapping, irregular nuclear membrane	Follicular Neoplasm	3	2.9
VI	Papillary fragment seen, intranuclear pseudoinclusion	Papillary Carcinoma	1	1.0

Above table reveal that majority of swellings belonged to Bethesda category II (84.3%) and the most common diagnosis was colloid goitre (54.9%) with FC singly and in clusters. About 3 cases belonged to category IV (follicular neoplasm) whereas 1 case each belonged to category III (AUS) and VI (papillary carcinoma).

Table 5: Distribution according to the Bethesda system for reporting thyroid cytopathology (TBSRTC), diagnosis and cellularity of smear based upon LBC smears

Bethesda Category	CS aspiration cellularity	CS diagnosis	Frequency (n=102)	Percentage
I	Acellular	Unsatisfactory	4	3.9
II	Benign follicular cells singly and in microfollicles	Benign follicular lesion	4	3.9
	FC singly and in clusters	Colloid cyst	4	3.9
	FC singly and in clusters	Colloid Goitre	71	69.6
	FC in sheets and clusters, anisonucleosis and lymphocytes	Hashimoto's Thyroiditis	8	7.8
	FC in sheets, hypercellular, anisonucleosis, Oxyphilic cells	Hyperplastic nodule	7	6.9
IV	FC in microfollicles and 3D clusters, nuclear overlapping, irregular nuclear membrane	Follicular Neoplasm	3	2.9
VI	Papillary fragments in 3-D cluster, intranuclear inclusion	Papillary Carcinoma	1	1.0

Above table reveal that majority of swellings belonged to Bethesda category II (92.2%) and the most common diagnosis was colloid goitre (69.6%) with FC singly and in clusters. About 3 cases belonged to category IV (follicular neoplasm) whereas 1 case belonged to category VI (papillary carcinoma).

Table 6: Comparison and Diagnostic rates of LBC with Bethesda as compared to FNAC

Bethesda Category	Diagnosis	CS by aspiration (n)	Correctly identified by LBC [n (%)]
I	Unsatisfactory	11	4 (36.4%)
II	Benign follicular lesion	2	2 (100%)
	Colloid cyst	12	4 (33.3%)
	Colloid Goitre	56	55 (98.2%)
	Hashimoto's Thyroiditis	9	8 (88.9%)
	Hyperplastic nodule	6	6 (100%)
	Subacute granulomatous thyroiditis	1	0 (0%)
III	AUS	1	0 (0%)
IV	Follicular Neoplasm	3	3 (100%)
VI	Papillary Carcinoma	1	1 (100%)
Total		102	83 (81.4%)

The findings of LBC were compared with that of FNAC by aspiration and the concordance rate was 81.4%. LBC could identify benign follicular lesion, hyperplastic nodule, follicular neoplasm and papillary carcinoma in 100% cases. LBC could identify colloid goitre in 98.2% cases, Hashimoto's thyroiditis in 88.9% cases. However, 36.4% smears were unsatisfactory in LBC. LBC was not helpful in diagnosis of AU S (Atypia of undetermined significance) and subacute granulomatous thyroiditis.

Results

- Mean age of patients presenting with thyroid swelling was 39 ± 14.79 years and 85.3% of the

cases were females. Thyroid USG revealed that majority of thyroid lesions belonged to TIRADS II (45.1%) whereas 41.2% cases belonged to TIRADS III. Majority of cases were euthyroid (70.6%) whereas about 25.5% and 3.9% cases had hypothyroidism and hyperthyroidism respectively.

- Aspirate obtained on FNAC was blood mixed in majority of cases (45.1%) whereas it was blood mixed colloid in 38.2% cases. Follicular cells were seen in 53.9% cases on non aspiration biopsy, whereas follicular cells with lymphocytes and Follicular cells with anisonucleosis & Oxyphilic cells were documented in 2% cases each. About 42.1% smears were acellular in non-aspiration biopsy.

- On non aspiration cytology, the background appeared haemorrhagic in majority of cases (42.2%), followed by colloid (29.4%) Aspirate on cytology revealed follicular cells singly and in clusters in majority i.e. 54.9% cases, macrophages were seen in 11.8% cases whereas about 10.8% smear were acellular on aspiration cytology. Majority of conventional smear by aspiration had colloid as well as haemorrhagic background (63.7%). Majority of cases with thyroid swelling were diagnosed as colloid goitre (54.9%), whereas about 11.8% swellings were due to colloid cyst and 10.8% smears were unsatisfactory. In majority of smears, follicular cells were seen singly and in clusters (69.6%) on LBC smears. Majority of swellings were diagnosed as colloid goitre (69.6%) on LBC, whereas 7.8% and 6.9% of the swellings were diagnosed as Hashimoto's Thyroiditis and Hyperplastic nodule respectively.
- All the Bethesda category I smear were found to be acellular. Only follicular cells were observed in majority of smears belonging to Bethesda category II (53.9%). Majority of swellings belonged to Bethesda category II (84.3%) and the most common diagnosis was colloid goitre (54.9%) with FC singly and in clusters on CS. About 3 cases belonged to category IV (follicular neoplasm) whereas 1 case each belonged to category III (AUS) and VI (papillary carcinoma).
- On LBC smears, majority of swellings belonged to Bethesda category II (92.2%) and the most common diagnosis was colloid goitre (69.6%) with FC singly and in clusters. About 3 cases belonged to category IV (follicular neoplasm) whereas 1 case belonged to category VI (papillary carcinoma). The concordance rate of CS and LBC was 81.4%. LBC could identify benign follicular lesion, hyperplastic nodule, follicular neoplasm and papillary carcinoma in 100% cases. LBC could identify colloid goitre in 98.2% cases, Hashimoto's thyroiditis in 88.9% cases. However, 36.4% smears were correctly identified by LBC which were unsatisfactory on CS. LBC was not helpful in diagnosis of AUS (Atypia of undetermined significance) and subacute granulomatous thyroiditis. LBC identified 4 cases as unsatisfactory (Bethesda I) whereas CS by non aspiration identified 43 cases as Bethesda category I.

Statistical analysis:

Data was compiled using MsExcel and analysis was done with the help of IBM SPSS software version 20. Categorical data was expressed as frequency and proportion whereas continuous data was expressed as mean and standard deviation. Categorical data between CS and LBS was compared.

Discussion

[A]conventional smear by non aspiration method

The thyroid gland, which is highly vascularized frequently produces aspirate that is clearly mixed with

blood. Santos and Leiman provided the scientific justification for this, claiming that the thyroid cells are not diluted by blood during non aspiration cytology yielding better cellularity by avoiding the negative suction pressure. In our study, the conventional smear prepared by non-aspiration method appeared haemorrhagic in majority of cases (42.2%) whereas it was colloid in 29.4% and mixed (colloid as well as haemorrhagic) in 28.4% cases. The smear showed only follicular cells in 53.9% cases and majority of cases belonged to Bethesda category II (57.9%). In about 2% cases each belonging to Bethesda category II, Follicular cells with anisonucleosis, Oxyphilic cells and Follicular cells with Lymphocytes were observed. About 42.1% cases belonged to Bethesda category I and the smear was acellular in such cases. [18-22]

Maurya AK et al (2010) documented that non-aspiration technique could yield less adequate but superior smears when compared to aspiration technique. Smear cellularity and cellular degeneration was reported to be higher in aspiration technique as compared to non aspiration technique. Jayaram G et al (1991) documented higher cellularity in aspiration smears than non aspiration smears. Ghosh A et al (2000) reported better retention of architecture in non aspiration method as compared to aspiration method. [23-26]

[B]conventional smear by aspiration method

The conventional smear prepared by aspiration technique was considered gold standard in our study. The smear appeared colloid and haemorrhagic in majority i.e. 63.7% cases and only haemorrhagic and colloid smears were documented in 19.6% and 16.7% cases respectively. Majority of swellings belonged to Bethesda category II (84.3%) on conventional smears and the colloid goitre was the most common diagnosis based upon conventional smear (54.9%) showing Follicular cells singly and in clusters. However, we documented 3 cases of follicular neoplasm, 1 case of AUS and 1 case of papillary carcinoma belonging to category IV, III and VI respectively. [27]

Mahajan S et al (2021) included 200 cases with thyroid lesions, and of them, majority of lesions were benign, majority being colloid goitre. Smears from about 7 lesions were unsatisfactory, 10 were AUS. 25 cases were follicular neoplasm and 34 cases were malignant on conventional smears. Similarly, in a study of Agrawal S et al (2018), Colloid goitre was found to be the most common cause of thyroid swelling on conventional smears

(62%), followed by hyperplastic nodule (13.6%) and 5.8% cases were papillary carcinoma. [28]

According to Sayer AO et al (2022), majority of thyroid swellings belonged to Bethesda II category on conventional smears (63.1%), followed by 23.7%

and 5.6% swellings belonging to Bethesda I and V category respectively. [71] Our study findings were also supported by findings of Gupta S et al (2018), in which majority of thyroid cases were categorized as benign (73.3%) whereas 8.3% cases each belonged to Bethesda category I and VI. [29]

The Bethesda system for reporting thyroid cytopathology (TBSRTC) based upon aspiration cytology

Bethesda category	I	II	III	IV	V	VI
Agrawal S et al (2018)[62]	75.6%	1%	4.4%	0.7%	7.5%	10.8%
Kumari M et al (2020)[68]	10%	78%	0%	2%	4%	5%
Mahajan S et al (2021)[70]	3.5%	59%	5%	12.5%	3%	17%
Sayer AO et al (2022)[71]	23.7%	63.1%	3.8%	0.7%	5.6%	3.1%
Our study (2023)	10.8%	84.3%	1%	2.9%	0%	1%

[C]lbc smears

In our study, the background in smears prepared with LBC technique was colloid in majority of cases (85.3%), whereas the background contained cellular debris in 2.9% cases. Majority of swellings on LBC smears belonged to Bethesda category II (92.2%) and the most common diagnosis was colloid goitre (69.6%) with FC singly and in clusters. About 3 cases belonged to category IV (follicular neoplasm) whereas 1 case belonged to category VI (papillary carcinoma). [30]

Similarly, in a study of Kumari M et al (2020), majority of cases with thyroid swellings were identified as benign (Bethesda II) on LBC(63%), followed by 19% and 10% cases belonging to

Bethesda category V and I respectively. However in a study of Mahajan S et al (2021), majority of smears on LBC belonged to Bethesda category II (51.5%), whereas 18% smears were unsatisfactory. [31]

Similarly, Agrawal S et al (2018) reported more than half of LBC thyroid smears to be benign (56.7%-majority being colloid nodule and colloid goitre) and 23.3% cases were malignant.[62] In contrast to present study, Sayer AO et al (2022) found approximately one third of LBC smears to be unsatisfactory and it was attributed to hypocellularity associated with LBC smears.[71] Obtaining LBC smears is a skillful technique, and we obtained only small proportion of unsatisfactory smears.

Bethesda system for reporting thyroid cytopathology (TBSRTC) based upon LBC

Bethesda category	I	II	III	IV	V	VI
Agrawal S et al (2018)	56.7%	5%	8.3%	2.5%	15%	12.5%
Kumari M et al (2020)	14%	63%	0%	1%	19%	2%
Mahajan S et al (2021)	18%	51.5%	5.5%	8.5%	4%	12.5%
Sayer AO et al (2022)	13.9%	71.3%	2.1%	2.7%	5.9%	4.1%
Our study (2023)	3.9%	92.2%	0%	2.9%	0%	1%

[D] Histopathology

Histopathology report was done in 10 cases only and it was suggestive of follicular adenoma in 3.9% cases, colloid goitre in 2.9% cases. Follicular carcinoma, Hashimoto's thyroiditis and papillary carcinoma were diagnosed in 1 case each. [32]

Histopathology was done only in few cases to overcome the limitation associated with FNAC. FNAC could not differentiate between follicular adenoma and follicular carcinoma. Few suspected cases where diagnosis on FNAC was doubtful, were subjected to histopathology to confirm the diagnosis. [33]

Comparison of conventional smear by aspiration and non-aspiration technique with lbc smears

FNAC Smears by aspiration cytology was considered as the gold standard method in our study. Based upon conventional smears by aspiration, the

overall diagnostic utility of LBC smears in evaluation of thyroid swelling was 81.4%. LBC was concordant with conventional smear for diagnosis of benign follicular lesion, hyperplastic nodule, follicular neoplasm and papillary carcinoma in 100% cases. Concordance rate of LBC with conventional smear was 98.2% for colloid goitre, 88.9% for Hashimoto's thyroiditis and 36.4% for unsatisfactory smears. LBC was not helpful in diagnosis of AUS and subacute granulomatous thyroiditis. [34]

The advantages of LBC are that LBC uses a single slide for screening, which cuts down on screening time. While the CSs had hemorrhagic backgrounds, the backdrop had practically little red blood cells, which did not always affect the overall appearance. The amount of colloid was dramatically decreased in LBC smears, and thus the diagnosis can often be missed for colloid nodule, which is a frequent

thyroid lesion in both the general population and the study. [35]

Kumari M et al (2020) documented higher unsatisfactory rate and higher suspicion of malignancy with LBC smears as compared to CS which could be due to high nucleocytoplasmic ratio and non crisp cytoplasmic and nuclear features. Our findings were supported by findings of Mahajan S et al (2021), in which the conventional smears had considerably greater cellularity than matched LBC smears (paired t test, P 0.005). Comparing the overall diagnostic effectiveness of LBC with CS revealed that they were equal in 59% of instances, that CS was superior to LBC in 37% of cases, and that LBC was only superior to CS in 4% of cases. When compared to CS, LBC smears had a greater unsatisfactory rate (18% vs. 3.5%). In 87% of cases in category 2, the two approaches were comparable. In categories 4 and 6, CS outperformed LBC. [36]

Gupta S et al (2018) found no statistically significant differences between LBC and CS in terms of cellularity, retained cell architecture, and informative background ($p > 0.05$). [37] However, they documented reduced concentration of colloid, which appeared fractured and thickened. Kaur N et al (2018) found CS to be more sensitive (93.18%) and accurate (91.75%) for assessment of thyroid lesions whereas the sensitivity and accuracy of LBC was 89.04% and 86.59% respectively. Sayer AO et al (2022) found identical malignancy rates in the biopsy samples by both the techniques with no statistically significant differences in the outcomes of the two approaches for thyroid nodules with Bethesda Categories II, III, IV, V, and VI and the unsatisfactory rate was higher with CS as compared to LBC. Later, we compared LBC with non-aspiration conventional smears and reported unsatisfactory smears in majority of cases ($n=43$). However, out of 94 category II cases on LBC, conventional smear by non aspiration method could identify 59 cases only. None of the swellings belonged to category III or above in non aspiration cytology technique. [38]

To best of our knowledge, none of previous studies have compared the diagnostic accuracy of LBC with that of non aspiration conventional smears. However, previous studies have compared FNAC by aspiration and non aspiration methods. The major advantages of FNAC sampling is its simplicity and complete control over operating hand, especially from clinically accessible sites such as neck, breast, cutaneous, or subcutaneous tissue. Additionally, the FNAC improves assessment of tumor consistency. Maurya AK et al (2010) in their study documented that though FNAC obtain diagnostically superior samples but the adequacy of samples is more with FNAC. Ramachandra L et al (2011) also concluded that FNAC yield better quality of samples in the form of cellularity and field obscuration due to blood

is also less whereas FNAC smears are diagnostically more adequate. [39,40]

Conventional smears prepared by fine needle aspiration cytology are definitely the better method for diagnosis of thyroid swelling according to Bethesda category. Liquid based cytology can be used as complementary method for classifying thyroid swelling as the LBC provides clear background so cytoplasmic and nuclear details are visualized clearly and the drawbacks of conventional cytology such as drying artefact and hemorrhagic background are minimized. The significant reduction in the number of nondiagnostic category in LBC seen in present study. [41]

Colloid was better appreciated in CS as compared to LBC in which it was fragmented and appreciated as colloid globules. Cytoplasm appear fragile and fragmented on LBC and nuclear appear shrunken in many cases. In Follicular neoplasm there were lesser microfollicles in LBC than CS. [42]

LBC is as good as CS (aspiration method) for diagnosis of benign follicular lesion, hyperplastic nodule, follicular neoplasm and papillary carcinoma. Non aspiration cytology is inferior for assessment of thyroid swellings as majority of smears are unsatisfactory and are of low diagnostic value

Conclusion

To conclude, LBC can be used as complementary to Conventional smear rather than replacing it. The residual material in LBC can be used for immunocytochemistry in suspected cases of malignancy.

Declarations:

Funding: None **Conflicts of interest/Competing interests:** None **Availability of data and material:** Code availability: Not applicable **Consent to participate:** Consent taken **Ethical Consideration:** There are no ethical conflicts related to this study. **Consent for publication:** Consent taken

Limitations of study

First, histopathology was not done in all the cases and hence, the final diagnosis was made based upon the findings of conventional smears. Thus diagnostic rates of both could not be compared. Second, the sample size of the study was small, however, a large sample would have yielded better results.

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