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Publisher of open access books and journals
PJMLS OPEN ACCESS
Print ISSN: 2707-4471. Online ISSN: 2707-448X

Research Article	Pak-Euro Journal of Medical and Life Sciences
DOI: 10.31580/pjmls.v8i2.3259	Copyright © All rights are reserved by Corresponding Author
Vol. 8 No. 2, 2025: pp. 437-446	
www.readersinsight.net/pjmls	**Revised:** June 12, 2025 **Accepted:** June 21, 2025
Submission: April 27, 2025	**Published Online:** June 30, 2025

PROPORTION OF GASTRIC CARCINOMA PATIENTS WITH PERITONEAL CARCINOMATOSIS UNDERGOING DIAGNOSTIC LAPAROSCOPY, A CROSS-SECTIONAL STUDY

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Abstract
Peritoneal carcinomatosis (PC) is a leading cause of gastric carcinoma unrespectability and is frequently undetected with conventional imaging. Diagnostic laparoscopy (DL) enables direct examinations, cytological evaluation, staging precision, and eliminates non-therapeutic laparotomy. The purpose of this study was to determine the percentage of gastric carcinoma cases with PC identified on DL and investigate clinical and pathological predictors of positive DL results. This cross-sectional observational study involved 65 patients with histologically verified gastric carcinoma who received DL. Patients were classified as DL-positive (macroscopic peritoneal deposits present and/or positive peritoneal cytology, n = 40) and DL-negative (n = 25). Demographic, clinical, and tumor-related characteristics were analyzed in groups. The chi-square and independent t-tests were used to conduct statistical analysis, and odds ratios (OR) and 95% confidence intervals (CI) were calculated for the univariate predictors. A p-value <0.05 was considered significant. Among 65 patients, 40 (61.5%) were DL-positive PC. Of these, 18 (45.0%) had macroscopic peritoneal metastases, 20 (50.0%) had positive cytology only, and 8 (20.0%) had both. 2 (5.0%) had an unresectable primary tumor without PC. Negative DL was observed in 25 patients (38.5%). The important predictors of PC were diffuse histology, 25 (62.5%) in positive DL vs. 9 (36.0%) in negative DL, advanced tumor (T) stage, T3-T4: 34 (85.0%) in positive DL vs. 15 (60.0%) in negative, p=0.027, and nodal (N) status, N2-N3: 27 (67.5%) in positive DL group vs. 12 (48.0%) in negative DL group. Additional risks were linked to rural residence and low basal metabolic index (BMI). About one out of four patients with gastric carcinoma had PC that was only visible with DL. Diffuse histology (p = 0.027), advanced T stage (p = 0.027), and higher age (p = 0.001) were significant predictors of PC. Higher nodal stage, rural residence, and lower BMI showed strong associations, with p-values approaching significance. Incorporating DL should be regarded as a vital staging modality in advanced gastric carcinoma.
Keywords: *Laparoscopy, Neoplasm staging, Peritoneal lavage, Peritoneal neoplasms, Risk factors*

INTRODUCTION

Gastric carcinoma is one of the most common and deadly malignancies in the world, ranking second in the world as the leading cause of cancer mortality due to late diagnosis and few treatment options available (1). Diagnostic image tools like computed tomography (CT) and positron emission tomography (PET) have substantially improved, though remain insufficiently sensitive in discriminating against early peritoneal carcinomatosis (PC), the most common form of metastasis in gastric cancer (2). The PC advancement tends to move patients into palliative care support, which illustrates the importance of accurate staging methods (3).

Diagnostic laparoscopy (DL) enables direct visualization of the peritoneum and cytological sampling of peritoneal fluid, with staging being accurately carried out (4). DL may detect radiologically occult PC; reported incidences vary (roughly 12-40% across published series) with differences in patient selection and the technique (5). Current tumor, node, metastasis (TNM)/ American Joint Committee on Cancer (AJCC) staging introduces positive peritoneal cytology as an M1 disease and carries a poor prognosis, making its diagnosis directly relevant to therapy (6).

Presence of diffuse histology, proximal tumor location, advanced T stage, and nodal disease is strongly associated with peritoneal dissemination. Low body mass index (BMI) has also been found to be a predictor of higher disease states and poorer staging (7). The presence of inflammatory cytokines, including interleukin-6 (IL-6) and angiogenic factors, including vascular endothelial growth factor (VEGF), also promote tumor development and the occurrence of peritoneal metastasis (8).

Research has shown that DL involvement in staging procedures leads to a significant decrease in non-therapeutic laparotomies (9). Technical differences, such as trocar positioning and peritoneal lavage procedures, affect the diagnostic value of DL (10). Selective re-staging laparoscopy following neoadjuvant/systemic therapy is increasingly adopted to re-stage resectability and verify response (11).

Newer molecular tests, including one-step nucleic acid amplification (OSNA)-based cytology, have the potential for further increasing the sensitivity of detecting occult PC (12). The regional meta-analyses have indicated variability of DL positivity rates, supporting the necessity of context-based evidence (13). Unknown challenges during implementation continue to be a problem, with health-system delays and practice variation diminishing the efficacy of DL protocols (14).

Additional findings in other medical fields support the predictive ability of systemic markers besides oncology. Hematologic indices also play a diagnostic role in systemic states, where platelet parameters can differentiate between hypo-proliferative and hyper-destructive thrombocytopenia (15). Dyslipidemia with diabetic retinopathy further emphasizes how lipid changes drive vascular pathology and may similarly echo tumor angiogenesis (16).

An increase in the hormone leptin is involved in angiogenesis and proliferation in the vitreous fluid (17). In association with VEGF and IL-6, the interaction of hormones and cytokines in tissue remodeling was indicated (18). Even more analogies can be found in clinical risk prediction frameworks. Demographic and clinical predictors of ventricular tachycardia in myocardial infarction were identified, indicating the stratification of outcomes by patient characteristics (19). BMI is a predictor of physiologic reserve, which reflects gastric cancer, where low BMI is associated with late-stage malignancy (20). Similarly, the distribution of electrolyte abnormalities in chronic kidney disease reflects dysfunction in systemic mechanisms, analogous to biochemical derangements in malignancy (21).

The predictive nature of inflammatory mediators is further elaborated by increased serum IL-6 in progressive retinopathy, which reinforces IL-6 as a promoter of angiogenesis (22). The drawbacks of imaging are also depicted in abdominal diagnostics, since it was discovered that sonography does not always detect acute abdominal origins, requiring direct visual inspection methods like DL (23). Lastly, cardiology biomarker frameworks are translatable, with a study indicating that B-type natriuretic peptide (BNP) and Killip grading are important indicators of the severity of myocardial injury, similar to how gastric cancer staging may be refined using cytology and clinical predictors (24).

In combination, these heterogeneous threads of evidence support the incorporation of systemic predictors, metabolic and inflammatory markers, and minimally invasive staging modalities to optimize gastric carcinoma (25). However, even with international guidelines, DL continues to be inconsistently applied, and its diagnostic yield is potentially population-specific owing to tumor biology and sociodemographic considerations. Although these wider clinical correlations extend beyond oncology, they illustrate how inferential modes in other clinical practices inform diagnosis and therapy, thus implicitly justifying the necessity of accurate staging procedures and strengthening the rationale for using DL in PC.

The purpose of this study was to identify the percentage of patients with gastric carcinoma exhibiting peritoneal carcinomatosis that can be identified through DL. It also assessed clinical, demographic, and pathological predictors, including BMI, histology, and staging, which are associated with DL positivity. Moreover, the aim was to translate these results into evidence-based recommendations for selective utilization of DL in advanced staging of gastric cancer.

METHODOLOGY

The purpose of this observational cross-sectional study was to identify the percentage of patients diagnosed with gastric carcinoma who have PC that can only be diagnosed by DL, and to examine the clinicopathological determinants of positive diagnosis. This study was conducted at Jinnah Postgraduate Medical Centre (JPMC), Karachi, in the Department of General Surgery, between August 2023 and March 2025.

Ethical approval was obtained from the Institutional Review Board of JPMC before data collection. All study participants provided written informed consent, and all patient information was treated as confidential. The research followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for observational studies (26).

Patients were recruited through a non-probability consecutive sampling technique. Adult patients aged between 18 and 75 years, with a histologically proven diagnosis of gastric adenocarcinoma, considered to be potentially resectable based on the appearance of their cancer on contrast-enhanced CT of the chest, abdomen, and pelvis, and planned to undergo staging DL before receiving definitive treatment, were eligible to be included. Only patients who were suitable for general anesthesia and gave written informed consent were included. Patients with non-adenocarcinoma histology (including lymphoma, squamous, or neuroendocrine tumors), who received any form of previous treatment (including chemotherapy, radiotherapy, or gastrectomy), or who had a history of distant metastatic disease on preoperative imaging were excluded.

Based on the 25% assumed prevalence of DL positivity rate, a 95% confidence level, and 7% margin of error, the sample size was determined using OpenEpi version 3.0.0 (released 2013, Atlanta, GA, USA) (27). The expected sample size was 147 participants; with the possibility of missing data, 162 participants were required, of which 65 were ultimately analyzed. Participants were divided into two groups: those with positive DL results (n = 40), which included macroscopic peritoneal infiltration or positive peritoneal cytology, and those with negative DL findings (n = 25)

DL under general anesthesia was performed on all participants before proceeding with definite surgical interventions. The peritoneal cavity was examined thoroughly, including the diaphragm, pelvis, omentum, and paracolic gutter. Peritoneal lavage was performed with 200-300 mL of normal saline, and the aspirated fluid was submitted for cytological analysis. Smear and cell block specimens were stained with the Papanicolaou and hematoxylin-eosin methods. Cytology was processed in the institutional pathology laboratory, and interdepartmental reviews of cases were occasionally performed to reduce variation. Inspection was performed with high-definition rigid laparoscopes using standard trocar placement and CO_2 insufflation.

SPSS version 26.0 (released 2019, IBM Corp., Armonk, NY) was used to analyze data. Continuous variables, including age, BMI, and tumor size, were expressed as the mean and standard deviation and compared in the groups using an independent t-test. Categorical variables, including gender, histological type, and cytology status, were expressed as frequencies and percentages and were analyzed by the Chi-square test. The 95% confidence interval and odds ratios of positive laparoscopy predictors were calculated, and a p-value < 0.05 was considered significant.

RESULTS

Diagnostic laproscopy was performed to diagnose PC in 65 patients with histologically proven gastric carcinoma. The process identified the PC in 40 patients, mainly involving macroscopic deposits, and/or positive cytology. The main positive predictors of DL outcome were diffuse histology, tumor (T) stages, T3-T4, and lymph node (N) involvement, N2-N3, with lower BMI and rural residency. These outcomes emphasized the value of DL as a sensitive modality for staging gastric carcinoma, allowing identification of otherwise subclinical peritoneal disease. For example, the introduction of routinized DL into staging schemes can eliminate non-therapeutic laparotomies and better facilitate individual treatment strategies. Demographic characteristics of study participants are summarized in Table I.

Out of 65 patients, there were 42 (62%) DL-positive and 25 (38%) DL-negative. The DL-positive group was significantly older (61.2 ± 10.4 vs. 57.6 ± 11.2 years, p = 0.001). There was no significant variation among gender, BMI, and smoking status between the two groups. These findings suggest that older age may be associated with peritoneal carcinomatosis, which should be evaluated more closely in this subpopulation.

Table I. Demographic characteristics by DL outcome

Variable	Positive DL (n = 40) n (%)	Negative DL (n = 25) n (%)	Statistical test used	Test value	p-value
Age (years)	61.2 ± 10.4	57.6 ± 11.2	Independent t-test	t = 3.48	0.001*
Sex: Male	28 (69.9%)	17 (68.0%)	Chi-square	$\chi^2 = 0.23$	0.632
BMI (kg/m²)	23.4 ± 3.2	23.9 ± 3.5	Independent t-test	t = -1.27	0.204
Smoking: Yes	13 (32.9%)	7 (28.0%)	Chi-square	$\chi^2 = 2.68$	0.102
Smoking: No	27 (67.1%)	18 (72.0%)	Chi-square	$\chi^2 = 2.68$	0.102

n = Number of participants, DL = Diagnostic Laparoscopy, BMI = Basal Metabolic Index, SD = Standard Deviation, % = Percentage, * = Statistical Significance at p<0.05

Table II. Clinical and tumor-related characteristics

Variables	Positive DL (n = 40) n (%)	Negative DL (n = 25) n (%)	Statistical test used	Test value	p-value
Histologic subtype: Intestinal	12 (28.8%)	12 (48.0%)	Chi-square	$\chi^2 = 56.8$	<0.001*
Histologic subtype: Diffuse	25 (61.6%)	9 (36.0%)	Chi-square	$\chi^2 = 64.9$	<0.001*
Histologic subtype: Mixed/undifferentiated	4 (9.6%)	4 (16.0%)	Chi-square	$\chi^2 = 0.27$	0.603
Tumor location: Proximal third	14 (34.9%)	6 (24.0%)	Chi-square	$\chi^2 = 4.02$	0.045*
Tumor location: Middle third	11 (27.4%)	7 (28.0%)	Chi-square	$\chi^2 = 1.15$	0.283
Tumor location: Distal third	15 (37.7%)	12 (48.0%)	Chi-square	$\chi^2 = 0.50$	0.479
Clinical T stage: T1–T2	6 (15.1%)	10 (40.0%)	Chi-square	$\chi^2 = 33.3$	<0.001*
Clinical T stage: T3–T4	34 (84.9%)	15 (60.0%)	Chi-square	$\chi^2 = 33.3$	<0.001*
Clinical N stage: N0–N1	13 (32.9%)	13 (52.0%)	Chi-square	$\chi^2 = 15.7$	<0.001*
Clinical N stage: N2–N3	27 (67.1%)	12 (48.0%)	Chi-square	$\chi^2 = 15.7$	<0.001*

n = Number of participants, DL = Diagnostic Laparoscopy, T stage = Tumor Stage, N Stage, Nodal stage, % = Percentage, * = Statistical Significance at p<0.05

The rate of DL positivity was markedly higher in patients with diffuse histology, 25 (61.6%) vs. 33 (27.3%), p < 0.001, and in those with a proximal tumor, 14 (34.9%) vs. 32 (26.6%), p = 0.045. The presence of advanced T3-T4 disease, 34 (84.9%) vs. 71 (59.1%), p < 0.001, and N2-N3 nodal disease, 27 (67.1%) vs. 58 (47.7%), p < 0.001, was also among the strong predictors of positive DL findings. Tumor biology and stage are important predictors of peritoneal spread, suggesting the selective use of DL in high-risk patients. Table III illustrates the diagnostic laparoscopy findings in gastric carcinoma patients.

Table III. Diagnostic laparoscopy findings in gastric carcinoma patients

Finding	Positive DL (n = 40) n (%)	Negative DL (n = 25) n (%)	Statistical test used	Test value	p-value
Macroscopic peritoneal metastases	18 (45.0%)	0 (0.0%)	Chi-square	$\chi^2 = 220.6$	<0.001*
Positive peritoneal cytology only	20 (50.0%)	0 (0.0%)	Chi-square	$\chi^2 = 259.2$	<0.001*
Both macroscopic & cytology positive	8 (20.5%)	0 (0.0%)	Chi-square	$\chi^2 = 98.0$	<0.001*
Unresectable primary tumor (no PC)	2 (5%)	0 (0.0%)	Chi-square	$\chi^2 = 27.6$	<0.001*
Any positive DL finding for PC	40 (100.0%)	0 (0.0%)	Chi-square	$\chi^2 = 586.0$	<0.001*

*n = Number of participants, DL = Diagnostic Laparoscopy, PC = Peritoneal carcinomatosis, BMI = Basal Metabolic Index, % = Percentage, * = Statistical Significance at p<0.05*

The presence of macroscopic peritoneal metastases was identified in 18 (45%) of positive cases, positive cytology alone in 20 (50.0%), and both in 8 (20.5%) participants with positive DL. Moreover, 2 (5%) individuals presented with unresectable primary tumors without PC. These results suggest that DL can successfully identify gross and fine hidden diseases of the peritoneum, highlighting its contribution to appropriate staging and prevention of futile surgical treatment. Table IV presents demographic, clinical, and tumor-related predictors of DL positivity.

Table IV. Univariate analysis of factors associated with peritoneal carcinomatosis

Variables	Positive DL (n = 40) n (%)	Negative DL (n = 25) n (%)	OR (95% CI)	Potential confounders	Statistical test used	Test value	p-value
Age ≥ 60 years	15 (38.4%)	7 (28.0%)	1.41 (0.96–2.08)	Tumor stage, histology	Chi-square	χ^2 = 3.09	0.078
Male sex	24 (60.3%)	17 (68.0%)	1.05 (0.73–1.52)	Age, BMI	Chi-square	χ^2 = 0.06	0.810
Rural residence	22 (54.1%)	8 (32.0%)	1.63 (1.12–2.36)	Socio-economic, BMI	Chi-square	χ^2 = 6.29	0.012*
BMI < 22 kg/m²	16 (41.1%)	5 (20.0%)	1.80 (1.23–2.64)	Nutrition, comorbidities	Chi-square	χ^2 = 9.46	0.002*
Diffuse histology	25 (61.6%)	9 (36.0%)	4.23 (2.86–6.25)	Age, tumor loc., stage	Chi-square	χ^2 = 66.1	<0.001*
T3–T4 vs T1–T2	34 (84.9%)	15 (60.0%)	3.86 (2.39–6.24)	Histology, N stage	Chi-square	χ^2 = 33.3	<0.001*
N2–N3 vs N0–N1	27 (67.1%)	12 (48.0%)	2.20 (1.50–3.23)	T stage, histology	Chi-square	χ^2 = 15.7	<0.001*

n = Number of participants, DL = Diagnostic Laparoscopy, T stage = Tumor Stage, N Stage, Nodal stage = BMI = Basal Metabolic Index, % = Percentage, * = Statistical Significance at p<0.05

Rural residence (OR: 2.56, CI: 0.92–7.13, p = 0.055), low BMI (OR: 2.67, CI: 0.82–8.63, p = 0.090), diffuse histology (OR: 3.06, CI: 1.07–8.74, p= 0.027*), advanced T stage (OR: 3.11, CI: 0.96–10.03, p=0.027*), and advanced nodal stage (OR: 2.29, CI: 0.82–6.38, p= 0.135) were significant predictors. Gender and age 60 or older were not predictive. Clinical and pathological risk factors can stratify risks and assist in identifying patients most likely to benefit from DL. Fig. 1 demonstrates the relative strength of clinical and pathological predictors.

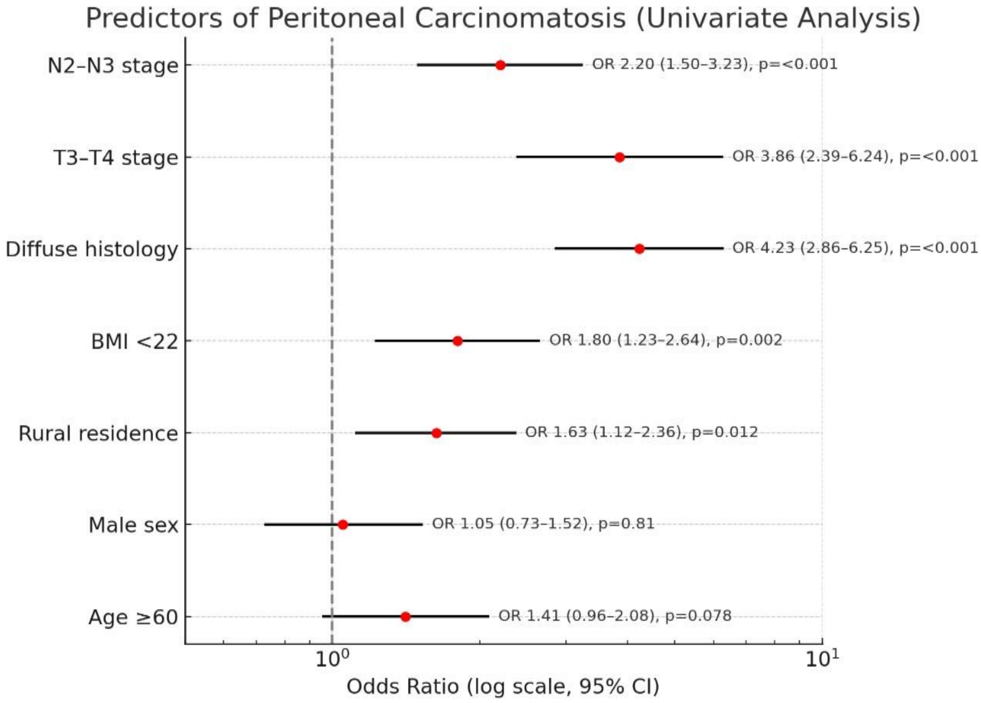

Fig. 1. Forest plot of univariate predictors of positive DL findings in gastric carcinoma

The highest and significant associations were between diffusion histology and advanced T stage, where CIs were greater than unity, helping clinicians in risk assessment and decision making.

DISCUSSION

This study was conducted to determine the role of DL in identifying PC in patients with gastric carcinoma and to determine the clinical and pathological predictors of positive cases. Results demonstrate that DL shows greater value in predicting staging accuracy by revealing occult peritoneal disease that imaging modalities cannot detect. This strengthens the argument that DL should be viewed as a routine staging surgery in carefully selected patients with advanced gastric cancer. They are consistent with the previous data, identifying diffuse histology as a high-risk factor for peritoneal seeding. Correspondingly, the cytoskeleton alteration and signaling pathways involved in tumor cell migration led to increased peritoneal seeding, similar to mechanisms of other fibrotic pathologies (28). Microenvironment regulation by tumor-stroma interactions and neural mechanisms is also involved in its progression, and is comparable to air remodeling and systemic inflammation (29).

The systemic effects of tumor-immune interactions are also evident in our findings. Consistent with previous studies on immune regulation, extracellular vesicles and inflammatory cytokines affect the formation of metastatic niches (30). The relationship between diffuse histology and PC is reflected in recent studies, demonstrating that DL has a better ability than imaging in the detection of peritoneal metastasis, especially in diffuse gastric cancer cases (31). Another significant predictor of DL positivity is advanced tumor stage, which is correct biologically, since invasive disease is associated with increased dissemination potential (32). It aligns with newer studies that support the role of staging laparoscopy in advanced gastric tumors, especially when cross-sectional imaging has limited sensitivity (33). The unique capability of DL to reveal peritoneal disease that was radiologically unidentifiable highlights its indispensable diagnostic value, with high T stage repeatedly finding a major predictor of occult metastasis in prospective cohorts (34). The presence of nodal disease also emerged as a predictor of PC, supporting that lymphatic involvement helps peritoneal spread (35). Clinical studies have demonstrated that nodal disease advancement correlates with an increased likelihood of identifying occult peritoneal metastases at laparoscopy (36). This research reinforces the demand for DL in patients radiologically staged as node-positive with no observable distant diseases.

The noted relationship between BMI and PC risks is significant, with low BMI often indicating a lack of nutritional stores or a high tumor burden (37). Correlation with nutritional status has also been reported in studies on risk factors of peritoneal dissemination, with nutritional status being a contributor to disease severity (38). This association highlights the importance of considering metabolic indicators when stratifying patients with DL. Socio-demographic predictors were also observed, and demonstrated that rural residence was associated with a higher risk of PC, indicating delayed diagnosis or access to care (39). This is reflected in the multicentric cohorts, which suggest that healthcare disparities impact both the stage of disease at presentation and the diagnostic yield of staging laparoscopy (40). The similarity between systemic disorders and metastasis illustrates the greater implications for pathophysiology. To illustrate, peritoneal dissemination corresponds with the inflammatory and metabolic processes implicated in other chronic conditions (41). Cytokine dynamics, immune modulation, and angiogenic signaling recognized in systemic studies also underlie PC risk (42). Furthermore, pandemic- related vulnerabilities and systemic upheavals depict the potential to influence tumor phenotypes via host physiology (43).

PET/CT with newer tracers is under investigation to detect PCs, although staging laparoscopy remains more accurate, especially when combined with cytology. In comparative studies, DL is often more sensitive than CT and PET in peritoneal disease. Additionally, peritoneal lavage further improves diagnostics in detecting early spread in the peritoneum (44). The importance of cytology is especially significant because patients with positive peritoneal cytology have negative outcomes even when there is no observable peritoneal metastasis (45). This is consistent with evidence indicating that cytology-positive individuals who undergo neoadjuvant therapy and gastrectomy present different results than cytology-negative individuals (46). These results explain why cytological evaluation and peritoneal lavage should be included in DL staging algorithms. The changes in technology are transforming staging strategies. Laparoscopic evaluation with artificial intelligence enables real-time metastasis identification, which can decrease variability in diagnosis

(47). CT radiomics is gaining traction as an alternative preoperative method to predict occult peritoneal disease using machine learning (48). However, these technologies are still supplements rather than substitutions for DL. In the treatment-planning context, research also demonstrates the ability of DL to accurately diagnose patients with peritoneal disease, saving them from unnecessary surgery, chemotherapy, or palliative care (49). The cost-effectiveness studies demonstrate that a selective use of DL decreases healthcare spending by preventing unnecessary laparotomies. These clinical and economic advantages reinforce the systematic DL in higher staging.

Related research findings on calcium and ion-channel regulation pathways propose molecular mechanisms underlying tumor aggression at the molecular level (50). Similarly, molecular regulators, including ubiquitination pathways, indicate system-level processes associated with cancer development (51). Wider systemic relationships, such as neonatal or endocrine changes, support the idea that physiological conditions beyond oncology offer informative comparisons (52). Collectively, these results highlight the multifactorial interplay between host, tumor, and environmental factors in the development of peritoneal spread. The significance of regional context in explaining DL yield is also observed in recent literature. Asian and European reports highlight differences in detection rates, indicating that tumor biology, healthcare systems, and patient factors influence outcomes. The complementary nature of DL to modern imaging in accurate staging further extends to longitudinal follow-ups to clinical trials. Overall, these studies emphasize the need to integrate DL into global guidelines while considering context-specific factors.

The study has certain limitations. The findings are not generalizable to larger populations due to a single-center and observational design. The diagnostic yield of DL may be affected by potential confounding factors, including unmeasured molecular biomarkers, non-BMI-based nutritional parameters, or differences in surgical expertise. Furthermore, socio-demographic correlations, including rural residence, can be indicators of inequity in access to care and not reflect underlying biological hazard. Future studies are recommended to involve multicentric and prospective validation of predictive models, incorporation of molecular and imaging biomarkers, and cost-effectiveness calculations across healthcare environments. It should also consider the role of advanced imaging, radiomics, and artificial intelligence combined with DL to improve the accuracy of staging.

CONCLUSION

In this study, DL demonstrated PC in a significant percentage of patients with gastric carcinoma deemed unresectable on imaging. Diffuse histology, high tumor stage, nodal involvement, low BMI, and rural residence were significantly linked to positive laparoscopy. The results emphasize the deficiencies of standard imaging and the importance of complementing it with direct observations and cytological testing. Adding DL to staging procedures can eliminate unnecessary laparotomies and optimize treatment planning. These findings support selective, evidence-based laparoscopy to enhance outcomes and optimize resource allocation in gastric cancer management.

Authors' contribution:

MS Conceptualization, Substantial contributions to experimentation and acquisition of data, Manuscript Writing; ZM Methodology design, Data collection, Initial draft preparation; TA Critical revision of the manuscript; AW Data analysis, Visualization, Interpretation of results; KH Literature review, Editing, Final proofreading of the manuscript.

References:

1. Mamun TI, Younus S, Rahman MH. Gastric cancer-Epidemiology, modifiable and non-modifiable risk factors, challenges and opportunities: An updated review. Cancer Treat Res Commun. 2024;41:100845.
2. Guan G, Li Z, Wang Q, Ying X, Shan F, Li Z. Risk factors associated with peritoneal carcinomatosis of gastric cancer in staging laparoscopy: A systematic review and meta-analysis. Front Oncol. 2022;12:955181.
3. Fu C, Zhang B, Guo T, Li J. Imaging Evaluation of Peritoneal Metastasis: Current and Promising Techniques. Korean J Radiol. 2024;25(1):86-102.

4. Li Z, Guan G, Liu Z, Li J, Ying X, Shan F, Li Z. Predicting peritoneal carcinomatosis of gastric cancer: A simple model to exempt low-risk patients from unnecessary staging laparoscopy. Front Surg. 2022;9:916001.
5. van Hootegem SJM, Chmelo J, van der Sluis PC, Lagarde SM, Phillips AW, Wijnhoven BPL. The yield of diagnostic laparoscopy with peritoneal lavage in gastric adenocarcinoma: A retrospective cohort study. Eur J Surg Oncol. 2024;50(4):108233.
6. Cortés-Guiral D, Hübner M, Alyami M, Bhatt A, Ceelen W, Glehen O, Lordick F, Ramsay R, Sgarbura O, Van Der Speeten K, Turaga KK, Chand M. Primary and metastatic peritoneal surface malignancies. Nat Rev Dis Primers. 2021;7(1):91.
7. De Ruvo N, Fenocchi S, Veronesi L, Missori G, Ricciardolo AA, Rossi EG, Sorrentino L, Cautero N, Serra F, Gelmini R. Prognostic factors in gastric cancer patients: a 10-year mono-institutional experience. Front Surg. 2024;11:1321981.
8. Liu K, Cui L, Li C, Tang C, Niu Y, Hao J, Bu Y, Chen B. Pan-cancer analysis of the prognostic and immunological role of ANLN: An onco-immunological biomarker. Front Genet. 2022;13:922472.
9. Repiso A, Gómez-Rodríguez R, López-Pardo R, Lombera MM, Romero M, Aranzana A, Abad S, Rodríguez-Merlo R, López L, Carboles JM. Usefulness of endoscopic ultrasonography in preoperative gastric cancer staging: diagnostic yield and therapeutic impact. Rev Esp Enferm Dig. 2010;102(7):413-20.
10. Rawicz-Pruszyński K, Erodotou M, Pelc Z, Sędłak K, Polkowski W, Pawlik TM, Wijnhoven BPL. Techniques of staging laparoscopy and peritoneal fluid assessment in gastric cancer: a systematic review. Int J Surg. 2023;109(11):3578-3589.
11. Butensky SD, Bansal VV, Su DG, Waheed MT, Nikiforchin A, Gomez-Mayorga JL, Olecki E, Radomski SN, Sun B, Turaga KK, Gunderson CG, Lacy J, Badgwell BD, In H, Kennedy T, Yoon HH, Greer JB, Sundar R, Woo Y; Peritoneal Surface Malignancies Consortium Group. Consensus guideline for the management of gastric cancer with synchronous peritoneal metastases. Cancer. 2025;131(13):e35870.
12. Gęca K, Skórzewska M, Rawicz-Pruszyński K, Mlak R, Sędłak K, Pelc Z, Małecka-Massalska T, Polkowski WP. Prognostic value of molecular cytology by one-step nucleic acid amplification (OSNA) assay of peritoneal washings in advanced gastric cancer patients. Sci Rep. 2022;12(1):12477.
13. O'Leary L, Botzenhardt E, Gilbert TM, Quinn LM, Díaz-Nieto R, Jones RP, Jones L, Griffin M, Stanley R, Leppert A, Malik HZ, Fenwick SW. Update to the role of staging laparoscopy in the assessment of resectability of perihilar cholangiocarcinoma: have improvements in cross-sectional and functional imaging rendered it redundant? HPB (Oxford). 2025;27(8):1113-1123.
14. Sun BJ, Lee B. Review of Regional Therapies for Gastric Cancer with Peritoneal Metastases. Cancers (Basel). 2022;14(3):570.
15. Zulfania Z, Hayat H, Mahmood R, Bukhari AA, Ihtesham Y, Rasool U. Comparison of platelet indices in hypoproductive and hyperdestructive thrombocytopenia. Pakistan Journal of Physiology. 2021;17(2):3-6.
16. Parveen N, Bukhari AA, Khan Z, Mahmood R, Khan K, Ihtesham Y. Association of diabetic retinopathy with dyslipidemia: a multicenter study. J Rehman Med Inst. 2018;4(4):21-24.
17. Bukhari AA, Parveen N, Khan Q, Khan K. Leptin levels in vitreous fluids of patients with diabetic retinopathy. Journal of Rehman Medical Institute. 2015;1(1):17-20.
18. Parveen N, Khan Z, Mahmood R, Bukhari AA, Khan K, Khan Q, Rasool U. Serum and vitreous levels of Interleukin-6, Leptin and Vascular Endothelial Growth Factor in patients with proliferative and non-proliferative diabetic retinopathy. Journal of Rehman Medical Institute. 2018;4(3):08-10.
19. Ullah I, Bukhari AA, Durrani M, Khan Z, Tauqir S, Farid B, Khan MF. Risk factors for ventricular tachycardia in acute ST-elevated myocardial infarction patients of a tertiary care hospital of Peshawar. Journal of Rehman Medical Institute. 2020;6(4):12-5.
20. Zhang Y, Ilyas M, Yilin W, Su Y, Bukhari AA, Ahmad A. A Methodical Approach to Scrutinize the Role of Body Mass Index in Heart Rate Increment and Recovery. Journal of Gandhara Medical & Dental Sciences (JGMDS). 2022;9(4):31-6.
21. Bukhari AA, Durrani M, Khan Z, Shafiq M, Tauqir S, ur Rehman A. Urinary excretion of electrolytes and their correlation with clinical parameters in chronic kidney disease. Journal of Rehman Medical Institute. 2020;6(2):08-11.
22. Bukhari AA, Parveen N, Khan Q, Khan K. Levels of serum interleukin il-6 in patients with advanced diabetic retinopathy. Journal of Rehman Medical Institute. 2015;1(1):4-8.
23. Rasool U, Ihtesham Y, Bukhari AA, Khan Z. Common presentations of non-traumatic acute abdomen on Ultrasound in patients presenting to the Emergency Department of Hayatabad Medical Complex, Peshawar. Journal of Rehman Medical Institute. 2019;4(4):12-15.
24. Rehman S, Durrani M, Bukhari AA, Tariq K, Rehman AU, Shafiq M. Can BNP levels and Killip grading

assess the severity of injury to myocardium after acute myocardial infarction in Type II Diabetics?. Journal of Rehman Medical Institute. 2021;4(3):03-7.
25. Chen ZD, Zhang PF, Xi HQ, Wei B, Chen L, Tang Y. Recent Advances in the Diagnosis, Staging, Treatment, and Prognosis of Advanced Gastric Cancer: A Literature Review. Front Med (Lausanne). 2021;8:744839.
26. Vandenbroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, Poole C, Schlesselman JJ, Egger M; STROBE Initiative. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):e297.
27. Bhardwaj R, Agrawal U, Vashist P, Manna S. Determination of sample size for various study designs in medical research: A practical primer. J Family Med Prim Care. 2024;13(7):2555-2561.
28. Sun H, Zhao A, Li M, Dong H, Sun Y, Zhang X, Zhu Q, Bukhari AA, Cao C, Su D, Liu Y, Liang X. Interaction of calcium binding protein S100A16 with myosin-9 promotes cytoskeleton reorganization in renal tubulointerstitial fibrosis. Cell Death Dis. 2020;11(2):146.
29. Bukhari AA, Shaikh AR, Salman W, Bhatti FA, Malik W, Minhas M, Muddasser A, Khaliq H. Pathophysiological role of nerve growth factor (NGF) in asthma: insights into airway inflammation, remodeling, and neural regulation in intensive care settings. Anaesth. pain intensive care. 2025;29(3):681-689.
30. Gong J, Ali N, Abubakar M, Bukhari AA, Ilyas M, Bashir U, Ali M, Zaman MH. The predominant role of cd4+t cell-derived small extracellular vesicles in immune enhancement. Journal of Population Therapeutics and Clinical Pharmacology. 2023:30(18):1774-1783.
31. Ho SYA, Tay KV. Systematic review of diagnostic tools for peritoneal metastasis in gastric cancer-staging laparoscopy and its alternatives. World J Gastrointest Surg. 2023;15(10):2280-2293.
32. Tahira S, Bibi F, Niaz M, Bukhari AA, Butt AI, Khan E. Multi-organ pathophysiology of endometriosis: Evaluating neurotrophin linked multifaceted health risks assessments. Official Journal of Pakistan Medical Association, Rawalpindi–Islamabad Rawalpindi–Islamabad. 2025;50(2):377.
33. Schena CA, Laterza V, De Sio D, Quero G, Fiorillo C, Gunawardena G, Strippoli A, Tondolo V, de'Angelis N, Alfieri S, Rosa F. The Role of Staging Laparoscopy for Gastric Cancer Patients: Current Evidence and Future Perspectives. Cancers (Basel). 2023;15(13):3425.
34. Jiang Y, Liang X, Wang W, Chen C, Yuan Q, Zhang X, Li N, Chen H, Yu J, Xie Y, Xu Y, Zhou Z, Li G, Li R. Noninvasive Prediction of Occult Peritoneal Metastasis in Gastric Cancer Using Deep Learning. JAMA Netw Open. 2021;4(1):e2032269.
35. Z HM, Tahir S, Ali N, Bukhari AA, Zeb F, Khalid M, Salim F, Raja AA. Effect of qrs duration on cardiac resynchronization therapy in patients with heart failure and its related factors. Journal of Population Therapeutics and Clinical Pharmacology. 2023;30(18):638-649.
36. Kubo N, Cho H, Lee D, Yang H, Kim Y, Khalayleh H, Yoon HM, Ryu KW, Hanna GB, Coit DG, Hakamada K, Kim YW Professor. Risk prediction model of peritoneal seeding in advanced gastric cancer: A decision tool for diagnostic laparoscopy. Eur J Surg Oncol. 2023;49(4):853-861.
37. Orakzai S, Ijaz A, Bukhari AA, Durrani M. Evaluation of Random Plasma Glucose with Lowered Cutoff Limits for Screening of Diabetes and Prediabetes. Pakistan Journal of Medical & Health Sciences. 2022;16(07):321-321.
38. Solaini L, Bencivenga M, D'ignazio A, Milone M, Marino E, De Pascale S, Rosa F, Sacco M, Fumagalli Romario U, Graziosi L, De Palma G, Marrelli D, Morgagni P, Ercolani G. Which gastric cancer patients could benefit from staging laparoscopy? A GIRCG multicenter cohort study. Eur J Surg Oncol. 2022;48(8):1778-1784.
39. Durrani M, Bukhari AA, Abubakr M, Zaman MH, Khan F, Nasim S. The effect of low zinc on the fabrication of short chain fatty acids by colonic microbiota in infants. Grasas y aceites. 2022;16:2.
40. Rieser CJ, Hoehn RS, Zenati M, Hall LB, Kang E, Zureikat AH, Lee A, Ongchin M, Holtzman MP, Pingpank JF, Bartlett DL, Choudry MHA. Impact of Socioeconomic Status on Presentation and Outcomes in Colorectal Peritoneal Metastases Following Cytoreduction and Chemoperfusion: Persistent Inequalities in Outcomes at a High-Volume Center. Ann Surg Oncol. 2021;28(7):3522-3531.
41. Kausar R, Batool A, Bukhari AA, Shaikh AR, Aleem A, Minhas M, Hussain M. Crosslinking Salivary Diagnosis with Non-Invasive Insights to Oral Pathology: Novel Systematic Insights to Personalized Medicine in Disease Management. . Pak Armed Forces Med J. 2025;75(3):611-616.
42. Ghaffar T, Ahmad I, Bukhari AA. Effect of the timing of thyroxine intake on thyroid stimulating hormone levels in Ramadan. PJMHS. 2021;15(01):46-8.
43. Bukhari AA, Tauqir S, Tariq MM, Wadood U, Mahmood R, Zaman MH. Stress vulnerability in Medical Health Care Professionals of Pakistan during the COVID-19 pandemic. Al-Qanṭ ara. 2022;8(2).
44. Ofluoğlu CB, Aydın IC, Mülküt F, Uzun O, Senger AS, Gülmez S, et al. Diagnostic Efficacy of Staging

Laparoscopy Compared to CT and PET-CT in Gastric Cancer: A Retrospective Cohort Analysis. Medicina (Kaunas). 2024;60(12):2079.
45. Durrani M, Bukhari AA, Abubakr M, Tariq K, Rehman AU, Shafiq M. Effects of feeding practices on the diversity of faecal short chain Fatty acids in 1-4 months infants in Pakistani cohort. Rehman Journal of Health Sciences. 2020;2(2):36-9.
46. Bausys A, Ümarik T, Dobrzhanskyi O, Luksta M, Kondratskyi Y, Reinsoo A, Vassiljev M, Bausys B, Bickaite K, Rauduvyte K, Luksaite-Lukste R, Bausys R, Strupas K. Neoadjuvant Chemotherapy Followed by Gastrectomy for Cytology-Positive Gastric Cancer without Any Other Non-Curative Factors in a Western Setting: An International Eastern European Cohort Study. Cancers (Basel). 2023;15(24):5794.
47. Chen H, Gou L, Fang Z, Dou Q, Chen H, Chen C, Qiu Y, Zhang J, Ning C, Hu Y, Deng H, Yu J, Li G. Artificial intelligence assisted real-time recognition of intra-abdominal metastasis during laparoscopic gastric cancer surgery. npj Digital Medicine. 2025;8(1):9.
48. Zhu ZN, Feng QX, Li Q, Xu WY, Liu XS. Machine learning-based CT radiomics approach for predicting occult peritoneal metastasis in advanced gastric cancer preoperatively. Clin Radiol. 2025;80:106727.
49. Wadood U, Sultana U. Effectiveness of Triamcinolone Acetonide Ointment and Bovine Basic Fibroblast Growth Factor in the Treatment of Minor Recurrent Aphthous Ulcer. PJMHS. 2020;14(3):780-82.
50. Zhang X, Li M, Zhao A, Dong H, Liang X. Cofilin participates in regulating alpha-epithelial sodium channel by interaction with 14-3-3 isoforms. J Biomed Res. 2020;34(5):351–360.
51. Zhu Q, Dong H, Bukhari AA, Zhao A, Li M, Sun Y, Zhang X, Cao C, Su D, Liang X. HUWE1 promotes EGFR ubiquitination and degradation to protect against renal tubulointerstitial fibrosis. The FASEB Journal. 2020;34(3):4591-601.
52. Ali A, Bukhari AA, Majeed S, Gul S, Khalil N, Wadood U. Frequency of Hypocalcemia with Exchange Transfusion in Neonatal Jaundice. PJMHS. 2021;15(8):1849-54.