



Original Article

Role of Ultrasonography and Elastography in Cervical Lymphadenopathy with Histopathological Correlation

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ABSTRACT

Background: The cervical lymphadenopathy is a typical clinical manifestation that occurs due to reactive, infective, and malignant factors. The traditional B-mode ultrasonography with colour Doppler imaging is applied to determine the structure of lymph nodes and the nature of blood flow, and strain elastography provides more data through the analysis of tissue elasticity and stiffness. Their combination may improve diagnostic accuracy beyond each modality alone.

Aims and Objectives: The aim of the study was to determine the effectiveness of B-mode ultrasonography, colour Doppler imaging and elastography in differentiating cervical lymphadenopathy with histopathological results as a gold standard of diagnosis.

Materials and Methods: This prospective cross-sectional study included 51 patients who visited BMC&H, Barpeta, between December 2024 and November 2025. The sonographic evaluation was done on an Alpinion XCUB90 system with a 7-11 MHz linear-array transducer. All the participants were subjected to standard B-mode ultrasonography, colour Doppler assessment and real-time elastographic analysis. Elastographic patterns were graded by the five-point Alam scoring system. FNAC or trucut biopsy provided histopathological confirmation. ROC curve analysis determined sensitivity, specificity, PPV and NPV.

Results: Mean age was 43.16 years (range 9–76); 52.9% were female. Histopathology identified 22 malignant (42.4%), 14 tuberculous (28.2%), 8 reactive (16.5%) and 7 benign (12.9%) nodes. Sonographic diagnosis achieved sensitivity 88.9%, specificity 98.0%, PPV 97.0%, NPV 92.3% (AUC 0.934). Elastographic diagnosis achieved sensitivity 88.9%, specificity 89.8%, PPV 86.5%, NPV 91.7% (AUC 0.893). Both comparisons with HPE were highly significant ($p < 0.0005$).

Conclusion: Strain elastography is a valuable non-invasive adjunct to conventional ultrasonography in cervical lymphadenopathy, reliably differentiating malignant from benign nodes. Definitive diagnosis is impossible without the histopathological confirmation.

Keywords: Cervical lymphadenopathy; ultrasonography; strain elastography; colour Doppler; histopathology; malignancy.

INTRODUCTION

One of the most common clinical conditions that are common in all ages is the cervical lymphadenopathy. There are about 800 lymph nodes in the human body, about 300 of which are located in the head and neck area.¹ These lymph nodes can swell to a broad range of physiological and pathological processes, with each having different underlying causes necessitating varied diagnostic tests and treatment approaches.

The most common cause is infection in children and young adults. In India, tuberculosis (TB) takes a disproportionate

burden among the infective causes: about 40 percent of the population is carriers of mycobacterium tuberculosis, and cervical lymphadenopathy represents about 63 percent of all extrapulmonary presentations of TB.² The primary cervical nodal metastasis is found in up to 80 percent of cases, and the prognostic implications of the nodal disease are serious: ipsilateral nodal disease reduces the 5-year survival by half, bilateral nodal disease by half, and extracapsular by half.^{3,4}

Cervical nodes are structurally classified according to levels of lymphatic drainage territory into the Shah et al. numerical level system (Levels I–VII) upon which diagnostic workup and surgical planning is based.⁵

The B-mode ultrasonography has continued to be the golden standard in the imaging of cervical lymph nodes and it gives information about the size of the nodules, contour, echotexture, hilar arrangement, and the existence of necrosis or calcification. Together with colour Doppler interrogation, it has a sensitivity of 73 per cent by itself, 92 per cent sensitivity and 93 per cent specificity with the addition of ultrasound-guided FNAC.⁶ but specificity is limited by imaging overlap with reactive, tuberculous, and metastatic nodes, and false negatives are caused by micro metastases in morphologically normal nodes.^{7,8}

Elastography overcomes this disadvantage by offering an objective map of tissue stiffness, which is non-invasive. Strain elastography uses freehand compression, and measures the relative tissue movement; malignant nodes - which are harder - give less strain, and have characteristic-colored patterns.^{10,11} The five-grade scoring system developed by Alam et al. offers a consistent classification system to be used in real-time clinical practice.¹²

Despite growing evidence, data from high-burden TB settings in India remain limited. Most elastography studies originate from Western populations where malignancy dominates the differential, leaving unanswered questions about performance where tuberculosis is prevalent. This study was designed to address that gap.

AIMS AND OBJECTIVES

Aim

To explore the diagnostic role of B-mode ultrasonography, colour Doppler imaging and elastography in assessing cervical lymphadenopathy by comparing imaging appearances with histopathology and to examine the diagnostic accuracy of both modalities separately and together.

Objectives

- (i) To assess the sonography and elastography of benign, reactive, tuberculous and malignant cervical lymph nodes and compare these results with histopathology diagnosis.
- (ii) To identify and compare the ability of B-mode ultrasonography, colour Doppler, and strain elastography in identifying and distinguishing cervical lymphadenopathy when used alone and in combination.
- (iii) To investigate whether or not the joint non-invasive evaluation offered by ultrasonography and elastography can effectively detect malignant lymph nodes and thus help selectively apply invasive tests like fine-needle aspiration cytology (FNAC) and biopsy.

MATERIALS AND METHODS

Study Design and Setting

The Department of Radiodiagnosis, Barpeta Medical College and Hospital (BMC&H), Barpeta, Assam, India conducted a prospective cross-sectional study at the hospital over a period of one year, between December 2024 and November 2025. Ahead of the study, the Institutional Ethics Committee gave ethical approval and all participants gave informed written consent or authorised a guardian to act on behalf of the participants.

Sample Size and Study Population

It was calculated that a sample size of 51 subjects was needed at the confidence level of 95%. The sample comprised of patients with clinically evident cervical lymphadenopathy who were referred to undergo ultrasonographic evaluation and USG-guided FNAC or biopsy.

Inclusion and Exclusion Criteria

Patients with unilateral or bilateral cervical lymph node enlargement, patients with proven or suspected head and neck malignancy involving cervical nodal involvement, patients with suspected cervical nodal involvement tuberculous cervical lymphadenopathy, and persistent cervical reactive lymphadenopathy, which had not been resolved despite clinical follow-up, were eligible.

Patients were excluded if they had received prior radiotherapy or chemotherapy to the cervical region; were on or had completed antituberculous therapy; had undergone previous cervical node excision or biopsy at the index site; or had conditions precluding adequate sonographic assessment.

Imaging Protocol

All patients were examined supine with the neck extended. B-mode ultrasonography was performed using the Alpinion XCUB90 system with an integrated Elastocan module and a 7–11 MHz broadband linear probe. A standardised sweep was performed from the submental region through the submandibular area and jugular chain (upper, middle, lower) to the supraclavicular and posterior triangle nodes bilaterally. Image depth was set at 40 mm with a lateral field of 40 mm. Nodal level was assigned according to the Shah classification.⁵

In each of the lymph nodes, the nodal level and nodal number, short-axis diameter (SAD), long-axis diameter (LAD), short-to-long axis (S/L) ratio were recorded and a ratio of 0.6 or more was taken as indicative of malignancy. The other sonographic features that were evaluated were nodal shape (oval or round), margin definition (sharp, unsharp, or ill-defined), echogenicity (hypoechoic, isoechoic, or hyperechoic), echogenic hilum, intranodal necrosis or cystic degeneration, calcifications, eccentric cortical thickening, and other related features like nodal matting and perinodal oedema). The largest node with the most imaging features of pathology was selected as the index node per patient.

Colour Doppler interrogation was performed after grey-scale examination using high sensitivity, medium persistence, a low wall filter (PRF 700 Hz), and gain adjusted to maximum sensitivity without background artefact. Vascularity was classified as hilar, peripheral, mixed (hilar and peripheral), displaced hilar or absent.

Strain elastography was performed after Doppler. An ROI box (35 mm depth × 30 mm width) encompassed the node with an equal margin of surrounding muscle as the reference tissue. Freehand compression-decompression cycles were performed until a stable elastogram was obtained; lateral probe movement was minimised. The machine colour convention designated blue as stiff (low strain) and red as soft (high strain), with green as intermediate. Elastographic patterns were graded using the Alam et al. five-point scoring system.¹²

Table 1. Elastographic pattern scoring system (Alam et al.¹²)

Pattern	Description	Elastographic Category
1	No hard or a small amount of hard (blue) in the node	Benign
2	Small scattered nodal areas, taking up less than 45 percent of the nodal area.	Benign
3	One or more big hard areas covering 45 percent and above of the node	Malignant
4	Hard peripheral region with a central soft area, which is suggestive of necrosis.	Malignant
5	Hard area that includes the whole node, and may or may not have a thin peripheral soft rim.	Malignant

Blue = stiff/low strain; Red = soft/high strain; Green = intermediate.

Histopathological Reference Standard

During the same imaging, ultrasound-guided core needle biopsy of the index lymph node was done. Where the latter proved to be technically difficult, ultrasound-guided FNAC was performed instead. All specimens were reported by the Department of Pathology, BMC&H, and served as the reference standard.

Statistical Analysis

Data were put into the MS Excel 2019 and analysed using the IBM SPSS Statistics v23.0. Continuous variables were reported in the form of mean ± SD or median (IQR), whereas the frequencies and percentages were used to show the categorical variables. The Chi-square test was used to determine associations between imaging findings and HPE. AUC, sensitivity, specificity, PPV, and NPV were calculated by ROC analysis of each modality, HPE was used as a reference standard and malignancy as a positive outcome. A p-value less than 0.05 was deemed to be significant.

RESULTS

Patient Demographics

The study involved 51 patients (27 females and 24 males) in total (52.9% female). The mean age was 43.16 ± 15.9 years, with ages ranging from 9 to 76 years. Left-sided cervical lymphadenopathy was the most prevalent (55.3) then right (41.2) and bilateral disease (3.5). The mean number of cervical lymph nodes was 6.68 (range 1 to 17) and one index node per patient was selected to be analyzed.

Table 2. Descriptive statistics for continuous variables (n = 51)

Variable	Mean	Median	SD	Min	Max
Age (years)	43.16	42.00	15.9	9	76
No. of nodes	6.68	6.00	3.44	1	17
Short-axis diameter (mm)	15.67	16.00	4.77	7	25
Long-axis diameter (mm)	23.85	24.00	5.24	13	36
S/L axis ratio	0.65	0.66	0.15	0.40	0.96

Sonographic Features

Shape: 62.4% of nodes were round, 37.6% oval. Echogenicity: 92.9% hypoechoic; 4.7% hyperechoic (all proved to be metastases from papillary thyroid carcinoma); 2.4% isoechoic. Margin: 54.1% unsharp, 28.2% sharp, 17.6% ill-defined. Echogenic hilum was absent in 62.4%. Intranodal necrosis or cystic change was present in 43.5%. Calcification was identified in 2 nodes (3.5%), both papillary thyroid carcinoma metastases. Eccentric cortical hypertrophy was observed in 11.8%. Matting or perinodal oedema was present in 28.2%, closely matching the proportion with histopathologically confirmed tuberculous disease.

Colour Doppler identified vascular patterns as: hilar 34.1%, peripheral 18.8%, mixed hilar and peripheral 31.8%, displaced hilar 8.2%, and absent 7.1%. Fifty percent of the lymph nodes had combined peripheral vascularity with or without hilar flow, versus 42.4% that proved to be malignant on histopathological examination, indicating that Doppler results alone are not very specific to malignancy.

Radiological and Elastographic Diagnoses Compared with HPE

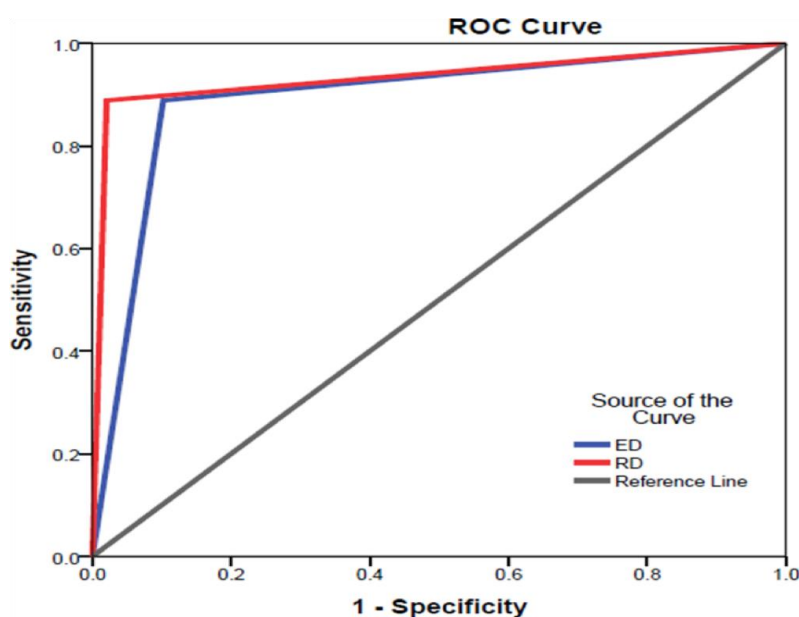
Table 3. Comparison of radiological, elastographic, and histopathological diagnoses (n = 51)

Histopathological Category	Radiological Dx, n (%)	Elastographic Dx, n (%)	HPE, n (%)
Benign	8 (15.7)	16 (31.4)	7 (13.7)
Reactive	9 (17.6)	13 (25.5)	8 (15.7)
Tuberculosis	14 (27.5)	-	14 (27.5)
Malignant	20 (39.2)	22 (43.1)	22 (43.1)

Both radiological vs. HPE and elastographic vs. HPE comparisons: Chi-square, $p = 0.0005$ (highly significant).

Diagnostic Performance - ROC Curve Analysis

ROC curve analysis was performed with malignancy as the positive diagnostic state and all non-malignant categories as negative.



Diagonal segments are produced by ties.

Figure 1: Receiver operating characterising curve for comparing sonography and elastography vs. HPE (malignancy as positive state)

Table 4. Diagnostic performance of sonography and elastography vs. HPE (malignancy as positive state)

Modality	AUC	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	95% CI
B-mode US + Doppler	0.934	88.9	98.0	97.0	92.3	0.869–0.999
Strain Elastography	0.893	88.9	89.8	86.5	91.7	0.816–0.971

All values $p < 0.0005$. AUC area under receiver operating characteristic (ROC) curve; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval.

DISCUSSION

This study evaluated 51 patients with cervical lymphadenopathy in a tertiary care facility in Assam with tuberculosis as

the most common non-malignant nodal enlargement etiology. The demographic background - average age 43.2 years, mild female dominance, and left-sidedness - shows a general agreement with the previous literature.^{13,16}

Ultrasound demonstrated robust diagnostic accuracy. The S/L ratio cut-off of 0.6 yielded sensitivity 88.9%, specificity 98.0%, PPV 97.0%, and NPV 92.3% (AUC 0.934), exceeding values reported by Hefeda and Badawy¹³ (sensitivity 79.2%, specificity 51.1%) and comparable with the comprehensive review by Ying et al.¹⁶ and the elastography study of Alam et al.,¹² who found 84% sensitivity with the same S/L criterion. Round nodal shape correlated with malignancy in all pathologically confirmed malignant cases, consistent with established morphological criteria.^{14,15}

Most nodes (92.9%) were hypoechoic, limiting the independent discriminatory value of echogenicity. The two hyperechoic nodes both proved to be metastases from papillary thyroid carcinoma - a well-documented finding attributable to intranodal thyroglobulin deposition.¹⁷ Intranodal necrosis was present in 43.5% of nodes, yet malignant and tuberculous nodes combined accounted for 67% of the study population - a discrepancy explained by the absence of frank liquefaction in early-stage disease. Eccentric cortical hypertrophy, though highly specific when present, was identified in only 30.3% of confirmed malignant nodes, limiting its use as a standalone criterion.

Colour Doppler identified peripheral vascularity (alone or combined with hilar flow) in 50.6% of nodes - substantially more than the 43.1% that proved malignant on HPE. Peripheral vascularity thus lacked adequate specificity, also appearing in reactive and inflammatory nodes. These findings parallel earlier reports by Hefeda¹³ and Ying et al.¹⁶ Displaced hilar vascularity, observed in 8.2% of nodes, correlated closely with tuberculous disease and served as a useful disease-specific Doppler pattern.⁹

Tuberculosis was diagnosed with 100% concordance between radiology and HPE (27.5% each), owing to its characteristic constellation of perinodal matting, intranodal cystic necrosis, displaced hilar vascularity, and perinodal oedema. Reactive nodes were similarly classified correctly in all cases. Malignant nodes were marginally underdiagnosed radiologically (39.2% vs. 43.1% on HPE), attributable to two nodes with atypical grey-scale morphology.

Strain elastography added complementary diagnostic value. The five-grade Alam classification achieved sensitivity 88.9% and specificity 89.8% (AUC 0.893). These results are consistent with the results of Alam et al.,¹² who found a sensitivity of 83 % and a specificity of 100 % in a study population which was predominantly malignant. The reduced specificity in our series reflects the challenge of tuberculosis: pattern 4 (peripheral hardening with central softening from necrosis) mimics malignancy and generated false-positive calls in some TB nodes. This overlap between hard-pattern TB and malignant elastographic appearances is a recognised limitation in TB-endemic populations - a nuance largely absent from Western elastography literature.¹⁸⁻²⁰

Benign and reactive nodes were reliably identified by soft patterns (grades 1 and 2). However, TB nodes with early or minimal necrosis could exhibit soft or intermediate patterns, leading to their misclassification as reactive. Elastography therefore proved most dependable for flagging malignancy (patterns 3, 4, 5) and least reliable for distinguishing the specific aetiology within the non-malignant spectrum - reinforcing its role as a complement to, not a substitute for, morphological and vascular criteria.

A logical diagnostic algorithm is formed: B-mode ultrasound with Doppler is the first-tier diagnostic test; the second-tier test is strain elastography, which is needed to clarify the sonographic impression or to rule out malignancy with certainty before deferring invasive biopsy, or to take the most representative node to biopsy. In cases where the two modalities are co-concurrently benign, then the chance of unnoticed malignancy diminishes significantly. Biopsy should be done in any hard elastographic pattern, regardless of the grey-scale appearance, as histopathological confirmation cannot be avoided altogether.

Its drawbacks are that freehand strain elastography is operator-dependent, only a single index node is analyzed per patient (capturing intra-patient heterogeneity), and there is sometimes an overflow of ROI boxes in very large nodes. Quantitative shear wave elastography, and multicenter designs with specific TB-prevalent populations-power should be included in future work.

CONCLUSION

B-mode ultrasonography, Doppler imaging, and strain elastography in this prospective study at a tertiary care centre with a high incidence of tuberculosis exhibited high diagnostic accuracy in making the distinction between malignant and benign cervical lymphadenopathy. Sonography had a better specificity (98.0 vs. 89.8%), and both modalities had the same sensitivity (88.9%). Elastography was a reliable method to detect hard-pattern malignant nodes with the ability to overlap with tuberculosis in the intermediate pattern cases, which is a characteristic of the disease burden in this environment.

Strain elastography is a non-invasive adjunct which should be included in the routine ultrasound examination of the cervical lymphadenopathy. It supplements morphological and vascular criteria, increases diagnostic confidence and selects targeted biopsy - it may eliminate unnecessary invasive modes of operation. Imaging alone will not detect a small percentage of malignancies, and thus histopathological confirmation is necessary.

The findings should be confirmed by larger multicenter studies that use quantitative shear wave elastography to determine the cut-offs that are population specific to populations with a high prevalence of tuberculous lymphadenitis.

Conflicts of Interest: The authors declare no conflicts of interest.

Source of Funding: None.

Ethical Approval: The study was approved by the Institutional Ethics Committee of BMC&H, Barpeta, before the commencement of the study. Written informed consent was obtained from all participants prior to enrollment.

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