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Research Article

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Comparing the Manual Liquid-Based Cytology with the Conventional Method in Bronchoaleolar Lavage Aspiration(BAL)/Bronchial Wash Fluids

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Abstract

The technique of Liquid-Based Cytology, is the advanced methods of preparing cytology specimen, has surpassed conventional pap smears because it has enhanced fixation, minimized interference, and reliable cell transfer. In LBC, samples are gathered by completely immersing the sampling device in a vial filled with a preservative solution, which facilitates the concurrent preservation and fixation of cells, in contrast to traditional smears where the sample is applied to a glass slide and fixed subsequently. Currently, there are two primary methods for liquid preparation - ThinPrep and SurePath. In our research, the goal was to compare the manual liquid-based cytology with the conventional method in bronchoalveolar lavageaspiration (BAL)/bronchial wash fluids.

Aim: *The aim was to compare the manual liquid-based cytology with the conventional method in bronchoalveolar lavage aspiration (BAL) /bronchial wash fluids.*

Material and Methods: *A total of 100 Brochoalveolar lavage aspiration samples were analyzed in this prospective investigation utilizing conventional method preparations and manual liquid-based cytology. Cellularity, background, cellular preservation, and nuclear preservation were evaluated in both manual liquid-based cytology smears and direct smears. A cytopathologist independently examined the slides. For the purpose of statistical evaluation, the Chai-square test was utilized to determine the p-value and to assess the histopathological correlation.*

Result: *The cellularity observed in MLBC and conventional smears is similar, but the MLBC approach improves the evaluation of cell morphology by reducing nucleus overlap, haemorrhage, and necrosis. The recorded P value was below 0.05, which is considered statistically significant. The sensitivity rates were 18.9% for CC and 34.5% for LBC, respectively, while the specificity for both methods was 42.7% and 47.5%. Consequently, LBC demonstrated a slightly superior sensitivity in this analysis. Likewise, the negative predictive value showed a slight enhancement with LBC technology (55.1% for LBC compared to 50.0% for CC). The positive predictive values were 100% for LBC and 55.6% for CC across both techniques.*

Conclusion: *In contrast to traditional BAL fluid methods, the MLBC preparation in BAL aspiration fluid is safe, straightforward, and quick, potentially offering significant diagnostic advantages; however, utilizing both CS and MLBC preparations is advised for enhanced diagnostic outcomes.*

Keywords: Lung cancer, Adenocarcinoma, Cell block, Conventional cytology (CC), Liquid-based cytology (LBC), Bronchoalveolar lavage (BAL), Bronchial wash (BW)

1. Introduction

Lung cancer is the top cause of cancer-related fatalities in India and is the leading cause of cancer mortality in many other nations [1]. Metastatic tumors are frequently found in the lungs, in addition to primary tumors [2]. Early-stage lung cancer is usually diagnosed incidentally through chest imaging or lung cancer screening programs aimed at high-risk populations, and patients frequently show no symptoms. As a result, approximately 70% of lung cancer cases are discovered during a more advanced stage [3]. Flexible bronchoscopy plays a crucial role in diagnosis as nearly half of the advanced cases involve the central airways.To increase the sensitivity of lung cancer diagnosis, the British Thoracic Society

has recommended using bronchoscopic biopsy in conjunction with bronchial brush or bronchoalveolar lavage (BAL) fluid cytology [4].

For BAL fluid samples, the conventional smear (CS) method has been frequently used to aid in the diagnosis of lung cancer. Nevertheless, this technique has demonstrated a number of shortcomings, including a lengthy sample preparation period, instances of excessively thick smears, and areas with overlapping cells. Additionally, the morphological evaluation of the nucleus and vital cells has been further restricted by the presence of inflammatory cells, blood cells, and artefacts from air-drying. The reduced sensitivity of the CS technique is believed to be a result of these technical difficulties [5]. Liquid-based cytology (LBC) provides enhanced diagnostic accuracy, better sample quality, and a lower rate of unsatisfactory results when compared to conventional Pap smears. Other advantages of liquid based cytology include a clearer background with minimal interference from blood or mucus, automated and uniform cell distribution, reduced chances of false negatives, and the option to conduct reflex HPV testing using the same sample.LBC has been used to diagnose lung cancer in a number of specimen types, such as sputum, bronchoalveolar lavage (BAL) fluid, bronchial brushing, and transbronchial needle aspiration [6–8]. Research indicates that LBC demonstrates greater sensitivity and specificity compared to Conventional smear (7); however, some researchers have reported conflicting findings. As a result, we initiated this study to compare LBC with CS and evaluate the diagnostic effectiveness of LBC in detecting lung cancer using BAL fluid. Cytology has been widely utilized in the diagnosis of lung cancer. When evaluating lung cancer, bronchial cytology samples are of significant diagnostic value, particularly when obtaining bronchoscopic biopsy specimens for histological analysis is challenging and when peripheral lesions are involved. There is a dearth of research on the use of LBC in BAL, and there are no firm recommendations. This study was therefore conducted to compare the diagnostic accuracy of LBC with conventional technique BAL/BW fluids.

2. Material & and Methods

The prospective study was carried out by the Pathology department at MM College of Medical Sciences and Research in Sadopur, Ambala from December 2024 to December 2025. Informed consent was secured from all patients prior to the commencement of the study. The study included cases with radiological and/or clinical signs of cancer. Cytology requisition forms were used to record clinical and radiological data. The aim of this study was to evaluate the effectiveness of conventional cytology (CC) versus liquid-based cytology (LBC) in analyzing specimens submitted within specified time frames. A total of 100 patients were included, focusing specifically on cases where a definitive diagnosis could be achieved through conventional techniques. Using the Bronchoalveolar Lavage (BAL) fluid, a Conventional smear was made. After wet-fixing one smear in 95% ethyl alcohol, the Pap method was used to stain it. An air-dried smear was made for May-Grünwald Giemsa (MGG) staining, and a second smear was reserved for MLBC. MLBC preparations were allocated to a second smear. All cases that allowed for a definitive diagnosis using conventional methods were included, as were cases with insufficient material to compare the cellularity of Conventional Smears (CS) versus MLBC. In order to create smears for CS, the sample was placed directly onto a slide and the other was wet-fixed in 95% ethyl alcohol and stained using the Pap method. The MLBC samples were collected in vials and preserved using an ethanol-based preservative. After centrifuging the material for five minutes at 1,500 rpm, the semi-automated BD SurePathTM system was used to process it, which uses the density gradient sedimentation principle. The cell or sample is first vortexed and strained to break up mucus and large cell aggregates before being subjected to a density gradient centrifugation procedure to remove blood. The cell pellet is resuspended and then allowed to settle on a glass slide. Wet-fixed smears were stained using the Pap method, while air-dried smears were stained using MGG. One of the factors examined was a comparison of the cellularity of MLBC and conventional smears.

3. Cytology Reporting

The slides were reported by the cytopathologists, with more than five years of experience. In most of the cases blinding was maintained by the cytopathologist but in few cases opinion was taken from radiology. The cases were divided into the following

S.NO	Diagnosis	Criteria
1.	Positive for malignancy	Included cases with definite malignant cells in adequate cellularity
2.	Suspicious of malignancy	Included cases with normal cellular components (alveolar macrophages, ciliated columnar cells) and/or inflammatory cells without any atypical cells.
3.	Negative for malignancy	Included case with bronchial epithelial cell and alveolar macrophages with dense inflammation in the background
4.	Inflammatory pathology	Included case with brochial epithelial cell and alveolar macrophages with dense inflammation in the background.
5.	Unsatisfactory	Included cases with few/no epithelial cells and alveolar macrophages, excessive background obscuration with inflammation, blood, mucus, or excessive degenerative

The correlation between conventional and MLBC as well as the histopathological correlation was ascertained using the ANOVAt-test.

4. Results

In our study, we analyzed 100 cases. Histopathological correlation was only possible for 11 cases (11%) out of the total 100. Each case exhibited a different diagnosis when assessed using traditional techniques in contrast to the MLBC technique. This research aimed to compare Bronchial washing/BAL (bronchoalveolar lavage fluid) in the histopathological diagnoses of the corresponding CS and MLBC preparations. The cellularity in MLBC was slightly reduced compared to conventional smears, with less nuclear overlap, allowing for a clearer and more detailed assessment of cell morphology. For the background analysis, we utilized the Chai Square test (Table-1), to perform a statistical evaluation of the obtained data. In cases of MLBC, occurrences of bleeding and necrosis were reduced compared to conventional methods, yielding a p-value. In our study, a p-value of less than 0.05, which indicates statistical significance, was observed. Categorical/ Scoring system data was examined through Chai Square test (Table 3), while measures of agreement were employed to compare two diagnostic tools. The ANOVA t-test was conducted to evaluate the correlation between conventional methods and MLBC, along with histopathological correlation (Table 4). The predictive values (sensitivity, specificity, PPV, NPV, and accuracy) were established for various lesions. A p-value of < 0.05 was statistically significant. The sensitivity rates were 18.9% and 34.5% for Conventional technique and liquid based cytology, respectively, while the specificity for both methods was 42.7% and 47.5%. As a result, LBC exhibited slightly superior sensitivity in this analysis. Similarly, the negative predictive value indicated a slight enhancement with LBC technology (55.1% for LBC compared to 50.0% for CC). The positive predictive value was 100% for LBC and 55.6% for CC across both techniques.

Background	Conventional technique (n-100)	Liquid based cytology (n-100)	P value
Necrosis	40	10	<0.001
Fibromixoid	20	05	0.003
Mucin	30	10	<0.001
Blood	35	08	<0.001

Table 1: Backgrounds Surrounding in Conventional and Liquid Based Cytology (Chai Square Test)

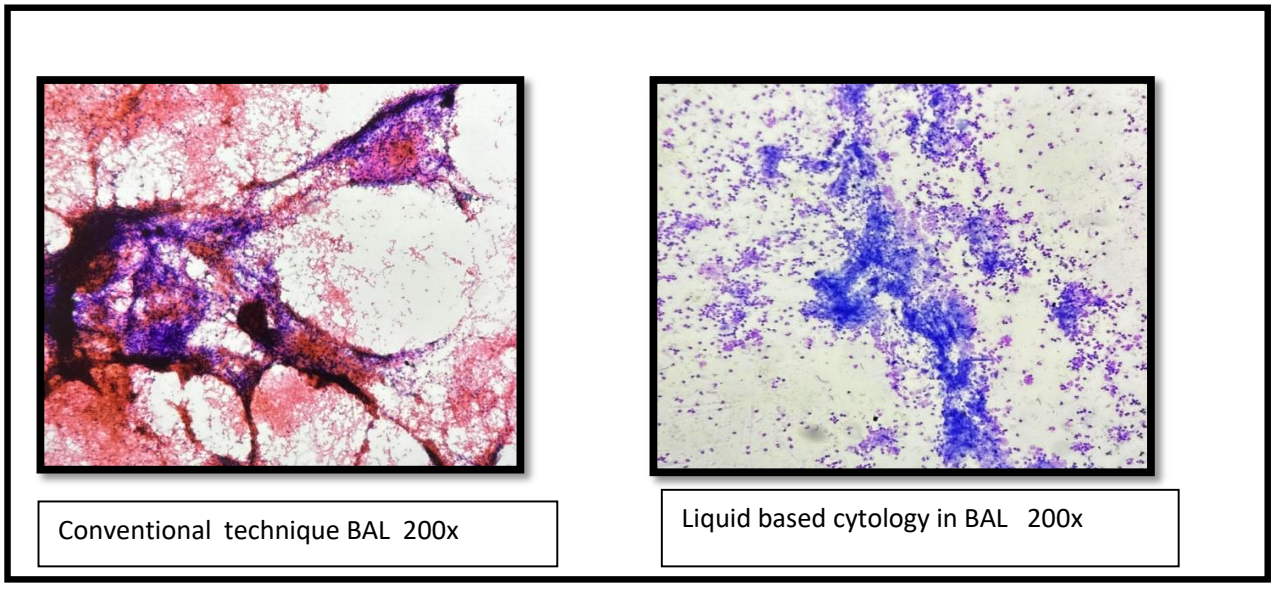

Figure 1: Hemorrhagic background in case of Squamous cell carcinoma respectively in conventional technique and liquid-based cytology technique in BAL fluid cytology in May-Grunwald-Giemsa stain (MGG).

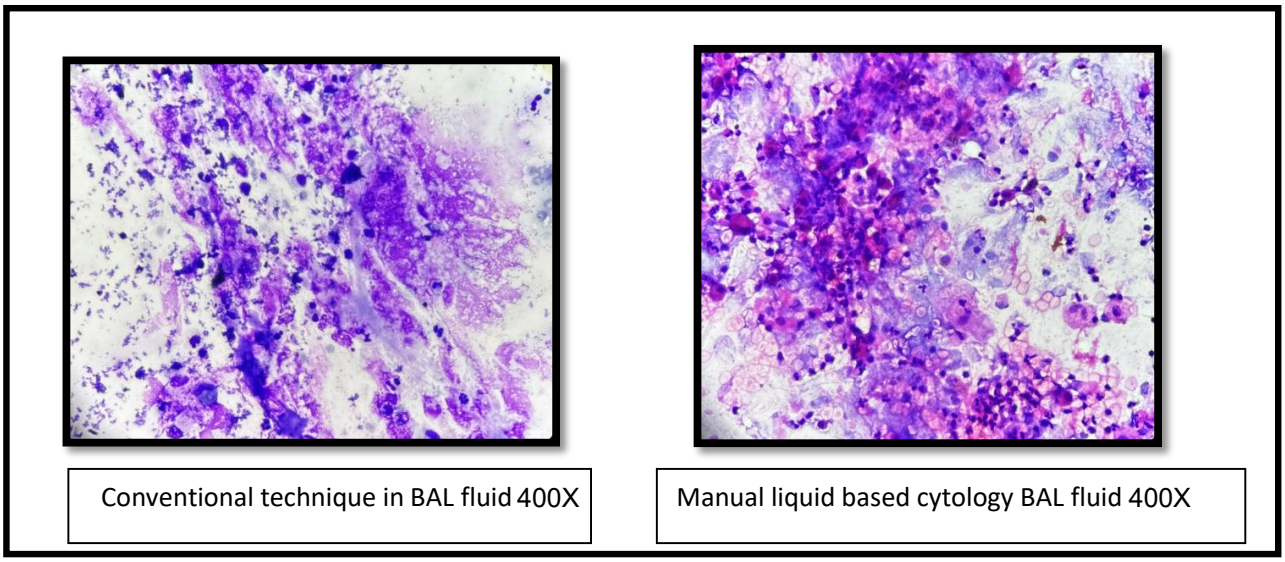

Figure 2: Nuclear characteristics in conventional technique and manual liquid-based cytology techniques in BAL fluid cytology in MGG stain.

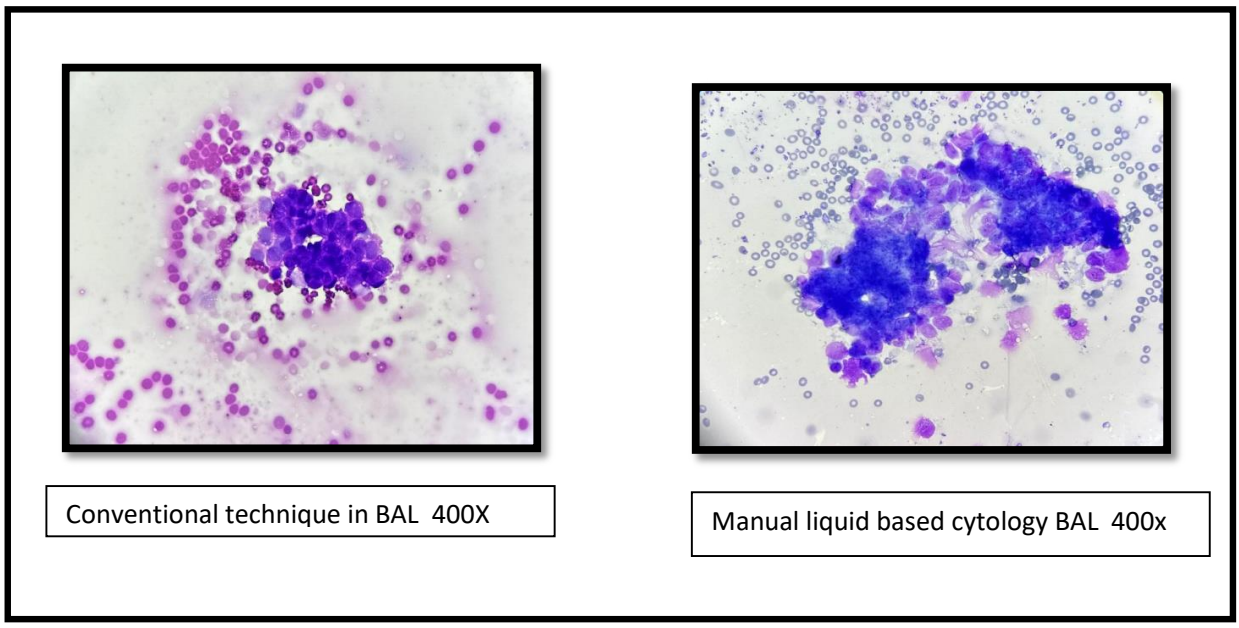

Figure 3: Cellularity background in case of adenocarcinoma of lung respectively in conventional tecnique and manual liquid-based cytology technique in BAL fluid cytology.

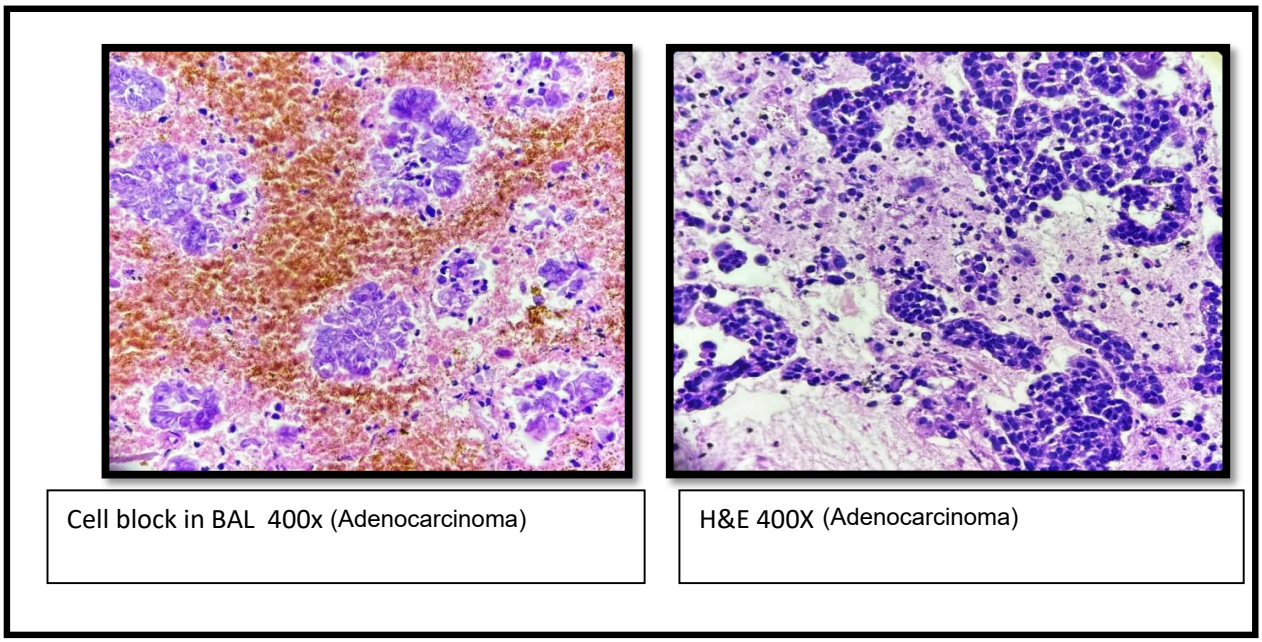

Figure 4: Cell block and Histopathological correlation in case of adenocarcinoma of lung.

CYTOLOGY FEATURE	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Cellularity	Nil	Scanty	Adequate	Abundant
Background blood, cell debris	Nil	Occasional	Good amount	Abundant
Cell architecture	Not recognized	Partially recognized	Well recognized	Cell architecture
Nuclear detail	Poor	Fair	Good	Very good
Cytoplasmic detail	Poor	Fair	Good	Very good

Table 2: BAL/BW Cytology Scoring System

Scoring system	Conventiona l (n100)	MLBC (n100)	P value
Cellularity	92	86	0.227
Cell architecture	79	93	0.008
Monolayered sheets	81	94	0.010
Nuclear detail	85	97	0.005
Cytoplasmic detailed	88	95	0.012

Table 3: Chai-Square Test for Scoring System fn Conventional and MLBC

	Conventional technique		Liquid based cytology		H& E
Positive for malignancy	10	10%	20	20%	11
Suspicious for malignancy	8	8%	0	0%	-
Negative for malignancy	35	35%	38	38%	-
Inflammatory pathology	27	27%	31	31%	-
Unsatisfactory	20	20%	11	11%	-
	Total:100				

Table 4: Correlation of BAL/BW Cytology with conventional technique, manual LBC and Histopathology

5. Discussion

Respiratory cytology is increasingly used in the initial evaluation of lung disorders, especially when lung cancer is suspected [10]. Cytological analysis of bronchial wash or bronchoalveolar lavage samples is a recognized, safe, simple, and minimally invasive approach for examining pulmonary abnormalities. Moreover, the bronchial wash method enables sampling of peripheral lung areas that cannot be reached through bronchial brushing alone [11].

The literature review reveals considerable variation in the sensitivity and specificity of bronchoalveolar lavage (BAL) for diagnosing lung carcinoma. Preparing high-quality smears can be challenging due to interference from mucus, blood, and inflammatory elements. In our study, we applied the liquid-based cytology (LBC) method using the semi-automated BD SurePath system, which offers a simpler, quicker, and safer alternative requiring less technical skill. From a pathologist's standpoint, LBC provides several advantages: it minimizes confounding materials such as blood, debris, and necrotic tissue, ensures superior cell preservation, reduces fixation-related artifacts—including those from air-drying—produces more uniform cell distribution, decreases cell overlap, and lowers the number of slides needed for evaluation compared to conventional techniques. This method is designed to reduce hemorrhage and necrosis while improving nuclear preservation for more accurate assessments. A comparable approach was reported by Thakur A et al. [9].

Liquid-based cytology (LBC), particularly the SurePath method, is an automated preparation technique now widely used for gynecological samples. It offers advantages such as a cleaner background, better cellular detail, and the possibility of using the same sample for additional tests [13, 14]. Despite these benefits, few studies have investigated its use for bronchial washings or lavage specimens, and there is still limited data in the scientific literature assessing its performance in these contexts.

In the present study, the sensitivity of bronchoalveolar lavage (BW/lavage) for the detection of lung cancer was found to be 18.9% for conventional cytology (CC) and 34.5% for liquid-based cytology (LBC). The adoption of the LBC technique led to a modest improvement, as noted by Thakur A et al., indicating that the sensitivity of bronchial washing/bronchoalveolar lavage (BW/BAL) in detecting lung cancer via liquid-based cytology (LBC) (Sure Path) was recorded at 55.8%, compared to 50.07% (CC) achieved through the traditional method [9]. A similar outcome was also reported in the study by Gaur DS et al. [12].

In our study, LBC preparations showed better performance than CS in identifying malignancy, particularly in cases involving necrosis and extensive hemorrhage. These findings are consistent with those of Pawar et al., who compared conventional FNAC with the MLBC method [14]. Additionally, the diagnosis of carcinoma in this study was supported by high cellularity, clear nuclear characteristics, and a clean background—features that correspond with the results described by Dey et al. [15].

This study found a higher rate of positive carcinoma detection with LBC (20%) compared to CC (10%), indicating that LBC is more effective at identifying malignant cases. These results are consistent with those reported in previous studies [16, 17]. Consequently, LBC seems to be a suitable substitute for CC in handling BAL/BW specimens, particularly in labs that are already utilizing an LBC system for gynaecological samples.

6. Conclusion

LBC demonstrated slightly higher diagnostic accuracy compared to CC, along with a lower rate of unsatisfactory samples. As a result, LBC serves as a practical alternative to CC, offering more standardized preparation and fewer inadequate results.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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