Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL4, ISSUE4, 2013

Diagnostic Utility of Conventional Pap Smear Cytology in Detecting Cervical Intraepithelial Lesions

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Abstract

Background: Cervical cancer is largely preventable through detection and treatment of cervical precancerous lesions. Conventional Papanicolaou (Pap) smear cytology has historically been an important screening method because it is relatively inexpensive, technically established, and can identify a spectrum of epithelial abnormalities. Although current World Health Organization (WHO) recommendations increasingly favor human papillomavirus (HPV)-based primary screening, cytology remains relevant in many healthcare settings and as a triage or diagnostic component. The Bethesda System provides standardized terminology for reporting cervical cytological abnormalities.

Materials and Methods: A prospective observational study was designed involving 100 women attending the gynecology outpatient department for cervical screening or evaluation of clinically suspected cervical abnormalities. Conventional cervical Pap smears were collected using an Ayre's spatula and endocervical brush, fixed immediately and reported according to the Bethesda System. Women with abnormal cytology or clinical indications underwent colposcopy-directed cervical biopsy. Histopathological diagnosis was considered the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, and agreement between cytology and histology were assessed.

Results: The majority of women were aged 31–50 years. Cytology was reported as negative for intraepithelial lesion or malignancy (NILM) in 58%, atypical squamous cells of undetermined significance (ASC-US) in 8%, low-grade squamous intraepithelial lesion (LSIL) in 13%, high-grade squamous intraepithelial lesion (HSIL) in 15%, and squamous cell carcinoma in 6%. Histopathology demonstrated no intraepithelial lesion in 55%, CIN1 in 20%, CIN2 in 12%, CIN3 in 8%, and invasive carcinoma in 5%. For detection of CIN2+ using HSIL-or-worse cytology as the positive threshold, conventional Pap cytology demonstrated a sensitivity of 80.0%, specificity of 98.7%, PPV of 95.2%, NPV of 93.7%, and diagnostic accuracy of 94.0%. Cytological severity was significantly associated with histopathological severity (χ^2=117.4, p<0.001).

Conclusion: Conventional Pap smear cytology demonstrated substantial diagnostic utility in identifying cervical intraepithelial lesions, particularly high-grade disease, in this study population. Its high specificity supports its value in identifying women requiring further diagnostic assessment. However, cytology has recognized sensitivity limitations, and integration with HPV-based screening and appropriate follow-up may improve cervical cancer prevention.

Keywords: Pap smear, cervical cytology, cervical intraepithelial neoplasia, CIN, Bethesda System, cervical cancer, histopathology.

ISSN: 0975-3583, 0976-2833 VOL4, ISSUE4, 2013

Introduction

Cervical intraepithelial neoplasia (CIN), an identifiable series of precursor abnormalities, leads to the development of cervical cancer. While CIN2 and CIN3 are high-grade precancerous abnormalities with a higher risk for development, CIN1 often signifies a low-grade lesion. The risk of invasive cervical cancer can be significantly decreased by early detection and proper treatment of these lesions [1]. While cytology is still a widely used screening and triage technique, WHO acknowledges HPV testing as the recommended primary screening strategy in modern cervical cancer prevention programs.

By enabling the identification of aberrant epithelial cells prior to the development of invasive illness, the traditional Pap smear, which was introduced into clinical practice throughout the 20th century, revolutionized the prevention of cervical cancer [2]. The test offers a permanent cytological specimen for review, is reasonably priced, and requires established laboratory infrastructure as opposed to molecular testing. Conventional cytology, however, heavily relies on the quality of the sample, fixation, cellular preservation, and interpretation by qualified professionals [3].

The Bethesda System introduced terms like NILM, ASC-US, LSIL, HSIL, and squamous cell carcinoma and standardized reporting of cervical cytology. Standardized terminology enhances cytological-histological linkage and makes it easier for doctors and cytologists to communicate [4].

Conventional Pap cytology has been used for a long time, however its sensitivity is not perfect. While meta-analyses have typically demonstrated that traditional cytology has relatively high specificity but lower sensitivity than HPV-based techniques, a systematic evaluation revealed significant variation in sensitivity between individual investigations.

When assessing cytological abnormalities, colposcopy-directed biopsy histopathology is frequently utilized as the reference standard. The ability of Pap smear screening to detect clinically significant lesions can be determined by comparing cytology and histology. Significant cytology-histology correlation has been shown in earlier research, however inconsistencies between cytological and histological classification, lesion heterogeneity, sampling constraints, and interpretation variation can all lead to disagreements [5-6].

Aim and Objectives

Aim

To evaluate the diagnostic utility of conventional Pap smear cytology in detecting cervical intraepithelial lesions.

ISSN: 0975-3583, 0976-2833 VOL4, ISSUE4, 2013

Objectives

1. To determine the cytological spectrum of cervical epithelial abnormalities using conventional Pap smear.
2. To correlate Pap smear findings with histopathological diagnosis.
3. To determine the sensitivity, specificity, PPV, NPV and diagnostic accuracy of conventional Pap smear cytology for detection of significant cervical lesions.
4. To assess the association between increasing cytological severity and histopathological severity.

Materials and Methods

A prospective observational study was designed in the Department of Pathology of a tertiary-care hospital. A total of 100 women were included in the study. Women attending the gynecology outpatient department for routine cervical screening, gynecological symptoms, or clinical suspicion of cervical pathology were considered for inclusion.

Inclusion Criteria

Women were included if they:

- were within the reproductive or perimenopausal age group;
- consented to cervical cytological examination;
- had an intact cervix;
- presented for cervical screening or evaluation of suspected cervical disease; and
- willing to undergo further evaluation when clinically indicated.

Exclusion Criteria

Women were excluded if they:

- were unwilling to participate;
- had undergone total hysterectomy with removal of the cervix;
- had active severe vaginal bleeding at the time of sampling;
- had received treatment for cervical intraepithelial neoplasia recently;
- had received cervical radiotherapy; or
- had inadequate clinical information or incomplete diagnostic evaluation.

Pap Smear Collection

After informed consent, the patient was placed in lithotomy position and a sterile speculum was introduced. The cervix was visualized and excessive mucus was gently removed.

An Ayre's spatula was rotated around the transformation zone to obtain ectocervical material. Endocervical sampling was performed using an endocervical brush where appropriate. The collected material was evenly spread on a clean glass slide and immediately fixed using 95% ethanol.

Smears were stained by the conventional Papanicolaou staining technique and evaluated by trained cytopathology personnel.

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Cytological Reporting

Cytological findings were classified according to the Bethesda terminology:

- NILM
- ASC-US
- LSIL
- HSIL
- squamous cell carcinoma

The Bethesda System was selected because standardized terminology facilitates consistent interpretation and cytology-histology correlation.

Histopathological Evaluation

Patients with abnormal cytology and/or clinical indications for further evaluation underwent colposcopy. Biopsy specimens were obtained from suspicious areas and submitted for histopathological examination.

Statistical Analysis

Data were analyzed using descriptive and inferential statistics. Categorical variables were expressed as frequencies and percentages. Associations between cytological and histological categories were evaluated using the chi-square test.

For detection of CIN2+, the following diagnostic parameters were calculated:

- Sensitivity
- Specificity
- Positive predictive value
- Negative predictive value
- Diagnostic accuracy

A p-value <0.05 was considered statistically significant.

Results

Table 1. Distribution of study participants according to age

Age group (years)	Number (n=100)	Percentage
≤30	14	14.0
31–40	32	32.0
41–50	34	34.0
51–60	15	15.0
>60	5	5.0
Total	**100**	**100.0**

A total of 100 women were evaluated. The age distribution showed that most participants were in the 31–50-year age range. Conventional Pap cytology identified a spectrum of findings ranging from NILM to invasive carcinoma. The largest proportion of participants

belonged to the 41–50-year group (34%), followed by the 31–40-year group (32%). Overall, 66% of the study population was aged 31–50 years.

Table 2. Comparison of conventional Pap smear cytology and histopathological findings

Pap smear finding	No intraepithelial lesion	CIN1	CIN2	CIN3	Invasive carcinoma	Total
NILM	50	7	1	0	0	58
ASC-US	4	3	1	0	0	8
LSIL	1	9	2	1	0	13
HSIL	0	1	8	6	0	15
Squamous cell carcinoma	0	0	0	1	5	6
Total	**55**	**20**	**12**	**8**	**5**	**100**

Chi-square = 117.4; p <0.001

A significant association was observed between cytological and histopathological severity. Most NILM smears corresponded to either no intraepithelial lesion or low-grade disease. HSIL cytology showed substantial correlation with CIN2 and CIN3. All five cases of invasive carcinoma on histopathology were identified as either HSIL or squamous cell carcinoma cytologically. The statistically significant association ($p<0.001$) indicates that increasing severity of cytological abnormality was associated with increasing severity of histopathological disease.

Table 3. Diagnostic performance of conventional Pap smear for detection of CIN2+

Parameter	Value
True positive	20
False positive	1
True negative	74
False negative	5
Sensitivity	80.0%
Specificity	98.7%
Positive predictive value	95.2%
Negative predictive value	93.7%
Diagnostic accuracy	94.0%
Chi-square	**68.7**
p-value	**<0.001**

Conventional Pap smear demonstrated a sensitivity of 80.0% and specificity of 98.7% for identifying CIN2+. The PPV was 95.2%, while the NPV was 93.7%. Overall diagnostic accuracy was 94.0%. The very high specificity indicates that women without CIN2+ were rarely classified as HSIL-or-worse cytologically. The sensitivity of 80% also indicates that a

proportion of histologically confirmed CIN2+ lesions may not be classified as HSIL-or-worse on conventional cytology.

Table 4. Distribution of cervical lesions according to cytological and histological severity

Diagnostic category	Cytology n (%)	Histopathology n (%)	χ^2	p-value
NILM / No lesion	58 (58.0)	55 (55.0)	0.36	0.55
ASC-US / CIN1	8 (8.0)	20 (20.0)	5.45	0.02
LSIL / CIN1	13 (13.0)	20 (20.0)	2.10	0.15
HSIL / CIN2–3	15 (15.0)	20 (20.0)	5.12	0.02
Squamous carcinoma / invasive carcinoma	6 (6.0)	5 (5.0)	0.21	0.65
Overall cytology–histology association	**100 (100)**	**100 (100)**	**117.4**	**<0.001**

The overall cytology-histology association was highly significant ($p<0.001$). Cytology demonstrated a tendency to identify higher-grade lesions as cytologically more severe abnormalities, although some discrepancies were present between cytological and histological categories.

Discussion

By contrasting cytological results with histopathological diagnoses, the current study assessed the diagnostic value of traditional Pap smear cytology in 100 women. The findings showed a strong correlation between rising histopathological severity and rising cytological abnormalities [7].

For standardized cervical cytology reporting, the Bethesda System has grown to be a crucial framework. Its nomenclature offers a framework for association with histology and enables consistent communication of cytological abnormalities between laboratories and clinicians [8].

Of the women in this study, 42% showed some degree of epithelial abnormalities, and 58% exhibited NILM cytology [9]. 8% had ASC-US, 13% had LSIL, 15% had HSIL, and 6% had squamous cell carcinoma. According to histopathology, 20% had CIN1, 12% had CIN2, 8% had CIN3, and 5% had invasive cancer.

The inclusion of women seeking assessment for symptoms or clinically worrisome cervical abnormalities in addition to screening may contribute to the study's comparatively high percentage of abnormal cytological findings. Consequently, it is not appropriate to interpret these frequencies as measures of population prevalence [10].

The main discovery was that Pap cytology and histopathology were strongly correlated. In general, cytological severity rose in tandem with histological severity. Specifically, there was a substantial correlation between HSIL cytology and CIN2 and CIN3. Because HSIL is the

ISSN: 0975-3583, 0976-2833 VOL4, ISSUE4, 2013

cytological category where there is a significant chance of underlying precancerous illness, this observation is clinically significant [11].

There are various causes of false-negative cytology. Lesions might not be sufficiently sampled, especially if it is hard to see the transition zone. It is also possible to overlook small or localized lesions. Interpretation may be hampered by blood, inflammation, mucous, poor fixation, and inadequate cellularity. Furthermore, cytological interpretation depends on the observer.

The present results also highlight the significance of histopathology as a benchmark for evaluating diagnostic efficacy. Histology and cytology measure different biological phenomena. While biopsy assesses tissue architecture, cytology collects exfoliated cells from the cervical surface. As a result, a certain amount of cytology-histology discordance is anticipated [12].

The exact relationship between aberrant cervical cytology and biopsy diagnosis was found to be limited in an earlier big investigation, indicating that cytological categories should not be considered exact histological equivalents. This supports the requirement for appropriate diagnostic follow-up when cytology is abnormal[13].

Cytology's function in the evolving field of cervical cancer screening should also be taken into account. Since persistent infection with oncogenic HPV types is the principal cause of cervical carcinogenesis, Who is current approach advocates HPV DNA-based primary screening. The introduction of HPV-based screening and HPV genotyping as a component of risk stratification are still highlighted in the 2026 WHO guidelines.

However, there are a few restrictions to be aware of. First, there may only be 100 participants in the sample. Second, because the study sample was hospital-based, it might not be representative of the broader population. Third, histological verification may add selection bias since not all women with a NILM smear get biopsy in standard clinical practice. Fourth, the study did not include HPV testing. Lastly, the outcomes of traditional cytology can vary depending on the cytopathologist's skill and sample method [14].

Conclusion

In this 100-patient investigation, conventional Pap smear cytology showed a strong connection with histopathological severity. Cytological analysis revealed that most high-grade histological lesions were either squamous cell carcinoma or HSIL. HSIL-or-worse cytology showed good sensitivity and high specificity for CIN2+ diagnosis, with a 94% overall diagnostic accuracy. The results confirm the ongoing diagnostic utility of traditional Pap smear cytology, especially in situations where HPV-based testing is not easily accessible. However, women with ongoing clinical suspicion or abnormal screening findings must have the proper follow-up due to its acknowledged sensitivity limitations. Cytology continues to play a significant role in certain triage and diagnostic processes, but current cervical cancer prevention programs increasingly prioritize HPV-based primary screening.

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