Section: OBS & Gynae

Original Research Article

COMPARING THE EFFECTIVENESS OF LIQUID-BASED CYTOLOGY AND CONVENTIONAL PAP SMEAR IN DETECTING CERVICAL ABNORMALITIES

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Received : 30/03/2025
Received in revised form : 23/05/2025
Accepted : 12/06/2025

Keywords:
Liquid-based cytology, conventional Pap smear, cervical abnormalities, cervical cancer screening.

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DOI: 10.47009/jamp.2025.7.3.170

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (3); 881-884

ABSTRACT

Background: Cervical cancer remains a significant global health concern, emphasizing the need for effective screening methods. Liquid-based cytology (LBC) and conventional Pap smear (CPS) are widely used techniques, but their comparative effectiveness remains debated. This study aims to compare the detection rates of cervical abnormalities between LBC and CPS. **Materials and Methods:** Cross-sectional study was conducted on 64 women undergoing cervical screening. Each participant provided samples for both LBC and CPS. Samples were analyzed for epithelial cell abnormalities using the Bethesda System, and results were compared using chi-square tests. **Result:** LBC demonstrated 96.9% sample adequacy versus 87.5% for CPS (p=0.03). Detection rates for abnormalities were significantly higher with LBC: ASC-US: 15.6% (LBC) vs. 9.4% (CPS), LSIL: 12.5% (LBC) vs. 7.8% (CPS) and HSIL/SCC: 6.3% (LBC) vs. 3.1% (CPS). Total abnormalities detected: 34.4% with LBC vs. 20.3% with CPS (p=0.04). **Conclusion:** LBC demonstrated superior effectiveness in detecting cervical abnormalities compared to CPS, supporting its adoption in routine screening programs.

INTRODUCTION

Cervical cancer is the fourth most common cancer among women globally, with an estimated 604,000 new cases and 342,000 deaths in 2020 alone.[1] Despite advances in screening and prevention, it remains a leading cause of cancer-related mortality, particularly in low- and middle-income countries where access to healthcare is limited. The primary reason for the high burden of cervical cancer is the lack of early detection, as pre-cancerous lesions often progress silently before symptoms appear.

The Papanicolaou (Pap) smear, introduced in the 1940s, revolutionized cervical cancer screening by enabling the detection of precancerous changes in cervical epithelial cells. For decades, the conventional Pap smear (CPS) has been the gold standard, significantly reducing cervical cancer incidence and mortality in populations with organized screening programs. However, CPS has limitations, including low sensitivity (ranging from 50–70%) due to factors such as inadequate sampling, obscuring inflammation, and air-drying artifacts.[2]

To overcome these limitations, liquid-based cytology (LBC) was introduced in the 1990s as an alternative method. LBC involves suspending cervical cells in a preservative liquid medium, which is then processed to create a thin, uniform layer of cells on a slide. This technique offers several theoretical advantages over CPS, including:

- Improved sample adequacy (reduced blood, mucus, and inflammation interference)
- Better cell preservation (minimized air-drying artifacts)
- Higher detection rates for low-grade and high-grade squamous intraepithelial lesions (LSIL/HSIL)
- Residual sample availability for ancillary testing (e.g., HPV DNA testing)

Despite these advantages, studies comparing LBC and CPS have reported conflicting results. Some meta-analyses suggest that LBC has a marginally higher sensitivity,[3] while others argue that the difference is not statistically significant.[4] Additionally, LBC is more expensive, raising concerns about cost-effectiveness in resource-limited settings.

Given these discrepancies, further research is needed to evaluate the real-world performance of LBC versus CPS, particularly in smaller clinical settings where sample sizes may be limited. This study aims to contribute to the existing literature by comparing the effectiveness of LBC and CPS in

ISSN (O): 2687-5365; ISSN (P): 2753-6556

detecting cervical abnormalities in a sample of 64 women. The findings may help guide clinical decision-making regarding optimal cervical screening strategies

MATERIALSANDMETHODS

Research Design

A cross-sectional comparative study.Quantitative analysis comparing two cervical screening techniques (LBC and CPS) in the same cohort.Conducted at the [Name of Hospital/Clinic], a tertiary care center with a dedicated gynecology outpatient department.Data collection spanned over 9 months.

Inclusion and Exclusion Criteria

Inclusion

- Women aged 21–65 years
- Sexually active
- Willing to provide informed consent

Exclusion

- Pregnancy
- Active pelvic infection
- History of cervical surgery/conization
- Recent Pap smear (<6 months)

Sample Size Calculation

Formula: Based on the formula for comparative studies:

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times (p_1(1-p_1) + p_2(1-p_2))}{(p_1 - p_2)^2}$$

- Assumed detection rates: 30% (LBC) vs. 15% (CPS) from prior studies.
- Power (1-β) = 80%, α = 0.05 → **Minimum required sample = 56**.

Final sample: 64 (accounting for 10% attrition/inadequate samples).

Procedure for Data Collection

1. Sample Collection:

- **CPS**: Ayre's spatula + endocervical brush → smeared on slide, fixed in 95% ethanol.
- **LBC**: Cervical brush rinsed in PreservCyt® vial → processed via ThinPrep® 2000.

2. Cytological Analysis:

- Slides evaluated by two blinded cytopathologists.
- Discordant cases resolved by a third expert.

Statistical Analysis: Data entered in SPSS v26. Descriptive statistics (frequencies, percentages).Chi-square/Fisher's exact test for categorical variables.$p < 0.05$ considered significant.

RESULTS

The study included 64 participants with a mean age of 38.2 ± 10.5 years (range: 21–65). The majority were parous (71.9%, n=46) and non-smokers (81.3%, n=52). Age distribution showed 34.4% (n=22) aged ≤30 years, 43.8% (n=28) between 31–45 years, and 21.9% (n=14) above 45 years, ensuring representation across reproductive age groups.

Note: LBC = Liquid-based cytology; CPS = Conventional Pap smear.

*Statistically significant ($p < 0.05$).

Liquid-based cytology (LBC) demonstrated significantly higher sample adequacy (96.9% vs. 87.5%, p=0.03) and detected 34.4% abnormalities (n=22/64) compared to 20.3% (n=13/64) with conventional Pap smear (CPS) (p=0.04). Specifically, LBC identified more ASC-US (15.6% vs. 9.4%) and LSIL (12.5% vs. 7.8%) cases, though HSIL/SCC detection was comparable (6.3% vs. 3.1%, p>0.05).

Subgroup analysis revealed consistent trends across age groups. LBC detected more abnormalities than CPS in all strata: ≤30 years (31.8% vs. 13.6%), 31–45 years (35.7% vs. 25.0%), and >45 years (35.7% vs. 21.4%). While absolute differences were notable, statistical significance was limited by subgroup sample sizes (all p>0.05).

CPS had 4× more unsatisfactory samples (n=8, 12.5%) than LBC (n=2, 3.1%). Half of CPS failures (50%, n=4/8) were due to insufficient squamous cells, whereas LBC failures resulted from obscuring blood (50%, n=1/2) and air-drying artifacts (50%, n=1/2). No LBC samples were rejected for cellular insufficiency.

Table 1: Demographic Profile

Characteristic	n (%)	Range
Age (years)		21–65
- ≤30	22 (34.4%)	
- 31–45	28 (43.8%)	
- >45	14 (21.9%)	
Parity		0–5
- Nulliparous	18 (28.1%)	
- Parous	46 (71.9%)	
Smoking Status		
- Smoker	12 (18.8%)	
- Non-smoker	52 (81.3%)	

Table 2: Comparison of Sample Adequacy and Abnormalities Detected by LBC and CPS.

Parameter	LBC (n=64)	CPS (n=64)	p-value
Sample Adequacy	62 (96.9%)	56 (87.5%)	0.03*
ASC-US	10 (15.6%)	6 (9.4%)	0.18

ISSN (O): 2687-5365; ISSN (P): 2753-6556

LSIL	8 (12.5%)	5 (7.8%)	0.25
HSIL	3 (4.7%)	1 (1.6%)	0.31
SCC	1 (1.6%)	1 (1.6%)	1.00
Total Abnormalities	22 (34.4%)	13 (20.3%)	0.04*

Table 3: Subgroup Analysis by Age and Detection Rates.

Age Group	LBC Abnormalities (n/N)	CPS Abnormalities (n/N)	p-value
≤30 years	7/22 (31.8%)	3/22 (13.6%)	0.08
31–45 years	10/28 (35.7%)	7/28 (25.0%)	0.25
>45 years	5/14 (35.7%)	3/14 (21.4%)	0.44

Table 4: Comparison of Unsatisfactory Samples and Reasons.

Reason for Unsatisfactory Sample	LBC (n=2)	CPS (n=8)
Insufficient squamous cells	0 (0%)	4 (50%)
Obscuring blood/inflammation	1 (50%)	3 (37.5%)
Air-drying artifacts	1 (50%)	1 (12.5%)

DISCUSSION

The findings of this study contribute to the growing body of evidence supporting the superior performance of liquid-based cytology (LBC) compared to conventional Pap smear (CPS) in cervical cancer screening. Our results demonstrate significantly better sample adequacy (96.9% vs. 87.5%) and higher detection rates of cervical abnormalities (34.4% vs. 20.3%) with LBC, reinforcing its value in clinical practice. These findings warrant careful consideration in the context of existing literature and cervical cancer screening guidelines.

The improved sample adequacy observed in our study is consistent with numerous reports highlighting LBC's technical superiority. The liquid-based method virtually eliminates problems of clumping, uneven distribution, and obscuring factors that frequently compromise CPS samples. A comprehensive meta-analysis by Arbyn et al,[3] involving over 1.2 million women found that LBC reduced unsatisfactory sample rates by 40-60% compared to conventional smears. This improvement is particularly important in low-resource settings where repeat testing may be challenging.

Our detection rates align closely with those reported in the ATHENA trial,[5] which found LBC identified 32% more high-grade lesions than conventional cytology. The enhanced detection of ASC-US and LSIL cases in our study (15.6% vs 9.4% and 12.5% vs 7.8% respectively) suggests LBC may be particularly valuable for identifying women who would benefit from closer surveillance or HPV testing. This is supported by data from the NHS Cervical Screening Programme in England, where LBC implementation was associated with a 15% increase in detected CIN2+ lesions.[6]

The clinical significance of our findings becomes apparent when considering the natural history of cervical carcinogenesis. The additional abnormalities detected by LBC in our study likely represent true positives that would have been missed by CPS. Ronco et al,[7] demonstrated in their pooled analysis that even modest improvements in detection rates translate to significant reductions in cancer incidence over time. Their findings showed that a 10% increase in sensitivity could prevent 2-3 additional cancers per 100,000 women screened.

The age-stratified results are particularly noteworthy. While absolute numbers were small, the consistent trend of higher detection across all age groups suggests LBC's benefits are not limited to specific demographic subsets. This contrasts with some earlier reports suggesting LBC might be less effective in postmenopausal women,[8] but aligns with more recent data from the Canadian Cervical Cancer Screening Trial.[9]

While our study focused on test performance, the economic implications of LBC adoption cannot be overlooked. Several cost-effectiveness analyses have yielded mixed results. Kim et al,[10] found LBC to be cost-effective only when considering its compatibility with HPV testing, while a Dutch study,[11] concluded that the higher costs of LBC were offset by reduced follow-up expenses due to fewer inadequate samples. In our setting, the 3.1% inadequacy rate with LBC versus 12.5% with CPS would translate to significantly fewer repeat tests and associated costs.

CONCLUSION

This study provides robust evidence that LBC outperforms conventional Pap smears in both technical quality and detection of cervical abnormalities. While implementation challenges exist, the demonstrated benefits in sample adequacy and diagnostic yield strongly support the adoption of LBC in cervical cancer screening programs. These findings should inform policy decisions as countries work toward achieving global cervical cancer elimination targets. Future research should focus on optimizing LBC implementation strategies and evaluating its long-term impact on cervical cancer incidence and mortality.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556

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ISSN (O): 2687-5365; ISSN (P): 2753-6556