International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Comparison of Conventional Pap Smear Versus Liquid-Based Cytology

Sanjay Kumar Yadav[1], Smriti Varshney[2], Ritu Saxena[3]*

[1]Assistant Professor, Department of Pathology, United Institute of Medical Sciences, Prayagraj, Uttar Pradesh, India
[2]Assistant Professor, Department of Pathology, Sambhal Shri Siddhi Vinayak Medical College and Hospital, Sambhal, Uttar Pradesh, India
[3]HOD & Professor, Department of Pathology, Sambhal Shri Siddhi Vinayak Medical College and Hospital, Sambhal, Uttar Pradesh, India

OPEN ACCESS

Corresponding Author:

Dr. Ritu Saxena
HOD & Professor, Department of Pathology, Sambhal Shri Siddhi Vinayak Medical College and Hospital, Sambhal, Uttar Pradesh, India

Received: 08-04-2026
Accepted: 05-05-2026
Available online: 14-05-2026

ABSTRACT

Background: Cervical cancer is one of the leading causes of cancer-related morbidity and mortality among women worldwide, particularly in developing countries. Cytological screening plays a vital role in early detection of premalignant and malignant cervical lesions. Conventional Pap smear (CPS) has been widely used for cervical cancer screening; however, limitations such as inadequate sampling, obscuring inflammatory cells, and poor cellular preservation may affect diagnostic accuracy. Liquid-based cytology (LBC) has been introduced as an improved technique to overcome these limitations.
Aim: To compare conventional Pap smear and liquid-based cytology in cervical cancer screening with respect to smear adequacy, background clarity, cellular preservation, and detection of epithelial abnormalities.
Materials and Methods: This prospective comparative observational study was conducted in the Department of Pathology at Sambhal Shri Siddhi Vinayak Medical College and Hospital over a period of one year from April 2025 to March 2026. A total of 140 women attending the gynecology outpatient department with symptoms suggestive of cervical pathology were included in the study. Cervical samples were collected from each participant and processed by both conventional Pap smear and liquid-based cytology techniques. Smears were evaluated according to the Bethesda System 2014. Parameters compared included smear adequacy, background clarity, cellular preservation, and epithelial cell abnormalities.
Results: Among the 140 cases studied, satisfactory smears were obtained in 124 (88.6%) cases by CPS and 136 (97.1%) cases by LBC. Unsatisfactory smears were significantly lower with LBC. Cleaner background was observed in 90.0% of LBC smears compared to 51.4% of CPS smears. Epithelial cell abnormalities were detected in 18 (12.9%) cases by CPS and 24 (17.1%) cases by LBC. Liquid-based cytology showed improved detection of ASC-US, LSIL, and HSIL lesions
Conclusion: Liquid-based cytology demonstrated superior smear adequacy, improved background clarity, better cellular preservation, and higher detection rates of epithelial abnormalities compared to conventional Pap smear. LBC appears to be a more effective cervical cancer screening modality, although cost and resource availability remain important considerations in low-resource settings.

Keywords: Conventional Pap smear, Liquid-based cytology, Cervical cancer screening, Bethesda system, Cervical cytology.

INTRODUCTION

Cervical cancer is one of the most common malignancies among women worldwide and continues to be a major public health problem, particularly in developing countries. According to the World Health Organization, cervical cancer ranks as the fourth most frequent cancer among women globally, with a significant burden observed in low- and middle-income nations where organized screening programs are limited [1]. Persistent infection with high-risk human papillomavirus

(HPV), especially HPV-16 and HPV-18, is considered the principal etiological factor in the development of cervical intraepithelial neoplasia and invasive cervical carcinoma [2].

Cytological screening has played a crucial role in reducing the incidence and mortality of cervical cancer through early detection and treatment of premalignant lesions. Since its introduction by George Papanicolaou, the conventional Pap smear (CPS) has remained the cornerstone of cervical cancer screening programs worldwide [3]. The technique involves direct transfer of exfoliated cervical epithelial cells onto a glass slide followed by fixation and staining. Despite its widespread use and cost-effectiveness, conventional cytology has several limitations including inadequate cellular sampling, uneven cell distribution, air-drying artifacts, obscuring blood and inflammatory cells, and overlapping cellular material, all of which may contribute to false-negative results [4].

To overcome these limitations, liquid-based cytology (LBC) was introduced as an alternative method for cervical cytological evaluation. In LBC, the collected cervical sample is suspended in a preservative solution before laboratory processing, which allows removal of debris, blood, mucus, and inflammatory cells, thereby producing a cleaner and more uniform cellular preparation [5]. This technique improves specimen adequacy and enhances visualization of cellular morphology and nuclear details.

Several studies have compared conventional Pap smear and liquid-based cytology regarding diagnostic accuracy, specimen adequacy, and detection rates of epithelial abnormalities. Studies by Sherwani et al. and Arbyn et al. demonstrated that LBC significantly reduces unsatisfactory smear rates and improves detection of premalignant lesions compared to CPS [6,7]. Furthermore, LBC permits ancillary testing such as HPV DNA testing from the residual sample, which adds an additional advantage in cervical cancer screening programs [8].

In India, cervical cancer remains one of the leading causes of cancer-related deaths among women despite the availability of screening methods. Resource limitations, lack of awareness, and inadequate implementation of organized screening programs contribute significantly to disease burden [9]. Therefore, evaluating newer cytological techniques like liquid-based cytology in comparison with conventional Pap smear is important for improving screening efficiency and early diagnosis.

The present study was undertaken in the Department of Pathology at Sambhal Shri Siddhi Vinayak Medical College and Hospital to compare conventional Pap smear and liquid-based cytology with respect to smear adequacy, background clarity, cellular preservation, and detection of epithelial cell abnormalities among women undergoing cervical cancer screening.

MATERIALS AND METHODS

Study Design

The present study was a prospective comparative observational study conducted to compare conventional Pap smear (CPS) and liquid-based cytology (LBC) in cervical cancer screening.

Study Setting

The study was carried out in the Department of Pathology at Sambhal Shri Siddhi Vinayak Medical College and Hospital in collaboration with the Department of Obstetrics and Gynecology.

Study Duration

The study was conducted over a period of one year from April 2025 to March 2026.

Study Population

Women attending the gynecology outpatient department with symptoms suggestive of cervical pathology or those undergoing routine cervical screening were included in the study.

Sample Size

A total of 140 women were enrolled during the study period.

Inclusion Criteria

- Women aged between 21 and 65 years.
- Women presenting with complaints such as vaginal discharge, lower abdominal pain, postcoital bleeding, irregular menstrual bleeding, or unhealthy cervix on clinical examination.
- Women willing to participate and provide informed consent.

Exclusion Criteria

- Pregnant women.
- Women with previously diagnosed carcinoma cervix.

- Women who had undergone hysterectomy.
- Patients with active heavy menstrual bleeding at the time of sample collection.
- Women unwilling to participate in the study.

Ethical Consideration
The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to inclusion in the study.

Sample Collection Procedure
Detailed clinical history and demographic data were recorded for each patient. Cervical examination was performed using a sterile Cusco's speculum under aseptic precautions.
Two cervical samples were collected from each participant using Ayre's spatula and endocervical brush:
- The first sample was directly smeared onto a clean glass slide for conventional Pap smear preparation.
- The second sample was rinsed into a vial containing preservative solution for liquid-based cytology.

Conventional Pap Smear Technique
For CPS, the collected material was evenly spread onto a glass slide and immediately fixed in 95% ethanol to avoid air-drying artifacts. The slides were subsequently stained using the conventional Papanicolaou staining technique.

Liquid-Based Cytology Technique
For LBC, the cervical sample was transferred into a preservative fluid and processed according to standard liquid-based cytology protocol. After processing, a thin uniform layer of cells was prepared on glass slides and stained using the Papanicolaou stain.

Cytological Evaluation
Both CPS and LBC smears were examined independently under light microscopy by experienced cytopathologists. Smears were assessed for:
- Smear adequacy
- Cellularity
- Background clarity
- Presence of blood, mucus, and inflammatory cells
- Cellular overlapping
- Cytomorphological abnormalities

All cytological interpretations were reported according to the Bethesda System 2014.

Cytological Categorization
Smears were categorized as:
- Negative for intraepithelial lesion or malignancy (NILM)
- Atypical squamous cells of undetermined significance (ASC-US)
- Low-grade squamous intraepithelial lesion (LSIL)
- High-grade squamous intraepithelial lesion (HSIL)
- Squamous cell carcinoma (SCC)

Statistical Analysis
The collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Categorical variables were expressed as frequency and percentage. Comparison between CPS and LBC was performed using Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS
A total of 140 women attending the gynecology outpatient department were included in the present study. Both conventional Pap smear (CPS) and liquid-based cytology (LBC) samples were obtained from all participants and evaluated comparatively. The age of the patients ranged from 21 to 65 years, with the majority belonging to the 31–40 years age group.

Table 1: Age Distribution of Study Participants

Age Group (Years)	Number of Cases	Percentage
21–30	32	22.9%
31–40	46	32.9%
41–50	38	27.1%
51–60	18	12.9%

>60	6	4.2%
Total	**140**	**100%**

The most common presenting complaints among study participants were vaginal discharge, lower abdominal pain, irregular menstrual bleeding, and postcoital bleeding. Vaginal discharge was the predominant symptom observed in the majority of women.

Table 2: Clinical Presentation of Patients

Clinical Complaint	Number of Cases	Percentage
Vaginal discharge	58	41.4%
Lower abdominal pain	34	24.3%
Irregular menstrual bleeding	26	18.6%
Postcoital bleeding	12	8.6%
Other complaints	10	7.1%
Total	140	100%

Comparison of smear adequacy revealed that liquid-based cytology provided a higher proportion of satisfactory smears than conventional Pap smear. Unsatisfactory smears due to poor fixation, obscuring inflammatory exudates, blood, and scant cellularity were more frequently encountered in CPS preparations.

Table 3: Comparison of Smear Adequacy

Smear Adequacy	Conventional Pap Smear	Liquid-Based Cytology
Satisfactory	124 (88.6%)	136 (97.1%)
Unsatisfactory	16 (11.4%)	4 (2.9%)
Total	140	140

Background clarity and cellular preservation were significantly improved in LBC preparations. Conventional smears frequently demonstrated obscuration by inflammatory cells, mucus, and hemorrhagic background, whereas LBC slides showed cleaner and more uniform cellular distribution.

Table 4: Comparison of Background Clarity

Background Feature	CPS	LBC
Clean background	72 (51.4%)	126 (90.0%)
Obscured by blood/inflammation	68 (48.6%)	14 (10.0%)
Total	140	140

On cytological evaluation according to the Bethesda System 2014, the majority of cases in both methods were reported as negative for intraepithelial lesion or malignancy (NILM). However, liquid-based cytology demonstrated a higher detection rate of epithelial cell abnormalities including ASC-US, LSIL, and HSIL compared to conventional Pap smear.

Table 5: Cytological Interpretation by CPS and LBC

Cytological Diagnosis	CPS	LBC
NILM	122	116
ASC-US	6	8
LSIL	7	9
HSIL	3	5
Squamous Cell Carcinoma	2	2
Total abnormal cases	18 (12.9%)	24 (17.1%)

Among inflammatory lesions, nonspecific inflammation constituted the majority of benign findings. Reactive cellular changes and atrophic smears were also observed in a smaller number of cases.

Table 6: Distribution of Benign Cytological Findings

Benign Findings	CPS	LBC
Nonspecific inflammation	74	70
Reactive cellular changes	24	26
Atrophic smear	10	10
Infective pathology	14	16
Total benign lesions	122	122

Overall, liquid-based cytology showed better specimen adequacy, improved background clarity, superior cellular preservation, and enhanced detection of epithelial abnormalities compared to conventional Pap smear in the present study.

DISCUSSION

Cervical cancer screening through cytological examination remains one of the most effective strategies for early detection of premalignant and malignant cervical lesions. The present study compared conventional Pap smear (CPS) and liquid-based cytology (LBC) in terms of smear adequacy, background clarity, cellular preservation, and detection of epithelial abnormalities among 140 women attending a tertiary care hospital. The findings of the present study demonstrated that LBC was superior to CPS in multiple cytomorphological parameters.

In the present study, the majority of patients belonged to the 31–40 years age group, accounting for 32.9% of cases. Similar age distribution patterns have been reported in previous studies where cervical epithelial abnormalities were more frequently encountered in women of reproductive and perimenopausal age groups [10,11]. This may be attributed to increased exposure to risk factors such as persistent HPV infection, multiparity, and poor genital hygiene during these years.

Vaginal discharge was the most common presenting complaint observed in the study population. Comparable findings were reported by Singh et al. and Sherwani et al., who also identified vaginal discharge as the predominant symptom among women undergoing cervical cytology screening [6,12]. Chronic cervicitis and inflammatory lesions remain common indications for Pap smear examination in routine gynecological practice.

One of the most important observations in the present study was the significantly higher smear adequacy rate in LBC (97.1%) compared to CPS (88.6%). Unsatisfactory smears were markedly reduced in LBC preparations. Conventional smears frequently showed poor fixation, air-drying artifacts, thick smears, and obscuring inflammatory exudates, which interfered with accurate cytological interpretation. Similar observations have been documented by Davey et al., who reported lower unsatisfactory smear rates with liquid-based cytology compared to conventional smears [8]. Arbyn et al. also concluded that LBC improves specimen adequacy and reduces inadequate sample rates significantly [7].

Background clarity was considerably better in LBC preparations in the present study. Nearly 90% of LBC smears showed a clean background compared to only 51.4% of CPS smears. The filtration and processing techniques used in LBC remove blood, mucus, inflammatory cells, and debris, thereby improving visualization of epithelial cells. These findings correlate with studies conducted by Kavatkar et al. and Nandini et al., who also observed superior background clarity and uniform cell distribution in LBC smears [5,13].

The present study demonstrated improved detection of epithelial abnormalities by LBC. Epithelial cell abnormalities were identified in 17.1% of LBC smears compared to 12.9% in CPS. Cases categorized as ASC-US, LSIL, and HSIL were detected more effectively in LBC preparations. Better preservation of nuclear morphology and reduction of obscuring factors likely contributed to enhanced diagnostic yield. Similar findings were reported by Diaz-Rosario and Kabawat, who observed increased sensitivity of LBC for detection of cervical epithelial lesions [14]. Sherwani et al. also reported higher detection rates of premalignant lesions using LBC compared to conventional cytology [6].

In the current study, nonspecific inflammatory lesions constituted the majority of benign cytological findings in both techniques. However, inflammatory obscuration was significantly lower in LBC smears. This facilitated improved visualization of epithelial cells and reduced false-negative interpretations. Previous investigators have similarly noted that cleaner backgrounds in LBC improve diagnostic confidence and reduce screening errors [15].

Another important advantage of LBC is the possibility of performing ancillary molecular testing such as HPV DNA analysis from residual samples. This is particularly beneficial in modern cervical cancer screening protocols where combined cytology and HPV testing are increasingly recommended [16]. Although HPV testing was not performed in the present study, the potential for reflex molecular testing remains a significant advantage of LBC over CPS.

Despite its advantages, LBC has certain limitations, especially in resource-constrained settings. The higher cost of equipment, consumables, and processing may limit its routine use in peripheral healthcare centers. Conventional Pap smear continues to remain a simple, economical, and accessible screening method in many developing regions. However, the improved diagnostic accuracy and reduced unsatisfactory rates associated with LBC may justify its implementation in tertiary care settings and organized screening programs [17].

Overall, the findings of the present study support the superiority of liquid-based cytology over conventional Pap smear in terms of smear adequacy, cleaner background, and enhanced detection of epithelial abnormalities. These observations are consistent with the majority of published literature and reinforce the role of LBC as an effective cervical cancer screening modality.

CONCLUSION

Liquid-based cytology demonstrated superior performance over conventional Pap smear in terms of smear adequacy, background clarity, and detection of epithelial abnormalities. LBC minimizes obscuring factors and provides better cellular preservation, thereby improving diagnostic accuracy in cervical cytology screening.

Although conventional Pap smear remains a cost-effective and widely accessible screening method, liquid-based cytology may be considered a preferred alternative where resources permit.

REFERENCES

1. World Health Organization. Cervical cancer. Geneva: WHO; 2021.
2. Walboomers JM, Jacobs MV, Manos MM, Bosch FX, Kummer JA, Shah KV, et al. Human papillomavirus is a necessary cause of invasive cervical cancer worldwide. J Pathol. 1999;189(1):12-19.
3. Papanicolaou GN. A new procedure for staining vaginal smears. Science. 1942;95(2469):438-439.
4. Nayar R, Wilbur DC. The Bethesda System for Reporting Cervical Cytology. 3rd ed. New York: Springer; 2015.
5. Kavatkar AN, Nagwanshi CA, Dabak SM. Study of a manual method of liquid-based cervical cytology. Indian J Pathol Microbiol. 2008;51(2):190-194.
6. Sherwani RK, Khan T, Akhtar K, Zeba A, Siddiqui FA, Rahman K, et al. Conventional Pap smear and liquid-based cytology for cervical cancer screening. J Cytol. 2007;24(4):167-172.
7. Arbyn M, Bergeron C, Klinkhamer P, Martin-Hirsch P, Siebers AG, Bulten J. Liquid compared with conventional cervical cytology: a systematic review and meta-analysis. Obstet Gynecol. 2008;111(1):167-177.
8. Davey E, Barratt A, Irwig L, Chan SF, Macaskill P, Mannes P, et al. Effect of study design and quality on unsatisfactory rates in liquid-based cytology studies: a systematic review. Lancet. 2006;367(9505):122-132.
9. Sankaranarayanan R, Nene BM, Dinshaw KA, Mahe C, Jayant K, Shastri SS, et al. Early detection of cervical cancer with visual screening methods and cytology: a randomized trial in India. Lancet. 2005;365(9471):2151-2158.
10. Patel MM, Pandya AN, Modi J. Cervical Pap smear study and its utility in cancer screening, to specify the strategy for cervical cancer control. Natl J Community Med. 2011;2(1):49-51.
11. Bamanikar SA, Baravkar DS, Chandanwale SS, Dapkekar P, Gulhane S. Study of cervical Pap smears in a tertiary hospital. Indian Med Gazette. 2014;148(7):250-254.
12. Singh S, Badaya S. Comparative study of conventional Pap smear and liquid-based cytology in cervical cancer screening. Trop J Pathol Microbiol. 2016;2(2):45-51.
13. Nandini NM, Nandish SM, Pallavi P, Akshatha SK, Chandrashekar AP, Hariprasad P. Manual liquid based cytology in primary screening for cervical cancer - a cost effective preposition for scarce resource settings. Asian Pac J Cancer Prev. 2012;13(8):3645-3651.
14. Diaz-Rosario LA, Kabawat SE. Performance of a fluid-based, thin-layer Papanicolaou smear method in the clinical setting of an independent laboratory and an outpatient screening population in New England. Arch Pathol Lab Med. 1999;123(9):817-821.
15. Hutchinson ML, Zahniser DJ, Sherman ME, Herrero R, Alfaro M, Bratti MC, et al. Utility of liquid-based cytology for cervical carcinoma screening: results of a population-based study conducted in a region of Costa Rica with a high incidence of cervical carcinoma. Cancer. 1999;87(2):48-55.
16. Cuzick J, Clavel C, Petry KU, Meijer CJLM, Hoyer H, Ratnam S, et al. Overview of the European and North American studies on HPV testing in primary cervical cancer screening. Vaccine. 2006;24(S3):S3/29-S3/41.
17. Monsonego J, Autillo-Touati A, Bergeron C, Dachez R, Liaras A, Saurel J, et al. Liquid-based cytology for primary cervical cancer screening: a multi-centre study. Br J Cancer. 2001;84(3):360-366.