Original

COMPARATIVE EVALUATION OF CONVENTIONAL PAP SMEAR AND LIQUID-BASED CYTOLOGY FOR CERVICAL CANCER SCREENING IN A CROSS-SECTIONAL STUDY

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ABSTRACT

Objective: To compare liquid-based cytology (LBC) and conventional Pap smear (CPS) in the detection of cervical cancer.

Study Design: This was a cross-sectional study.

Place and Duration of Study: This research was conducted at Liaquat University of Medical and Health Sciences Jamshoro from February 2025 to February 2026

Methods: Total 200 women aged 20-65 years with symptomatic presentation indicative of cervical pathology were included. CPS and LBC were used to collect cervical samples. Smear adequacy, endocervical cell presence, and cytological findings were assessed. Histopathological findings were used as a reference standard where available. SPSS version 26 was used to analyze the data. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were computed. The p-value of <0.05 was found to be statistically significant.

Results: The mean age of participants was 44.9±6.5 years. LBC demonstrated a significantly higher rate of satisfactory smears (n=188, 94.0%) compared to CPS (n=166, 83.0%) (p<0.001). Endocervical cells were more frequently detected in LBC (n=112, 56.0%) than CPS (n=78, 39.0%) (p<0.001). For LSIL, LBC had higher sensitivity (88.0%) and specificity (99.0%) compared to CPS (72.0% and 98.0%). In the case of HSIL, LBC showed better sensitivity (77.0% and 99.0%) and specificity (62.0% and 98.5%) than CPS. PPV and NPV were consistently higher with LBC.

Conclusion: LBC demonstrated better performance than CPS in terms of smear adequacy and diagnostic accuracy. It may be considered a more effective method for cervical cancer screening. Additional large-scale studies using HPV testing are recommended.

INTRODUCTION

One of the highly preventable malignancies that leads to significant morbidity and mortality is cervical cancer in the context of weak screening systems [1]. In 2022, approximately 660,000 new cases and 350,000 deaths were caused by cervical cancer worldwide [2]. In Pakistan, recent burden modelling indicates an adjusted age-standardized incidence of approximately 7.6 per 100,000 women, which translates to approximately 6,166 new cases each year, although underdiagnosis is likely [1,3]. Most cases result from chronic infection with high-risk human papillomavirus (HPV), but the progression of precursor lesions to advanced disease

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is a lengthy process; therefore, timely diagnosis is very effective [4]. That is why screening remains a key factor in cervical cancer management: it identifies the pre-neoplastic lesions of the epithelium even earlier than they turn invasive, and can be treated in its early pre-neoplastic stages [1]. The decrease in the incidence rate of cervical cancer in countries with well-developed screening systems has once again confirmed the usefulness of cytology-based programs, yet the efficiency of this tool has not been replicated in the majority of low- and middle-income countries [3, 4].

Effective screening is one of the approaches to cervical cancer prevention since precancerous lesions can be detected and treated before they turn into an invasive disease. The screening tool of choice over the decades has been the traditional Papanicolaou (Pap) smear or conventional cytology [5]. Its sensitivity in identifying cellular lesions such as low-grade squamous intraepithelial lesions (LSIL) and high-grade squamous intraepithelial lesions (HSIL) has led to significant declines in incidence where the program is in place. However, traditional Pap smears are severely limited by low sample rates, which result from masking effects of blood, mucus, inflammation, or cell-poor preservation [5, 6].

To overcome these technical constraints, liquid-based cytology (LBC) was developed, in which cells in preservative fluid are used to produce cleaner, more standardized slides and to preserve the remaining material for additional testing [7]. These practical benefits are supported by recent comparative studies. Satisfactory smears were described in 98.6% of LBC samples compared with 95% of conventional smears in a cross-sectional study of 600 women, suggesting that more endocervical cells were more frequent in LBC preparations and that a hemorrhagic background was much less common in LBC [8]. There is also some evidence of better detection of middle-grade epithelial abnormalities with LBC, and some studies have argued that the more important benefit is increased adequate workflow and specimen adequacy, not an essential enhancement in diagnostic quality [9, 10].

n Pakistan, where cervical screening is poorly structured and has limited coverage, the selection of the cytological method directly affects the program's effectiveness and scalability. It has local evidence growing, though very little of it [3, 8]. This gap is significant to laboratory practice and to policy decisions aimed at identifying which screening method is more suitable, sustainable, and clinically useful in Pakistan. This research aims to make a comparative analysis between CPS and LBC as screening tools for cervical carcinoma in Pakistan.

METHODOLOGY

The research had 200 participants and was calculated using the WHO sample size calculator at a 95% confidence level and a 6.2% margin of error. The sample size included women with complaints that constituted a symptomatic cervical lesion or an unhealthy cervix. All participants provided written informed consent. The study sample consisted of 200 women aged 20 to 65. Women who were pregnant or postpartum, women who had undergone a hysterectomy previously, and women who had been previously diagnosed and treated with cervical carcinoma were excluded. Moreover, the non-consenting individuals were not recruited.

Demographic and clinical information, such as age, menstrual history, and use of contraceptives, was gathered in a structured proforma. All participants were examined under a per speculum with a Cusco speculum to demonstrate the existence of any apparent disorders of the cervix. An Ayre spatula was used to collect cervical samples in CPS. The material was collected on glass slides and immediately fixed in 95% ethyl alcohol. The slides were additionally stained using the modified Papanicolaou procedure and viewed using a microscope.

In LBC, a cervical broom was used to collect samples in the transformation zone. The brush head was removed and stored in a vial containing a preservative solution. A thorough vial mixing was performed to achieve an adequately suspended sample, and the sample was then sent to the laboratory for processing. The CPS and LBC findings were compared and analyzed against histopathological findings, where possible.

Data were analyzed using SPSS 26. Quantitative variables were reported as means and standard deviations, whereas qualitative variables were reported as frequencies and percentages. Stratification was used to control for effect modifiers, and analysis was performed using the Chi-square test, with p-values of 0.05 or lower considered statistically significant. CPS and LBC were compared for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) in the detection of squamous intraepithelial lesions.

RESULTS

The study involved 200 women with a mean age of 44.96 ± 5.5 years. The majority belonged to rural areas (n=115, 57.5%) compared to urban residents (n=85, 42.5%). Most participants were from lower socioeconomic status (n=115, 57.5%), followed by middle (n=73, 36.5%) and upper class (n=12, 6.0%). Regarding clinical presentation, white discharge per vagina was the most common complaint (n=94, 47.0%), followed by lower abdominal pain (n=56, 28.0%). Intermenstrual bleeding (n=25, 12.5%),

burning micturition (n=14, 7.0%), and post-coital bleeding (n=11, 5.5%) were less frequent. Most women had undergone tubectomy (n=111, 55.5%) (Table 1).

Table 1: Baseline Socio-Demographic Profile and Clinical Characteristics of Study Participants (n = 200)

Characteristics	Number (%) / Mean ± SD
Age (years)	44.9 ± 6.5
Socioeconomic Status	
Upper	12 (6.0%)
Middle	73 (36.5%)
Lower	115 (57.5%)
Area of Residence	
Rural	115 (57.5%)
Urban	85 (42.5%)
Clinical Presentation	
White Discharge Per Vagina	94 (47.0%)
Lower Abdominal Pain	56 (28.0%)
Intermenstrual Bleeding	25 (12.5%)
Burning Micturition	14 (7.0%)
Post-Coital Bleeding	11 (5.5%)
Contraceptive Use	
Tubectomy	111 (55.5%)
None	76 (38.0%)
Barrier Methods	8 (4.0%)
Oral Contraceptive Pills	5 (2.5%)

LBC demonstrated a higher rate of satisfactory smears (n=188, 94.0%) compared to CPS (n=166, 83.0%). Similarly, detection of endocervical cells was greater in LBC (n=112, 56.0%) than CPS (n=78, 39.0%). The differences between LBC and CPS were statistically significant (p<0.001) (Table 2).

Table 2: Comparative Assessment of Sample Adequacy and Endocervical Cell Yield in LBC and CPS

Study Variable	LBC (n = 200)	CPS (n = 200)	P-Value
Endocervical Cells Present	112 (56.0%)	78 (39.0%)	<0.001
Satisfactory Smear	188 (94.0%)	166 (83.0%)	<0.001

LBC showed slightly higher detection of normal cytology (n=22, 11.0%) compared to CPS (n=16, 8.0%). Negative for intraepithelial lesion or malignancy was comparable between LBC (n=112, 56.0%) and CPS (n=118, 59.0%). Overall epithelial abnormalities were similar in both methods (n=66, 33.0% each); however, LBC demonstrated marginally higher detection of ASCUS (n=24, 12.0%) and LSIL (n=26, 13.0%), while CPS showed slightly higher HSIL detection (n=12, 6.0%). Differences were not statistically significant (Table 3).

Table 3: Comparison of Cytological Findings and Microscopic Features between LBC and CPS

Microscopic Features	LBC (n = 200)	CPS (n = 200)	P-Value
Normal Cytology	22 (11.0%)	16 (8.0%)	
Negative for Intraepithelial Lesion or Malignancy	112 (56.0%)	118 (59.0%)	
Epithelial Abnormalities	66 (33.0%)	66 (33.0%)	0.6115
ASCUS	24 (12.0%)	20 (10.0%)	
LSIL	26 (13.0%)	23 (11.5%)	
HSIL	10 (5.0%)	12 (6.0%)	
SCG	4 (2.0%)	6 (3.0%)	
AGC-NOS	2 (1.0%)	5 (2.5%)	

The diagnostic performance of LBC was higher than that of CPS for detecting LSIL and HSIL. In the case of LSIL, LBC was more sensitive (88.0%) and more specific (99.0%) than CPS (72.0% and 98.0%). Likewise, in HSIL detection, LBC was more sensitive (77.0%) and specific (99.0) than CPS (62.0% and 98.5%). PPV and NPV also remained higher with LBC in both lesion types, demonstrating that it is more reliable for cervical lesion screening (Table 4).

Table 4: Comparative Diagnostic Performance of LBC and CPS for Detection of LSIL and HSIL

Parameters	LSIL LBC (%)	LSIL CPS (%)	HSIL LBC (%)	HSIL CPS (%)
Sensitivity (%)	88.0	72.0	77.0	62.0
Specificity (%)	99.0	98.0	99.0	98.5
PPV (%)	92.0	85.0	89.0	82.0
NPV (%)	98.0	96.0	98.0	97.0

DISCUSSION

CPS has been widely used as a screening procedure for cervical cancer. However, it has several inherent limitations in its diagnostic accuracy. The high rate of false negatives, which can be very high (up to 50 percent) in certain situations due to inefficient sampling, uneven cell distribution, and other obscuring factors such as blood or inflammatory exudate, is one of the most critical issues related to CPS [11]. Moreover, during smear preparation, a large proportion of the harvested cellular material is poorly transferred to the glass slide, further undermining diagnostic accuracy. LBC has been created as an improved alternative solution to address these inefficiencies. Recent studies have also shown that LBC produces a meaningful impact on specimen adequacy, reduces unsatisfactory smears, and has a higher rate of detection of epithelial abnormalities than CPS [10, 12].

This study evaluated LBC and CPS as screening modalities for cervical carcinoma. LBC, in our series, yielded a much higher percentage of satisfactory smears than CPS (94.0% vs 83.0%) and a higher recovery rate of endocervical cells (56.0% vs 39.0%), both significant. These results confirm the supposition that the benefit of LBC starts at the point of specimen preparation and not necessarily at the point of microscopic interpretation [8, 9]. Our findings are broadly consistent with a study from Western Maharashtra, Patel et al. reported satisfactory smears in 98.6% of LBC samples compared with 95.0% of CPS samples, while endocervical cells were present in 60.0% of LBC smears versus 49.0% of CPS smears [8]. However, a study from Georgia by Ekaterina et al. reported lower unsatisfactory smear rates with LBC (1.33%) than with conventional Pap smear (7.33%) [9].

The endocervical cell findings in our study also align with several recent reports. Patel et al. found endocervical cells in 60% of LBC smears and 49% of CPS smears, which mirrors the direction of our results [8]. A study by Sharma et al. reported a much larger difference, with endocervical cells present in 97.97% of satisfactory LBC smears compared with 45.33% of conventional smears [13].

In our analysis, LBC outperformed CPS for LSIL and HSIL, with higher sensitivity, specificity, positive predictive value, and negative predictive value. Andola et al. also found the same LSIL (3.6% CPS versus 3.0% LBC) and HSIL (2.2% versus 2.0%) frequencies, and epithelial abnormalities were not significantly different between methods in an Indian study of 500 paired samples [14]. Similar trends were observed in the study by Das et al., where LSIL was found in CPS at 1.33% and 3.33%, and HSIL at 2% and 2%, respectively [15]. On the other hand, Garg et al. reported a more consistent separation, with LBC showing 7.2% positive results compared to 4.3% with CPS, indicating that in certain high-risk cohorts, LBC can detect more lesions than CPS [16].

LBC performed significantly better on diagnostic performance measures than CPS. These findings are in agreement with a study by Fatima et al., which reported LBC sensitivity of 85.6% vs 71.2% against CPS in precancer lesions ($P<0.05$) with higher specificity (96.1 vs 94.8), and better predictive values [17]. Elas (2026) found that using LBC, sensitivity and specificity are 92% and 96, respectively, compared to 78% and 88% using CPS ($p< 0.05$) [18]. However, Garg et al. observed that the high-grade detection difference (LBC 100% and accuracy 96.6% vs. CPS 14.2% and 91.1%) is so great that the advantage of LBC is particularly pronounced in cases where unsatisfactory smears or interpretation problems are more frequent [16]. In Pakistan, where screening coverage is low and follow-up may be challenging, higher sensitivity and reliability of LBC in identifying LSIL and HSIL would lead to fewer missed opportunities for earlier intervention without a major increase in the burden of referred cases to colposcopy.

There are limitations to this study. The small sample size of the study may limit generalizability, and results may differ in larger studies. Moreover, no HPV testing was done, which failed to determine the prevalence of HPV in the individuals who had squamous and glandular lesions.

CONCLUSION

LBC outperformed CPS in terms of smear adequacy and detection of LSIL and HSIL. This suggests that LBC can be adopted more efficiently in cervical cancer screening. LBC could be advantageous to CPS in the clinical setting because it is a more precise diagnostic instrument. Larger multicenter studies should, however, confirm these findings. To further improve the use of cervical cancer screening and early diagnosis, future research should also encompass HPV testing in order to establish its relation with cytological outcomes.

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