Section: Obstetrics and Gynecology

Original Research Article

COMPARISON OF LIQUID-BASED CYTOLOGY AND CONVENTIONAL PAP SMEAR FOR CERVICAL CANCER SCREENING: A COMPREHENSIVE ANALYSIS OF SPECIMEN ADEQUACY, DIAGNOSTIC ACCURACY, AND CLINICAL CORRELATION

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Abstract

Background: This study aimed to compare the effectiveness of Liquid-Based Cytology (LBC) and conventional Pap smear in detecting cervical cytological abnormalities. **Materials and Methods**: A total of 111 women underwent both LBC and Pap smear tests. Specimen adequacy, detection of cytological abnormalities, and the presence of infectious agents were evaluated. Histopathological examination was used as the reference standard. Sensitivity and specificity of both methods were calculated. **Results:** LBC demonstrated higher specimen adequacy (98.1% vs. 93.6%, $p<0.05$). The prevalence of abnormal findings was higher in LBC (47%) compared to Pap smear (27%) ($p<0.05$). LBC showed 100% sensitivity and specificity, while Pap smear showed 55.8% sensitivity and 100% specificity. Infectious agents were detected more frequently with LBC (15 cases) than with Pap smear (4 cases) ($p<0.05$).
Conclusion: LBC is superior to Pap smear in terms of specimen adequacy, sensitivity, and detection of cytological abnormalities and infectious agents. LBC should be considered as the preferred method for cervical cancer screening.

INTRODUCTION

In the realm of public health, understanding and Cervical cancer remains one of the leading causes of cancer-related morbidity and mortality among women worldwide, particularly in developing countries like India.[1] Early detection and appropriate intervention are critical for improving outcomes and reducing the burden of this disease.[2] Screening programs have been pivotal in identifying precancerous changes in the cervix, allowing for timely treatment. Among the various screening methods, the Papanicolaou (Pap) smear has been a cornerstone since its introduction in the mid-20th century.[2] However, technological advancements have led to the development of Liquid-Based Cytology (LBC), which promises improved sample quality and diagnostic accuracy.[3]

Conventional Pap smear, though highly beneficial, has several limitations. These include inadequate sample collection, presence of obscuring elements such as blood or mucus, and variable interpretation due to subjective assessment. These limitations can lead to false-negative results, thereby missing early precancerous or cancerous changes in the cervical epithelium.[4] Liquid-Based Cytology, introduced as an alternative, addresses some of these limitations by using a different sample collection and preparation method. In LBC, the sample is collected in a liquid medium, allowing for removal of blood and debris and creating a more homogeneous and representative sample for microscopic examination.[3]

Given the potential advantages of Liquid-Based Cytology over conventional Pap smear, it is essential to evaluate and compare these two methods in terms of their efficacy in the early detection of cervical cancer. This study aims to provide a comprehensive comparison between LBC and conventional Pap smears in a specific population—women aged 30 to 60 years attending a government tertiary care hospital in Tamil Nadu. By doing so, we aim to determine which method offers superior diagnostic performance and better sample quality, ultimately guiding future screening strategies.

The primary objective of this study is to conduct a comparative analysis between Liquid-Based

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Cytology and conventional Pap smears concerning histopathological findings among the study participants. By comparing the two methods, we aim to determine which technique provides more accurate and reliable results in detecting precancerous and cancerous lesions. Furthermore, we intend to assess the sensitivity, specificity, positive predictive value, and negative predictive value of LBC compared to conventional Pap smear. These metrics are crucial for evaluating the diagnostic accuracy and overall utility of the screening methods.

Another significant aspect of this study is to evaluate the quality of the samples obtained through both methods. Sample quality is a critical factor in cytological examination as it directly impacts the accuracy of the diagnosis. High-quality samples are essential for reducing the likelihood of false-negative results and ensuring that any abnormalities are accurately identified.

Early detection of cervical cancer significantly improves treatment outcomes and survival rates.[5] Cervical cancer often progresses through well-defined precancerous stages, providing a window of opportunity for intervention before invasive cancer develops. Screening methods that can accurately identify these precancerous changes are invaluable in the fight against cervical cancer.[6] Therefore, improving the screening process by adopting more effective methods like Liquid-Based Cytology could play a pivotal role in reducing the incidence and mortality associated with cervical cancer.

Previous studies comparing Liquid-Based Cytology with conventional Pap smears have shown mixed results. Some studies report higher sensitivity and specificity for LBC, while others find no significant difference between the two methods.[5-7] These discrepancies highlight the need for context-specific research. Factors such as population demographics, prevalence of cervical abnormalities, and local healthcare practices can influence the outcomes of such studies.

This study aims to provide a thorough comparison between Liquid-Based Cytology and conventional Pap smear in the early diagnosis of cervical cancer. By assessing the diagnostic performance and sample quality of both methods, we hope to identify the most effective screening tool for women in the specified age group attending a government tertiary care hospital in Tamil Nadu.

MATERIALS AND METHODS

Study Setting: This cross-sectional study was conducted at the Government Medical College in Dindigul, Tamil Nadu, from November 2022 to October 2023. The study aimed to compare Liquid-Based Cytology (LBC) with conventional Pap smear for the early diagnosis of cervical cancer among women aged 30 to 60 years.

Study Participants: Inclusion criteria included women aged 30 to 60 years presenting with abnormal vaginal discharge, irregular periods, lower abdominal pain, post-coital bleeding, and abnormal cervical findings on per speculum examination. Exclusion criteria were pregnant women, women who have undergone hysterectomy, women with prior treatment for cervical intraepithelial neoplasia (CIN), women with proven cervical cancer, women with cognitive impairment, participants with incomplete information, and participants who cannot be contacted for further interviews.

Sample Size: The sample size was calculated based on the formula for estimating a single proportion, considering a 95% confidence level and a 5% margin of error. Using published sensitivity (97.6%) and prevalence (27%) rates, the required sample size was determined to be 111 participants.

Sampling Technique: Convenient sampling was employed to select the study participants. All eligible women presenting to the gynecologic outpatient department during the study period were invited to participate. Those who consented were included in the study.

Study Methodology: After obtaining informed consent and detailed medical histories from the participants, a comprehensive clinical examination was conducted. This included the collection of cervical specimens for cytological analysis, followed by colposcopy-guided biopsy procedures when indicated. The study utilized Ayer's spatula, cytobrushes, LBC collection vials, colposcope, and standard laboratory equipment for processing and staining cytological specimens.

- **Conventional Pap Smears**: Obtained using Ayer's spatula during per-speculum examination. Cells were immediately fixed on glass slides using a 1:1 mixture of 95% ethyl alcohol and ether, then sent to the laboratory for processing, staining with Papanicolaou stain, and subsequent analysis. Conventional Pap smears included variable smear thickness with potential for more debris and cell overlap.
- **Liquid-Based Cytology (LBC):** Cervical samples were collected using a cytobrush and transferred to LBC collection vials. In the laboratory, LBC specimens were processed by centrifugation, and the cellular material was deposited onto glass slides for staining and analysis. Cells were distributed over a small circular area of 13 mm, minimizing debris, mucus, blood, and cell overlap. This enhanced the visualization of infectious organisms and reduced air-drying artifacts, with lower leukocyte counts facilitating clearer visualization of epithelial and abnormal cells.
- **Colposcopy**: An outpatient procedure using a colposcope with magnification and high-intensity halogen light was performed. Sequential application of saline, 3% acetic acid, and Lugol's iodine to the cervix were done for enhanced visualization. Punch biopsies were obtained from aceto white and iodine-negative areas, or from the

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anterior cervical lip near the squamo-columnar junction if no abnormalities were detected.

- **Cytology Reporting**: Results reported using the Bethesda System (2001 modification), categorizing abnormalities into infection, inflammation, reparative changes, and epithelial cell abnormalities (e.g., LSIL, HSIL, atypical squamous intraepithelial lesions). Specimen were classified as satisfactory or unsatisfactory based on cell count and visualization criteria.
- **Biopsy Reporting**: Cervical biopsy reports utilized CIN terminology, with biopsy-proven CIN serving as the gold standard for assessing cytology sensitivity. Cutoff points for cytology and histology results were ASC-US or higher and CIN1 or higher, respectively, for sensitivity calculations.

Statistical Analysis: Data were coded, checked for accuracy, and recorded in Excel before being analyzed using SPSS. Descriptive analysis using frequencies, percentages, and means was performed. Sensitivity, specificity, positive predictive value, and negative predictive value analyses were conducted to compare the diagnostic performance of LBC and conventional Pap smear.

Ethical Issues: Ethical approval was obtained from the institutional ethics committee before the commencement of the study. Informed consent was obtained from all participants, ensuring confidentiality and privacy of the collected data. Participants were informed about the study's purpose, procedures, potential risks, and benefits.

RESULTS

A total of 111 women aged 30 to 60 years participated in the study. The age distribution indicated that most participants were within the 30-40 years age group, constituting 65.7% (n=73). Participants aged 41-50 years comprised 25.2% (n=28), and those over 50 years constituted 9.1% (n=10). Abnormalities were more prevalent in the older age groups, particularly in those over 50 years (Table 1).

The primary presenting symptom was abnormal vaginal discharge (67.5%, n=75), followed by lower abdominal pain (18%, n=20), and post-coital bleeding (9%, n=10). Abnormal uterine bleeding was noted in 5.4% (n=6) of the participants (Figure 1). Clinical findings showed that most participants had a normal cervix (86.4%, n=96), while other findings included ulcerated cervix (4.5%, n=5) and erosion cervix (2.7%, n=3) (Figure 2). The adequacy of specimens collected via LBC was higher, with 98.1% (n=109) satisfactory samples, compared to 93.6% (n=104) for Pap smears (Table 2).

Cytological analysis using LBC detected abnormalities in 47% (n=52) of the samples, while Pap smears detected abnormalities in 27% (n=30). The distribution of cases according to the Bethesda category revealed that 68.5% (n=76) were normal, 15.3% (n=17) were LSIL, 9.9% (n=11) were HSIL, 1.8% (n=2) were ASC, and 4.5% (n=5) were SCC in LBC. For Pap smears, 82.8% (n=92) were normal, 4.5% (n=5) were LSIL, 0.9% (n=1) were HSIL, 8.1% (n=9) were ASC, and 3.6% (n=4) were SCC (Table 3).

The comparison of LBC and Pap smear with histopathological examination (HPE) showed that LBC had a higher detection rate of CIN1, CIN2, and CIN3 compared to Pap smears. LBC detected 17 cases of LSIL, 11 cases of HSIL, and 5 cases of SCC, while Pap smears detected 5 cases of LSIL, 1 case of HSIL, and 4 cases of SCC (Tables 3 and 4).

LBC demonstrated a sensitivity of 100% and a specificity of 100%, indicating its high accuracy in detecting cervical abnormalities. In contrast, Pap smears showed a sensitivity of 55.8% and a specificity of 100% (Table 5).

Table 1: Characteristics of the study participants

Variable		Normal	Abnormal	Total (%)
Age category	30-40 years	55	18	73 (65.7%)
	41-50 years	17	11	28 (25.2%)
	>50 years	3	7	10 (9.1%)
Place of residence	Rural	19	6	25 (22.5%)
	Urban	56	30	86 (77.5%)
Socioeconomic class	Class II	1	0	1 (0.9%)
	Class III	20	11	31 (27.9%)
	Class IV	54	25	79 (71.1%)
Age at first coitus	<20 years	26	25	51 (45.9%)
	21-25 years	46	11	57 (51.3%)
	>25 years	3	0	3 (2.7%)
Parity index	Para 1	18	2	20 (18.1%)
	Para 2	48	9	57 (51.3%)
	Para 3	8	18	26 (23.4%)
	Para 4	1	7	8 (7.2%)

Table 2: Distribution of cases according to the Bethesda category

Variable	Bethesda category	Number	Percentage
LBC	Normal	76	68.50%
	LSIL	17	15.30%

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	HSIL	11	9.90%
	ASC	2	1.80%
	SCC	5	4.50%
PAP	Normal	92	82.80%
	LSIL	5	4.50%
	HSIL	1	0.90%
	ASC	9	8.10%
	SCC	4	3.60%

Table 3: Comparison of LBC with HPE

LBC	CIN1	CIN2	CIN3	Normal	SCC	Total
ASC-US	2	0	0	0	0	2
BV	0	0	0	3	0	3
Candida	0	0	0	4	0	4
HSIL	2	6	3	0	0	11
LSIL	12	5	0	0	0	17
Normal	0	0	0	59	0	59
SCC	0	0	0	0	5	5
TV	0	1	0	7	0	8
Unsatisfactory	0	0	0	2	0	2
Total	16	12	3	75	5	111

Table 4: Comparison of PAP and HPE

PAP	CIN1	CIN2	CIN3	Normal	SCC	Total
ASC-H	0	2	0	0	0	2
ASC-US	3	2	2	0	0	7
Candida	0	0	0	2	0	2
HSIL	0	0	1	0	0	1
LSIL	3	2	0	0	0	5
Normal	10	5	0	66	0	81
SCC	0	0	0	0	4	4
TV	0	0	0	2	0	2
Unsatisfactory	0	1	0	5	1	7
Total	16	12	3	75	5	111

Table 5. Sensitivity and Specificity Comparison

Cytology	Sensitivity	Specificity
LBC	100%	100%
PAP	55.8%	100%

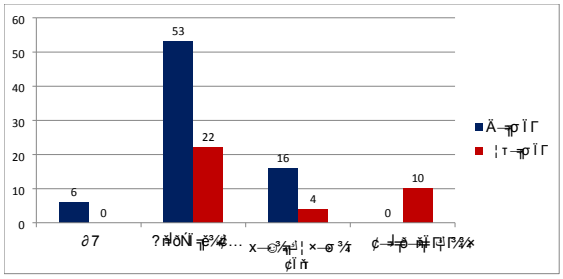

Figure 1: Symptoms present in the study participants

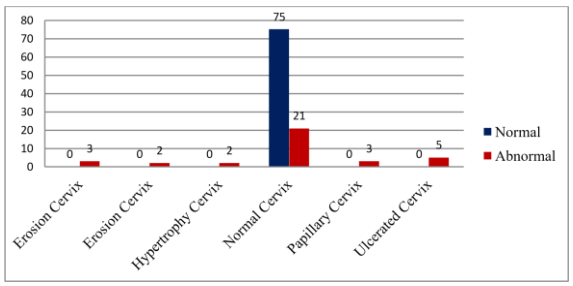

Figure 2: Clinical findings among the study participants

DISCUSSION

This study aimed to compare the effectiveness of Liquid-Based Cytology (LBC) and conventional Pap smear in detecting cervical cytological abnormalities. Our findings indicate that LBC is superior in both sensitivity and specimen adequacy compared to the Pap smear, providing more reliable results for early detection of cervical cancer and its precursors.

The age distribution of our study population showed that most participants were between 30-40 years, with 65.7% falling in this category. The prevalence of abnormal findings increased with age, particularly in those over 50 years. In our study, the incidence of abnormalities was 47% in LBC and 27% in Pap smear, which aligns with previous research indicating that the risk of cervical abnormalities increases with age.[8]

Urban residents constituted 77.5% of our study population, with a higher prevalence of abnormal cytology findings compared to rural residents (30 vs. 6). This finding correlates with previous studies suggesting that urban women have better access to healthcare services, leading to higher detection rates of cervical abnormalities. Our study found that lower socio-economic status was associated with a higher

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prevalence of abnormal findings. Class IV individuals accounted for 71.1% of the total study population, with a significant proportion showing abnormalities. These results are consistent with prior research indicating that socio-economic factors influence the accessibility and frequency of cervical cancer screening.[9]

We observed that early sexual activity (<20 years) was associated with a higher prevalence of abnormal cytological findings. In our study, 25 out of 51 women who had their first coitus before the age of 20 had abnormal results, supporting the hypothesis that early sexual activity is a risk factor for cervical dysplasia. This finding is consistent with studies that show early onset of sexual activity increases the risk of persistent HPV infection, leading to higher rates of cervical intraepithelial neoplasia (CIN).[10]

Our data indicated that higher parity was associated with an increased prevalence of abnormal findings. Women with a parity index of three or more had a higher incidence of abnormalities. This finding supports previous studies which suggest that multiparity is a risk factor for cervical cancer, possibly due to hormonal changes and cervical trauma associated with multiple pregnancies.[11]

The most common presenting symptom in our study was abnormal vaginal discharge, reported by 67.5% of women, followed by lower abdominal pain (18%) and postcoital bleeding (9%). These symptoms are well-documented in the literature as common indicators of cervical pathology. The high incidence of abnormal findings among symptomatic women underscores the importance of prompt cytological evaluation in symptomatic patients.[12]

The comparison between LBC and Pap smear in detecting abnormalities showed that LBC detected a higher number of abnormal cases (47% vs. 27%). This finding is supported by several studies that have demonstrated the superior diagnostic accuracy of LBC in identifying precancerous lesions and cervical cancer.[13]

The distribution of cases according to the Bethesda system revealed that LBC detected more high-grade squamous intraepithelial lesions (HSIL) and squamous cell carcinoma (SCC) compared to Pap smear. Specifically, LBC identified 9.9% HSIL and 4.5% SCC, whereas Pap smear identified only 0.9% HSIL and 3.6% SCC. This indicates that LBC is more effective in detecting clinically significant lesions, which is consistent with prior research findings.[14]

Histopathological examination confirmed the cytological findings, with 14.4% of cases showing CIN1, 10.8% CIN2, 2.7% CIN3, and 4.5% SCC. The high concordance between LBC results and histopathology underscores the reliability of LBC in accurately diagnosing cervical abnormalities. Similar studies have reported high concordance rates, reinforcing the role of LBC as a reliable diagnostic tool.[12, 15]

The sensitivity and specificity of LBC were 100%, while Pap smear showed a sensitivity of 55.8% and specificity of 100%. These findings are consistent with numerous studies that have demonstrated the superior sensitivity of LBC in detecting cervical lesions. The higher sensitivity of LBC ensures that fewer cases of cervical abnormalities are missed, thereby improving early detection and treatment outcomes.[16]

Our study had some limitations. The sample size was relatively small, and the study was conducted in a single center, which may limit the generalizability of the findings. Additionally, the follow-up period was not long enough to assess the long-term outcomes of patients with detected abnormalities. Future studies with larger, multi-center populations and longer follow-up periods are needed to validate these findings.

CONCLUSION

Our study demonstrated that LBC is a more effective screening method for cervical cytological abnormalities compared to the conventional Pap smear. LBC showed higher sensitivity, better specimen adequacy, and superior detection rates for both precancerous lesions and infectious agents. These findings support the adoption of LBC as the preferred method for cervical cancer screening, especially in settings where accurate and early detection is crucial for reducing the burden of cervical cancer. Given the higher detection rates and reliability of LBC, healthcare providers can consider transitioning from conventional Pap smear to LBC for cervical screening programs.

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