



A COMPARATIVE ANALYSIS OF LIQUID-BASED CYTOLOGY VERSUS THE CONVENTIONAL PAPANICOLAOU SMEAR FOR CERVICAL CANCER SCREENING

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ABSTRACT

Background: Due to screening with cervical cytology, mortality rates caused by cervical cancer reduced significantly. Two methods are regularly applied to cytological evaluation: the standard Papanicolaou (Pap) smear and liquid-based cytology (LBC). Even though LBC has been found to have a significant diagnostic benefit in comparison with other populations, the comparative data are still scarce. This paper compared the diagnostic value of LBC and the traditional pap smear in the diagnosis of cervical epithelial lesions.

Duration and Place of Study: This study was conducted at Larkana Institute of Nuclear Medicine & Radiotherapy / Shaikh zaid women Hospital Larkana from December 2024 to December 2025.

Methods: 94 females were under screening of cervical cancer. Out of them, 41 samples were done in LBC and 53 by the traditional Pap smear method. A cytological examination was done on all the cytological specimens and reported following the Bethesda System of Reporting Cervical Cytopathology.

Results: The age range of the participants was 39.46+ _ 11.14 years in mean. In total, 97.8 percent of samples were good enough to be assessed. The inadequacy rate of the conventional pap smear was 3.7 and that of the LBC was 0. The majority of the specimens (95.7) were reported to be negative in regard to intraepithelial lesion or malignancy. In all samples, 2.1% of squamous epithelial abnormalities were detected. LBC showed a better detection rate of squamous intraepithelial lesions (4.8) over that of the conventional Pap smear (0%). The abnormalities of glandular findings were found in the LBC samples and traditional Pap smears (2.4 and 1.8, respectively).

Conclusion: LBC had a higher rate of detection of cervical epithelial abnormalities than the conventional Pap smear. The results indicate that LBC should be further adopted as a means of cervical cancer screening.

Keywords: Cervical Cytology, Papanicolaou Smear, Liquid-Based Cytology, Cervical Cancer Screening, Bethesda System.



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INTRODUCTION

Cervical cancer is still one of the most preventable malignancies among women, but the disease still has a substantial global burden, especially in low- and middle-income countries, where no or unsystematic screening programme is established. In spite of the progress in vaccination and molecular tests, cytology-based screening remains one of the pillars of early detection approaches in numerous health care systems [1]. With the advent of cervical cytology in the middle of the twentieth century, the

incidence and mortality rates of cervical cancer dropped dramatically due to the capacity of screening to detect the precancerous lesions prior to the development of invasive cancer. With time, two major cytological methods have developed, which include the traditional Pap smear and liquid-based cytology (LBC) [2]. The two procedures are designed to identify cellular abnormalities that are suggestive of cervical intraepithelial neoplasia (CIN) or malignancy, but significant differences in sample collection, processing, and diagnostic accuracy exist.

The traditional Pap smear has been in use for decades and is highly available since it is inexpensive and simple in its methodology. Nonetheless, the following limitations can affect diagnostic accuracy, which include uneven cell distribution, obscuring of blood or inflammatory cells and air-drying artefacts [3]. These deficiencies have led to the invention of LBC that preserves the collected cells in a preservative medium and then automates processing. This method enhances the adequacy of samples, minimises obscuring material and enables ancillary testing such as high-risk human papillomavirus (HPV) assays using the same sample. This has seen LBC being embraced as a screening method of choice in most countries [4].

Recent reports have gone ahead to compare the relative performance of LBC and conventional cytology, especially when it comes to sample adequacy, detection of epithelial abnormalities and overall diagnostic yield [5]. Several studies published since 2020 have reported increased CIN detection rates and better quality of the specimen with LBC, which supported previous evidence indicating that it is better in a routine screening environment. In other words, cross-sectional and institutional studies have shown that LBC has a negative effect of decreasing the proportion of unsatisfactory samples and increasing the identification of both the glandular and the squamous lesions [6]. The usefulness of LBC in supporting reflex HPV testing is also emphasized in other studies, which are progressively incorporated into current screening algorithms [7, 8]. The results are in line with the trends in the world to adopt more sensitive and reproducible screening technologies.

Although these are the benefits, the shift of the traditional cytology to LBC is not universal. The cost factor, laboratory facilities, and employee development are still major constraints in most areas [9]. Moreover, there are studies which have reported the same detection rate between the two techniques and this might imply that the advantages of LBC might vary with the population traits, lab competence and screening procedures [10, 11]. This inconsistency highlights the importance of context-based assessments over environments where the limitations of resources affect screening procedures. Knowledge of the relative performance of the two

techniques on various populations is critical for policy formulation and maximizing screening results [12].

The current change to the use of HPV as a primary screening method has also sensitized the use of cytology as a method of triage instead of using it as a one-off test. This is a changing environment where the accuracy and reliability of cytological methods are of vital concern [13]. LBC, which has the capability of integrated molecular testing, can have benefits in programmes that are shifting to HPV-oriented strategies. Nevertheless, it is still useful and comparative data are still viable to inform clinical practice, particularly in areas where HPV testing is not yet embedded in the routine practice [14].

With these in mind, it is quite significant to consider the diagnostic utility of LBC as compared to the conventional Pap smear as a research area. Research carried out on different populations helps to bring a more wholesome knowledge on the performance of each technique in different clinical and operating circumstances. This especially applies to healthcare systems that want to strike a balance between the accuracy of the diagnosis and both functionality and affordability. Comparative studies can assist in assessing the significance of transitioning to LBC by evaluating the adequacy of samples, the ability to detect abnormalities of the epithelial, and general diagnostic yield [15].

The current paper adds to this emerging body of evidence through its comparison of the performance of LBC and conventional Pap smear in the detection of lesions of the epithelial cervix. This study will offer information that can be used to make informed decisions on cervical cancer screening interventions through examination of sample adequacy and cytological results.

METHODOLOGY

This study involved 94 women who were screened for cervical cancer. Women who have a history of gynecological malignancies were excluded. All samples of cervical cytology were taken in the gynecology clinic by the trained gynecologist through standard sampling methods. The specimens were then processed and evaluated by the Cytopathology Department after collection.

Out of the entire number of samples, 41 specimens were developed with the help of liquid-based cytology (LBC), whereas 53 samples were developed with the help of the conventional Pap smear method. Comparison of smears prepared by both procedures was done in order to determine the adequacy of samples and to detect any abnormalities in the cervical epithelial cells.

In the case of the standard Pap smear, a spatula and endocervical brush were used to obtain the samples. The material was collected directly on a glass slide that was fixed immediately and the stained material was stained by the Pap staining method. In the case

of LBC, the samples were taken with the help of a cytobrush and rinsed completely in a container with a preservative solution. The vials were automated through a liquid-based cytology processor, creating monolayered slides.

The rate of poor sampling and the percentage of epithelial abnormalities detected using the two techniques were compared. The screening of all slides was done by qualified cytotechnologists and later reviewed and reported by consultant cytopathologists. Cytologic interpretation of both LBC and the conventional Pap smear preparations was done based on the Bethesda System of Reporting Cervical Cytopathology.

RESULTS

The analysis used 94 cervical cytology samples, 53 conventional Pap smears and 41 liquid-based cytology (LBC) preparations. The average age of the women was 39.46 ± 11.14 years. Adequacy of the sample was excellent in general, and most of the specimens in both groups were considered satisfactory to be assessed. Two samples only were reported as inadequate, both of those belonging to the conventional Pap smear group, leading to a rate of inadequacy of 3.7% in conventional cytology and none were inadequate in the LBC group. The difference was not significant, but the lack of poor samples in the LBC arm was indicative of better sample preservation and a cleaner background of the liquid-based preparations.

Negative intraepithelial lesion or malignancy (NILM) was the most common cytological category that was reported among satisfactory samples. NILM was found in 51 traditional Pap smears and 39 LBC samples, which constitute the majority of the two samples. Distribution of NILM diagnosis with the two methods showed no significant difference, with LBC showing a slightly higher percentage of non-NILM diagnosis and this indicates its stronger capacity to detect small changes of epithelial changes.

In both cytological methods, a variety of benign and infectious diseases were detected. Five cases were diagnosed with candidiasis and conventional cytology and LBC had an equal distribution. In both groups, the bacterial vaginosis was detected. The study population did not have any instances of trichomoniasis, actinomycosis, or viral cytopathic changes. The atrophic vaginitis was rather prevalent and was described in 14 cases in general, with the same proportions in both groups. The presence of endometrial cells was determined in one conventional Pap smear, and none in LBC samples. It was observed in three cases that there were

reactive cellular changes, which showed no significant difference in the two methods.

One of the most frequent outcomes was nonspecific inflammation found in 28 conventional Pap smears and 20 LBC samples. Though both of the approaches showed some inflammatory alterations, the relatively higher percentage in the conventional group can be explained by the existence of obscuring inflammatory debris, which is better eliminated in LBC preparations. Although this difference is not statistically significant, it corresponds to the established benefits of LBC to create cleaner and more readable slides.

In terms of epithelial lesions, LBC showed a greater sensitivity rate of detecting squamous lesions than the Pap smear used conventionally. The LBC group had two cases of squamous intraepithelial lesions, including one low-grade squamous intraepithelial lesion (LSIL) and one high-grade squamous intraepithelial lesion (HSIL). However, the conventional Pap smear group showed the absence of any squamous lesions. This disparity has a small number basis, yet it indicates the better cellular preservation and distinct morphology that is linked to LBC that could be used to identify dysplastic alterations that might be missed in standard smears. Two cases identified atypical squamous cells of undetermined significance (ASC-US) in one case each in both groups and therefore demonstrate that the two methods could identify borderline squamous abnormalities. Glandular malfunction was rare, reported to occur in one of the conventional Pap smear group only, atypical glandular cells (AGUS), and no case in the LBC group. In both arms of the study, no instances of adenocarcinoma were found.

In comparison of an overall distribution of diagnostic categories, LBC provided a higher rate of yield of epithelial abnormalities, especially squamous lesions and conventional Pap smear had slightly higher prevalence of inflammatory and reactive changes. Though the small sample size had a diminishing statistical power of the comparisons, the trends were observed to be consistent with the already known benefits of LBC in enhancing the sample adequacy and increasing the ability to identify clinically relevant epithelial abnormalities. Combined, the results of the current study suggest that LBC offers a better sample quality and a high detection rate of squamous intraepithelial lesions than the traditional Pap smear, although it can be compared to the conventional Pap smear with regard to the identification of benign, infectious, and inflammatory foci. These findings contribute to the increasing amount of evidence that LBC can provide significant diagnostic value to cervical cancer screening programmes.

Table 1: Comparison of Liquid-Based Cytology and Conventional PAP Smear in Terms Of Diagnostic Categories

Cytological Diagnostic Category	Conventional PAP Smear (n = 53)	LBC (n = 41)	Total (n = 94)	P-Value
Inadequate	2 (3.7%)	0 (0%)	2 (2.1%)	—
NILM	51 (96.2%)	39 (95.1%)	90 (95.7%)	—
Squamous epithelial lesions	0 (0%)	2 (4.8%)	2 (2.1%)	—
Glandular epithelial lesions	1 (1.8%)	1 (2.4%)	2 (2.1%)	—

Table 2: Comparison of LBC and Conventional PAP Smear in Terms of Individual Diagnoses

Cytological Diagnosis	Conventional PAP Smear (N = 53)	LBC (N = 41)	Total (N = 94)	P-Value
Inadequate	2 (3.7%)	0 (0%)	2 (2.1%)	—
Candidiasis	3 (5.6%)	2 (4.8%)	5 (5.3%)	—
Bacterial vaginosis	1 (1.8%)	1 (2.4%)	2 (2.1%)	—
Trichomoniasis	0 (0%)	0 (0%)	0 (0%)	—
Actinomycosis	0 (0%)	0 (0%)	0 (0%)	—
Viral changes (herpes simplex)	0 (0%)	0 (0%)	0 (0%)	—
Atrophic vaginitis	8 (15.0%)	6 (14.6%)	14 (14.9%)	—
Endometrial cells	1 (1.8%)	0 (0%)	1 (1.1%)	—
Reactive changes	2 (3.7%)	1 (2.4%)	3 (3.2%)	—
Radiation changes	0 (0%)	0 (0%)	0 (0%)	—
Nonspecific inflammation	28 (52.8%)	20 (48.7%)	48 (51.1%)	—
ASC-US	1 (1.8%)	1 (2.4%)	2 (2.1%)	—
LSIL	0 (0%)	1 (2.4%)	1 (1.1%)	—
HSIL	0 (0%)	1 (2.4%)	1 (1.1%)	—
AGUS, favor neoplastic	1 (1.8%)	0 (0%)	1 (1.1%)	—
Adenocarcinoma	0 (0%)	0 (0%)	0 (0%)	—
NILM (NOS)	6 (11.3%)	8 (19.5%)	14 (14.9%)	—

DISCUSSION

The current research has shown that liquid-based cytology (LBC) has significant benefits over the traditional Pap smear in reference to adequacy of the sample and the detection of epithelial abnormalities. Despite the small sample size, the tendencies present are in line with the existing international evidence and confirm the diagnostic usefulness of LBC in the screening of cervical cancer. The total lack of

substandard samples in the LBC-based group versus the 3.7% deficiency in the traditional smears is indicative of the well-documented capacity of LBC to reduce obscuring agents like blood, mucus, and inflammation residues. This observation is consistent with the findings of Yildiz et al., who determined that unsatisfactory smears were substantially lower with LBC in a large Turkish cohort [16]. Another similarity in their study was the

enhanced clarity and consistency of LBC preparations, which led to increased dependability in cytological interpretation.

As both groups would manifest a greater proportion of NILM, the higher proportion of NILM results in the screening group is not surprising; nonetheless, the weakly increased rate of non-NILM results in the LBC group indicates greater sensitivity to subtle cytological anomalies. This tendency can be compared to the results of Santos et al. in Brazil, which indicated that LBC elevated the rates of LSIL and HSIL and reduced the rate of NILM reports [17]. Their findings confirm their hypothesis that LBC could also capture early epithelial changes not captured by conventional smears because of overlapping cells or air-drying artefacts.

Similar results were found in the detection of benign and infectious conditions, such as candidiasis, bacterial vaginosis, and atrophic vaginitis, but nonspecific inflammation was more commonly reported in conventional smears. This can be an indication of the existence of surrounding debris, which can blur epithelial images and cause over-interpretation of inflammatory evidence. Italian researchers (Romano et al.) also observed that the conventional smears tend to be more obscuring in nature, and LBC gives a clearer background that enables more precise evaluation of inflammatory and reactive changes [18]. Their results coincide with the crystalized morphology that we can see in our LBC slides.

The clinically meaningful difference that was most important in our study was the identification of epithelial abnormalities. LBC revealed LSIL and HSIL, but no squamous lesion was seen in the conventional Pap smear group. This finding is in line with the prospective study conducted by Mehta et al. in India, which showed that LBC was significantly more effective in detecting ASCUSL, LSIL, and HSIL than the conventional cytology [19]. On the same note, Park et al. in Korea demonstrated that LBC possessed greater sensitivity on CIN2+ lesions but with similar specificity, implying clinical applicability of the HSIL case that was identified in our LBC group [20]. All these findings support the diagnostic superiority of LBC in detecting premalignant lesions.

The glandular abnormalities were infrequent in our group, with only one case of AGUS in the conventional group. Although this could be due to a small sample size, it is unlike the results of Lopez-Garcia et al. in Spain, who found that LBC was better than the conventional method in detecting glandular lesions since the nuclear and cytoplasmic details are better preserved [21]. The fact that glandular deviations were not present in our LBC group cannot, however, be taken as a disadvantage of the technique, but the fact is that in the study population, such lesions occurred frequently.

The larger effects of the shift in the traditional cytology to LBC were examined at the population level. In the United Kingdom, Brown et al. assessed the effects of LBC incorporation into a local screening programme and found that there was less inadequate smears and more clinically significant abnormalities, similar to our study direction of effect [22]. Their results demonstrate the possible beneficial impact of the broader implementation of LBC on public health and especially in environments in which maximization of diagnostic accuracy is crucial.

Lastly, Hassan et al. in Egypt were able to show that LBC not only enhances the quality of samples, but also the inter-observer agreement of cytopathologists, which is probably because LBC slides are more standardized in their processing and their morphology is clearer [23]. This observation is in turn echoed to our experience in which LBC preparations helped to gain a more confident notice of epithelial abnormalities.

Combined, the results of the current research are consistent with the evidence of the world showing that LBC gives better sample adequacy, clearer morphology, and higher rates of detection of squamous intraepithelial lesions than traditional Pap smears do. Even though our comparisons cannot be performed in large scale due to the small sample size, the fact that our results are consistent with various larger studies bolsters the assumption that LBC has significant diagnostic benefits. These advantages are especially applicable because cervical cancer screening programmes are starting to use more and more HPV-based strategies, in which cytology is used as a triage method and diagnosis is also of vital importance. More screening will help to determine the role of LBC in maximizing the effectiveness of screening and lowering the incidence of cervical cancer.

CONCLUSION

This paper shows that the liquid-based cytology yields better morphology, better adequacy, and more epithelial abnormalities than the standard Pap smear. LBC removes the distorting artefacts and aids in preserving cells better, which leads to increased diagnostic confidence and the ability to identify clinically significant lesions earlier. Despite the small number of participants, the results are consistent with the evidence on the international level and support the importance of LBC in the current screening pathways of the cervix. Since HPV-based screening strategies are becoming more and more part of screening programmes, it is highly necessary to adopt cytological approaches that aim to maximise accuracy. Such observations would be better substantiated by larger multicentre studies and help justify the large-scale use of LBC in clinical practice.

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