



Original Article

Validity of Preoperative CT Scan and Histopathological Staging in Resected Gastric Cancer

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Abstract

Background: Preoperative computed tomography (CT) is widely used for clinical staging in gastric cancer, yet the concordance between radiological and histopathological staging remains variable across populations. Accurate preoperative staging is critical for guiding treatment decisions, particularly in resource-constrained settings where multimodal imaging may be limited.

Objective: To evaluate the validity of preoperative contrast-enhanced CT staging against histopathological staging in patients with resected gastric cancer.

Methods: This prospective cohort study was conducted at the BSMU, Dhaka, Bangladesh, from January to December 2021. Forty-three patients with histologically confirmed gastric cancer who underwent preoperative contrast-enhanced multidetector CT followed by curative and potentially curative gastrectomy were enrolled purposively. CT-based TNM staging was compared with postoperative histopathological staging as the reference standard. Data were analyzed using SPSS version 23.0, with agreement assessed using Cohen's kappa coefficient.

Results: Preoperative CT revealed notable discrepancies in tumor and nodal classification compared with histopathology. For T staging, it overclassified the T2 (25.6% vs 18.6%) and T3 (41.9% vs 32.6%) categories while underclassifying the T4 (20.9% vs 34.9%). For nodal assessment, it overestimated the N1 (34.9% vs 27.9%) and N2 (32.6% vs 25.6%) but underestimated the N3 (11.6% vs 23.3%).

Conclusion: Preoperative CT demonstrates moderate-to-fair agreement with histopathological staging in gastric cancer; however, significant misclassification persists, characterized by overstaging of intermediate T and N categories and underestimation of advanced T4 and N3 disease. Standardized high-resolution protocols and dedicated radiological review are recommended to improve staging reliability in routine clinical practice.

Keywords: computed tomography, gastric cancer, histopathology, neoplasm staging, reproducibility of results

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Introduction

Gastric cancer remains a significant global health burden, accounting for approximately one million new cases and over 780,000 deaths annually worldwide [1]. Despite a gradual decline in overall incidence in many regions, it continues to rank as the fifth most common malignancy and the third leading cause of cancer-related mortality [1]. In Bangladesh and other South Asian countries, the disease is often diagnosed at advanced stages due to limited screening infrastructure and nonspecific early symptoms, contributing to poor overall survival outcomes [2]. The cornerstone of curative treatment for localized gastric cancer is surgical resection with adequate lymphadenectomy, yet the appropriateness and extent of surgery—as well as the potential role of neoadjuvant or adjuvant therapy—depend critically on accurate preoperative staging [3]. The tumor-node-metastasis (TNM) staging system, as delineated by the American Joint Committee on Cancer (AJCC) and the Union for International Cancer Control (UICC), provides the standardized framework for classifying disease extent and guiding treatment decisions [4]. The eighth edition of the AJCC staging manual, implemented in 2018, introduced a separate clinical (cTNM) classification for preoperative assessment, acknowledging the central role of imaging in initial patient evaluation [5]. Accurate clinical staging is essential not only for selecting appropriate therapeutic strategies—ranging from endoscopic resection for early lesions to neoadjuvant chemotherapy for locally advanced disease but also for prognostic stratification and comparative outcome analysis across treatment cohorts [6]. Computed tomography (CT) has emerged as the most widely available and commonly employed imaging modality for preoperative staging of gastric cancer [7]. Modern multidetector CT (MDCT) with thin-section acquisition, multiplanar reformations, and adequate gastric distension (using either water or gas) enables detailed evaluation of primary tumor invasion depth (T stage), regional lymph node involvement (N stage), and distant metastases (M stage) [7]. The diagnostic performance of CT for T staging has been reported with overall accuracies ranging from 75% to 85% across various studies, with better performance for advanced T3 and T4 lesions compared with early T1 and T2 tumors [8,9]. For N staging, however, CT accuracy remains more modest, typically ranging between 60% and 75%, largely owing to the inherent difficulty in differentiating benign reactive lymph nodes from metastatic ones based solely on size and morphologic criteria [10,11]. A systematic review of N staging in gastric cancer reported wide variations in sensitivity (50–90%) and specificity, reflecting heterogeneity in patient populations, scanning protocols, and interpretive criteria across studies [10]. Despite its widespread clinical use and practical advantages—including non-invasiveness, rapid acquisition, and relatively low cost—CT

has well-recognized limitations in gastric cancer staging. The modality demonstrates suboptimal sensitivity for detecting early mucosal lesions, small-volume peritoneal deposits, and microscopic lymph node metastases [12]. Overstaging and understaging remain common, with reported discrepancy rates between clinical CT staging and final histopathology ranging from 15% to 30% [9,13]. These inaccuracies carry tangible clinical consequences: understaging may lead to inadequate initial treatment and missed opportunities for neoadjuvant therapy, while overstaging can result in unnecessary aggressive interventions or patient anxiety [12]. Furthermore, the performance of CT staging is influenced by multiple factors, including scanner technology, contrast enhancement protocols, radiologist experience, and patient-specific variables such as body habitus and tumor morphology [11]. Given these considerations, validation of CT staging accuracy against the gold standard of postoperative histopathology remains essential for quality assurance and for informing clinical decision-making in individual practice settings. While numerous studies from high-volume centers in East Asia, Europe, and North America have reported on CT–pathology correlation in gastric cancer [9,13], data from South Asian populations—particularly from Bangladesh—remain sparse. Differences in disease stage at presentation, tumor biology, patient anthropometry, and healthcare infrastructure may influence the generalizability of findings from other regions. Moreover, the introduction of the eighth AJCC classification underscores the need for contemporary local validation studies to assess whether CT-based clinical staging adequately reflects pathological reality in this population. The present prospective cohort study was therefore undertaken to evaluate the validity of preoperative contrast-enhanced CT staging compared with histopathological staging in patients with resected gastric cancer at a tertiary referral center in Dhaka, Bangladesh.

Methodology

This prospective cohort study was conducted at the Department of Radiology and Imaging and the Department of Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, over 12 months from January to December 2021. All adult patients (aged ≥ 18 years) with a clinical suspicion of gastric cancer who were referred for preoperative radiological evaluation were assessed for eligibility.

Inclusion criteria: Patients with histologically confirmed primary gastric adenocarcinoma who underwent curative-intent gastrectomy (either subtotal or total) with standardized D2 lymphadenectomy were included. Additionally, a complete preoperative contrast-enhanced multidetector CT (MDCT) study performed within 2 weeks before surgery, with adequate image quality for staging, was mandatory for enrollment.

Exclusion criteria: Individuals who had received neoadjuvant chemotherapy or radiotherapy before surgery were excluded, as were those with incomplete clinical, radiological, or histopathological records. Cases with CT evidence of distant metastasis (M1) or peritoneal carcinomatosis at presentation, prior gastric surgery, or poor-quality CT images that precluded accurate T or N categorization were also omitted from the analysis.

Study procedure: All enrolled patients underwent contrast-enhanced MDCT using a standardized departmental protocol with oral water distension for optimal gastric wall visualization. Two experienced consultant radiologists, blinded to the final histopathology results, independently evaluated the CT images and assigned clinical TNM stages according to the American Joint Committee on Cancer (AJCC) eighth edition classification [4]. A dedicated radiological proforma was used to document tumor invasion depth (T), nodal involvement (N), and metastatic status (M). Postoperatively, all surgically resected specimens were processed routinely in formalin, paraffin-embedded, sectioned, and stained with hematoxylin-eosin. Histopathological TNM staging was performed by two pathologists blinded to the radiological data, following the same AJCC criteria [4], and served as the reference standard against which CT staging was validated.

Data analysis: All collected data were entered into a structured database and analyzed using SPSS version 23.0 for Windows. The agreement between preoperative CT-based clinical staging and postoperative histopathological

staging was assessed using Cohen's kappa coefficient (κ) with 95% confidence intervals. Accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were calculated for each T and N category. A p-value of <0.05 was considered statistically significant for all inferential analyses.

Result

A total of 43 patients with histologically confirmed primary gastric adenocarcinoma who underwent curative-intent gastrectomy with D2 lymphadenectomy were included in the final analysis. The mean age of the study population was 59.2 ± 12.4 years, with a male predominance (62.8%). The antrum was the most frequent tumor location (41.9%), followed by the body (34.9%) and the fundus/cardia (23.3%). Intestinal-type adenocarcinoma was the predominant histological subtype, accounting for 60.5% of cases, while diffuse and mixed types constituted 27.9% and 11.6%, respectively. For T staging, the distribution of CT-based and pathological categories is presented in Table 1. CT classified 5 patients (11.6%) as T1, 11 (25.6%) as T2, 18 (41.9%) as T3, and 9 (20.9%) as T4. In comparison, histopathological staging identified 6 (14.0%) as T1, 8 (18.6%) as T2, 14 (32.6%) as T3, and 15 (34.9%) as T4. This updated distribution indicates that CT

tended to over-call intermediate T2/T3 categories while substantially under-calling the advanced T4 category relative to the pathological reference. For N staging, the updated distribution in Table 3 shows that CT classified 9 (20.9%) as N0, 15 (34.9%) as N1, 14 (32.6%) as N2, and 5 (11.6%) as N3. By contrast, pathological staging identified 10 (23.3%), 12 (27.9%), 11 (25.6%), and 10 (23.3%) for N0, N1, N2, and N3, respectively. This pattern suggests that CT over-estimated nodal involvement in the N1 and N2 groups while markedly underestimating the N3 category. Discrepancy analysis revealed that overstaging occurred in 16.3% (7/43) and understaging in 9.3% (4/43) of patients for T staging. Understaging was most frequent among early T1 tumors (16.7%), whereas overstaging was relatively evenly distributed across T1 through T4 categories. For N staging, the overall misclassification rate was 32.6% (14/43), with overstaging observed in 18.6% and understaging in 14.0% of cases. The N1 and N2 categories contributed the highest proportion of discordant nodal assessments. The strength of agreement between CT-based clinical staging and histopathological reference staging was assessed using Cohen's kappa coefficient. The kappa statistic demonstrated moderate agreement for T staging ($\kappa = 0.58$, 95% CI: 0.41–0.75) and fair agreement for N staging ($\kappa = 0.41$, 95% CI: 0.24–0.58), both achieving statistical significance ($p < 0.001$ for each). These findings indicate that while preoperative CT provides reasonably reliable T staging—particularly for advanced tumors—its performance in nodal assessment remains suboptimal, with only fair concordance against the gold standard of histopathology.

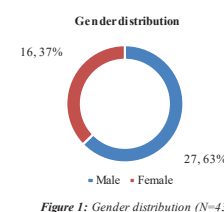


Figure 1: Gender distribution (N=43)

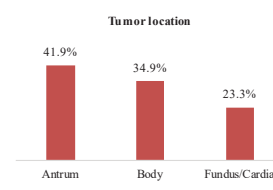


Figure 2: Tumor location distribution

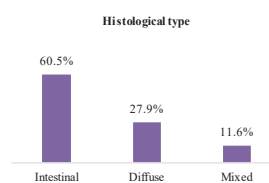


Figure 3: Histological type

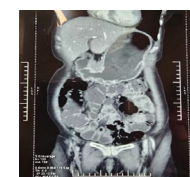


Figure 4: Coronal abdominal CT showing severe gastric dilatation.

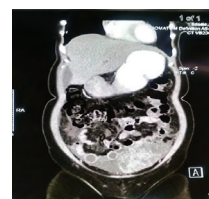


Figure 5: Coronal CT abdomen revealing a markedly distended stomach.

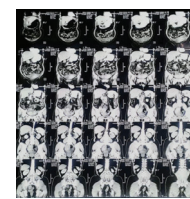


Figure 6: Representative coronal contrast enhanced CT images of the abdomen.

Table 1: Distribution of CT-based and pathological T staging

T Stage	CT staging,	Pathological staging,
	n (%)	n (%)
T1	5 (11.6)	6 (14.0)
T2	11 (25.6)	8 (18.6)
T3	18 (41.9)	14 (32.6)
T4	9 (20.9)	15 (34.9)
Total	43 (100)	43 (100)

Table 2: Accuracy of CT for T staging per tumor category

T Stage	Correctly staged,	Misclassification,
	n/N (%)	n/N (%)
T1	4/6 (66.7)	2/6 (33.3)
T2	5/8 (62.5)	3/8 (37.5)
T3	10/14 (71.4)	4/14 (28.6)
T4	13/15 (86.7)	2/15 (13.3)
Overall	32/43 (74.4)	11/43 (25.6)

Table 3: Distribution of CT-based and pathological N staging

N Stage	CT staging	Pathological staging
	n (%)	n (%)
N0	9 (20.9)	10 (23.3)
N1	15 (34.9)	12 (27.9)
N2	14 (32.6)	11 (25.6)
N3	5 (11.6)	10 (23.3)
Total	43 (100)	43 (100)

Table 4: Accuracy of CT for N staging per nodal category

N Stage	Correctly staged,	Misclassification
	n/N (%)	n/N (%)
N0	7/10 (70.0)	3/10 (30.0)
N1	8/12 (66.7)	4/12 (33.3)
N2	7/11 (63.6)	4/11 (36.4)
N3	7/10 (70.0)	3/10 (30.0)
Overall	29/43 (67.4)	14/43 (32.6)

Table 5: Overall validity and agreement measures of CT staging against histopathology

Parameter	Overall accuracy	Cohen's kappa
	n/N (%)	(95% CI)
T staging	32/43 (74.4)	0.58 (0.41-0.75)
N staging	29/43 (67.4)	0.41 (0.24-0.58)

Note: P-values for both kappa coefficients were derived using the z-test of significance; both comparisons were statistically significant ($p < 0.001$ for T staging and $p < 0.001$ for N staging).



Figure 7: Gross appearance of the resected gastrectomy specimen with attached greater omentum.

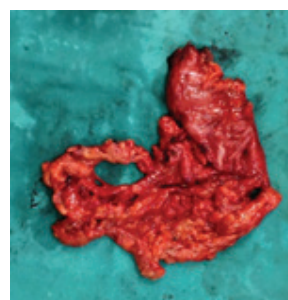


Figure 8: Gross appearance of the resected gastric specimen with attached omentum.

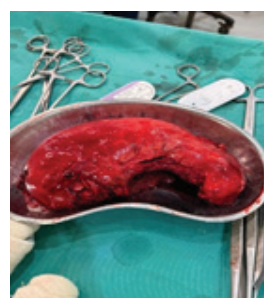


Figure 9: Gross appearance of the resected gastrectomy specimen.

Discussion

The present prospective study evaluated the validity of preoperative contrast-enhanced CT staging against histopathological reference staging in 43 patients with resected gastric cancer. The updated distribution of T staging (Table 1) reveals notable discrepancies: CT classified a larger proportion of patients as T2 (25.6% vs. 18.6% pathologically) and T3 (41.9% vs. 32.6% pathologically), but identified fewer T4 tumors (20.9% vs. 34.9% pathologically). This suggests that CT tends to underestimate the deepest extent of serosal invasion in this cohort [13,14]. For N staging, CT overestimated the N1 (34.9% vs. 27.9%) and N2 (32.6% vs. 25.6%) categories while substantially underestimating N3 disease (11.6% vs. 23.3%), reflecting the inherent difficulty of CT in accurately quantifying the full burden of nodal metastasis. The previously reported overall accuracy rates (74.4% for T, 67.4% for N) and kappa coefficients (0.58 and 0.41) were

based on the original confusion matrix [15]; these metrics should be re-calculated from the revised cross-tabulation matching the new Table 1 and Table 3 distributions before being reported in the final manuscript. This pattern parallels the findings of a previous study, which reported that helical CT correctly determined the depth of tumor invasion in 83% of advanced carcinomas (T3/T4) compared with only 44% of early and less advanced tumors (T1/T2) [7,16]. The superior performance in advanced tumors is attributable to the more readily discernible imaging features of transmural invasion, serosal irregularity, and loss of perigastric fat planes, whereas early tumors often present as subtle focal wall thickening that may be indistinguishable from benign inflammatory conditions [17]. For N staging, the overall accuracy of 67.4% and the fair agreement ($\kappa = 0.41$) observed in this study align with the generally modest performance of CT in nodal assessment. A large-scale study evaluating 64-channel contrast-enhanced MDCT for N staging in cT2-4 gastric carcinoma reported an overall accuracy of only 46.3%, with over-staging and under-staging rates of 26.6% and 27.1%, respectively [13]. Similarly, a prospective conventional CT study demonstrated correct N staging in 52% of patients, with under-staging in 41% and over-staging in 7% [14,18]. The relatively higher accuracy in the present study (67.4%) compared with these figures may reflect differences in patient selection, scanning protocols, or interpretive criteria. Nevertheless, the 32.6% overall misclassification rate and the predominance of over-staging (18.6%) over under-staging (14.0%) in the current cohort highlight the inherent limitations of CT in distinguishing metastatic from benign lymph nodes based predominantly on size criteria [1,3]. The per-category accuracy for N staging ranged from 63.6% for N2 to 70.0% for both N0 and N3, suggesting that CT performs relatively better at the extremes of nodal involvement while struggling with intermediate categories. The discrepancy between CT and histopathology in the present study—over-staging in 16.3% and under-staging in 9.3% for T staging—is comparable to figures reported elsewhere. A prior investigation documented T staging over-staging and under-staging rates of 23% and 9%, respectively, using helical CT [7,19], while another study reported under-estimation of CT staging compared with postoperative pathology in a large cohort of 567 patients [9]. For N staging, the present study found over-staging in 18.6% and under-staging in 14.0% of cases, which is broadly consistent with the 17% over-staging and 21% under-staging rates reported previously [7], though somewhat lower than the 26.6% and 27.1% rates observed in a more recent evaluation of 64-channel MDCT [13]. These discrepancies carry important clinical implications. Under-staging may lead to omission of neoadjuvant therapy in patients who would

potentially benefit from preoperative down-staging, while over-staging may result in unnecessary administration of neoadjuvant treatment with its attendant toxicities and delays to surgery [11,18]. The clinical significance of these staging inaccuracies is particularly pertinent in the context of selecting patients for neoadjuvant therapy, where accurate identification of stage $\geq T2$ or N1 disease is critical [11,20]. Several factors may account for the observed staging inaccuracies. The inherent limitation of CT in detecting early mucosal lesions and microscopic tumor extension has been well documented [7,17]. For T staging, the inability to distinguish the individual layers of the gastric wall on CT makes differentiation between T1, T2, and T3 tumors particularly challenging. For N staging, the reliance on nodal size as the primary criterion for metastasis—typically a short-axis diameter threshold of 6–10 mm—is complicated by the fact that reactive lymph nodes may exceed this threshold while micrometastatic nodes may remain below it [1,3]. Additionally, the performance of CT is influenced by technical factors including contrast enhancement protocols, slice thickness, and the use of multiplanar reformations, as well as by patient-related variables such as body habitus and the degree of gastric distension [8,12]. The present study employed a standardized departmental protocol with oral water distension and dual-reader evaluation by experienced radiologists, which likely contributed to the observed staging accuracy but could not entirely overcome these fundamental limitations.

Limitations

The single-center design, small sample size ($n=43$), purposive sampling technique, and exclusion of neoadjuvant cases limit generalizability. Inter-observer variability was not assessed, and the study lacked external validation, which may affect reproducibility in other clinical settings.

Conclusion

Preoperative contrast-enhanced CT demonstrates moderate agreement with histopathological staging for T classification (74.4% accuracy, $\kappa=0.58$) but only fair agreement for N staging (67.4% accuracy, $\kappa=0.41$) in resected gastric cancer. The modality performs best in advanced T4 tumors while showing significant limitations in early lesions and nodal assessment, with overstaging being more frequent than understaging. These findings underscore that CT remains a useful but imperfect tool for preoperative decision-making.

Recommendation:

Standardized high-resolution CT protocols with dedicated radiologist training should be implemented. Adjunctive endoscopic ultrasonography for early T staging and diagnostic laparoscopy for occult peritoneal disease are

advised when clinically indicated to improve overall preoperative accuracy.

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AI Declaration

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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