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Surgical Oncology

Preoperative Evaluation of Gastric Cancer: Is it Discordant with Postoperative Staging?

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Abstract	Original Research Article

Gastric cancer is one of the most common human cancers worldwide. Preoperative knowledge of adjacent organ invasion and distant metastasis is important in planning the operative procedure, allowing the surgeon to decide whether surgery is potentially curative or palliative in nature. Computed tomography is an imaging modality used for preoperative staging. The aim of this study was to evaluate and explore any discordance between pre- and postoperative staging of gastric cancer by comparing the imaging findings with post-operative histopathological findings. This longitudinal observational study was conducted in the department of surgery, Chittagong Medical College and Hospital, Chattogram, Bangladesh. Histopathologically confirmed gastric adenocarcinoma patients were included. Detail history taking, relevant clinical examination, preoperative staging, multidisciplinary team meeting, intraoperative findings with peritoneal lavage and postoperative histopathological examination were done to determine any disparity or discordance between pre- and post-operative staging of gastric cancer. The mean age of the patient was 54.30 ± 12.60 (Mean ± SD) years. Male-female ratio was 1.37:1. Preoperative staging with CT scan showed that 54 patients (52.94%) were T3 stage, and 56 patients (54.90%) were N0 stage. Curative operation was done in 69.60% patients. Intraoperative findings showed that in 40 patients (39.2%) tumors extended to surrounding structure, 41 patients (40.2%) had lymph node involvement, 23 patients (22.5%) had ascites, 20 patients (19.6%) had distal metastases, and liver is the most common site (10 patients, 9.8%). Peritoneal lavage cytology was positive in 18 patients (17.6%). Pre- operative and post-operative staging were discordance in all T and N stages. Overall sensitivity of T stage was 97% and specificity was 100%. Overall sensitivity of N staging was 51% and specificity was 100%. Pre- and post-operative staging of gastric cancer shows that there is discordance in most of the parameters in T and N stages.
Keywords: Gastric cancer, Staging, Multidetector Computed Tomography, Tumour Node Metastasis, discordance.

INTRODUCTION

Gastric cancer (GC) is a major global health challenge worldwide. It was the fifth most common cancer with approximately 1.1 million new cases and fourth most common cause of cancer-related deaths in the world in 2020 [1]. Worldwide, there is a considerable geographic variation in gastric cancer incidence. Incidence of GC is highest in eastern Asia (22.4 per 100000 people), followed by eastern and central Europe (11.3 per 100000 people), and Polynesia and south America (equally about 8.6 per 100000 people). The lowest rate reported was in southern Africa (3.3 per 100000 people) [2], [3]. More than three quarters (75.3%; 819944) of all GC cases are residents of Asia.

The highest incidence rates of GC were recorded in countries of eastern Asia (Mongolia, Japan, and Republic of Korea), while the highest death rates were observed in countries of western Asia (Tajikistan, Kyrgyzstan, Iran). The lowest incidence and mortality rates of stomach cancer were recorded in Northern America and Northern Europe, Australia/New Zealand and some African countries [4].

In Bangladesh, there is no definite national population-based statistics for cancers. According to the reports of few specialized hospitals including National Institute of Cancer Research and Hospital, Mohakhali, Dhaka, gastric cancer is the 5th most common cancer & 3rd most common cancer among males in Bangladesh [5].

According to the American Joint Committee on Cancer (AJCC) staging guidelines (8th Edition), TNM (tumor, node, and metastasis) classification is the most used system to stage gastric adenocarcinoma [6]. The Japanese classification is harmonized with the TNM system, with more detail regarding the preoperative macroscopic appearance of the lesions and the designation of the nodal stations involved [7]. These staging systems help to choose the appropriate treatments based on tumor invasion and metastasis. Deep tumor invasion into an adjacent organ (T4) and the presence of multiple, metastatic lymph nodes (N3 or N4) or presence of distant metastasis (M1) limit the resectability of GC [8]. Furthermore, the recent development of chemotherapeutic agents prolongs the survival of patients with advanced diseases. Thus, the TNM staging system has been shown to accurately predict patient prognosis.

Treatment of GC largely depends on the stage of the disease. Surgery, chemotherapy and radiation therapy are the modalities. The management plan should be done through a multidisciplinary meeting (MDM) where staging and relevant information is available to all members of the team. Patients should be informed about the available treatment options, risks and benefits [9].

Surgical resection is the primary management of gastric cancer and complete surgical resection is thought to be the only successful option for gastric cancer. The type and extent of surgery depends on the location of the tumor, its depth and invasion and potential lymph node metastases. The intention of surgical resection is to achieve microscopically negative surgical margins (R0 resection) and clearance of the adjacent lymph node groups. To achieve R0 resection for locally advanced GC neoadjuvant chemotherapy (NACT) has been investigated [10]. The goal of NACT is to have significant tumor downstaging and pathological complete response (pCR). It has been proven that patients who have a pCR may achieve superior overall survival (OS) and fewer local or systemic recurrence than those with a partial or no response [11].

Preoperative staging demonstrates the extent of disease, defines the prognosis, and permits treatment planning. Available preoperative staging modalities include abdominal ultrasound (AUS), computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET) [12]. Multidetector computed tomography (MDCT) is considered the primary imaging modality for detection of local tumor invasion and metastatic disease [13]. MDCT may aid with guiding the selection of treatment options and avoiding unnecessary surgery [14]. Plain chest X-ray P/A view can give information about lung and adjacent bony metastasis.

Unnecessary laparotomies are done if metastases are not identified by preoperative imaging.

Unnecessary laparotomy may lead to increase morbidity and mortality [15]. Peritoneal dissemination during surgery is a common cause of GC recurrence due to the spread of free cancer cells, present in the peritoneal cavity. The presence of free cancer cells is associated with advanced GC stage and poor prognosis**.** The European Society for Medical Oncology (ESMO) recommendation is to perform the peritoneal washings analysis in all patients with a potentially resectable GC (stages IB–III) [16]. Therefore, the aim of the present study is to compare preoperative findings with intraoperative assessment and postoperative histopathology results to evaluate the accuracy and discordance of preoperative staging of gastric cancer.

MATERIALS AND METHODS

This longitudinal observational study was conducted at department of surgery, Chittagong Medical College Hospital, Chattogram, Bangladesh over the period of January 2023 to June 2024. During this period, 102 diagnosed gastric cancer patients with histologically confirmed gastric adenocarcinoma admitted to the surgery ward for operation were included. Patients with conditions other than gastric adenocarcinoma, recurrent gastric cancer and a history of neoadjuvant chemotherapy were excluded. Detail clinical history, relevant physical examination and proper investigations were done in all the enrolled patients. Diagnosis of gastric adenocarcinoma was confirmed by histopathology of endoscopic biopsy. Preoperative staging according to AJCC was done by conventional MDCT scan of the whole abdomen with contrast and chest X-ray. Further decisions were made through a multidisciplinary team approach. The operation was done under general anesthesia with fulfillment of all necessary prerequisites. Intraoperative findings like tumor location, invasion to surrounding structure, ascites, peritoneal and parietal deposit, liver metastases and paraaortic lymph nodes involvement were recorded. Peritoneal fluid washed with normal saline was collected for cytological examination. Operative procedure was done based on the instant findings. Resected specimens were sent for histopathological examination and proper pathological staging. Post-operative staging was done by histopathological findings of resected specimen as per TNM staging system. pTNM (histopathological staging) was done by competent histopathologist. Predesigned structured case record forms were used to record the data. Case record forms included the variables of interest. All data were analyzed by using SPSS version 25.0 (IBM Corp., Armonk, NY). Mean ± SD was calculated for quantitative variables. Frequencies and percentages were calculated for categorical variables. Chi-square test was used to assess the association between two categorical variables. P-value ≤ 0.05 was considered significant. Any disparity or discordance between pre- and post-operative staging of gastric cancer was observed. Informed consent was obtained from all the patients after describing the objectives and nature of the study. Ethical clearance was taken from the Ethical Review Committee

of Chittagong Medical College (memo no-59.27.0000.013.19.PG.2023.009.918).

RESULTS

This study was done to explore any discordance between pre- and post-operative staging of gastric cancer. 102 patients of gastric carcinoma who were admitted to the surgery department, Chittagong Medical College, Chattogram were enrolled based on selection criteria. The mean age of the patients was 54.30±12.60 (Mean ± SD) years with the range of 27 to 85 years. Most of the patients (30.4%) were in the 41-50 years age group. Male- Female ratio was 1.37: 1. Among them 48 patients (47.06%) had smoking history, 39 patients (38.24%) had history of taking extra salt, 28 patients (27.45%) had history of taking dry fish & 10 (9.80%) patients had family history of gastric cancer. Clinical signs of the patients showed that 99 patients (97.06%) were anaemic, 28 patients (27.45%) presented with abdominal mass and 21 patients (20.59%) were dehydrated (table 1).

Table 1: Clinical presentations of patients

Clinical presentation	Frequency	%
Anemia	99	97.06%
Abdominal mass	28	27.45%
Dehydration	21	20.59%
Palpable Virchow's gland	1	0.98%
Visible peristalsis	3	2.94%
Jaundice	1	0.98%
Oedema	9	8.82%
Ascites	3	2.94%

All patients presented with multiple symptoms. The presentation of classical 'alarm' symptoms showed most of the patients (92 patients, 90.2%) presented with weight loss, 71 patients (69.61%) presented with vomiting, 68 patients (66.67%) presented with abdominal pain and 39 patients (38.24%) presented with anorexia. Pre-operative staging with MDCT of abdomen and Chest X-ray showed that 54 patients (52.94%) were T3 stage, 56 patients (54.90%) were N0 stage, and 16 patients (15.69%) were M1 (table 2).

Table 2: Preoperative staging with MDCT of abdomen and Chest X-ray (*n*=102)

Stage		Frequency	%
CT stage T	T0	3	2.94%
	T1	3	2.94%
	T2	28	27.45%
	T3	54	52.94%
	T4	14	13.73%
CT stage N	N0	56	54.90%
	N1	24	23.53%
	N2	15	14.71%
	N3	7	6.86%
CT and Chest X-ray	M1	16	15.69%
Stage M	M0	86	84.31%

Endoscopic findings showed that antrum was the most common site of involvement of gastric carcinoma (75 patients, 73.5%). Post-operative histopathological examination showed that 60 patients (59%) were poorly differentiated, 39 patients (38%) were moderately differentiated, and 3 patients (3%) were well differentiated adenocarcinoma.

In our study 102 operative procedures were done. Curative surgery was done in most of the patients (71 patients, 69.6%). 31 patients (30.4%) were done palliative procedure. The most common surgery done was lower radical gastrectomy (57 patients, 55.9%), followed by palliative gastrojejunostomy (15 patients, 14.7%), total gastrectomy (14 patients, 13.7%), feeding jejunostomy (12 patients, 11.8%) and open and close (4 patients, 3.9%). Intraoperative macroscopic findings showed that 40 patients (39.2%) had tumor extension to surrounding structure, 41 patients (40.2%) had macroscopic lymph node involvement, and 20 patients (19.6%) had macroscopic distal metastasis. Liver is the most common site (10 patients, 9.8%) but there was involvement of multiple sites of same patient. 23 patients (22.5%) had ascites (table 3).

Table 3: Intraoperative macroscopic findings (*n*=102)

Findings	Frequency	%
Macroscopic tumor extension to surrounding structure		
Yes	40	39.2
No	62	60.8
Macroscopic lymph node involvement		
Yes	41	40.2
No	61	59.8
Macroscopic distal metastasis		
Yes	20	19.6
Liver	10	9.8
Liver and peritoneum	2	2.0
Mesentery	2	2.0
Peritoneum	4	3.9
Peritoneum, parietal wall	1	1.0
Parietal wall	1	1.0
No	82	80.4
Ascites		
Yes	23	22.5
No	79	77.5

Peritoneal lavage cytology showed that 84 patients (82.4%) had negative results, and 18 patients (17.6%) had positive results.

A test of significance was done for pre- and postoperative T staging of 71 patients, who had curative surgery. Pre- and postoperative T staging were discordance in all stages. The result showed that the overall sensitivity of T staging in MDCT was 97% and specificity was 100%. P value was found <0.05 by Chi-square test revealing that the difference between pre- and postoperative T staging in MDCT was statistically significant (table 4).

Table 4: Comparison of pre- and post-operative T stage between patients underwent curative surgery (*n*=71)

Pre-operative T stage	Post-operative T stage						*P* value
	Total	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	
Stage 0	3	0	0	2	1	0	0.00*
Stage 1	2	0	0	2	0	0	
Stage 2	27	0	1	9	17	0	
Stage 3	36	0	0	1	35	0	
Stage 4	3	0	0	0	2	1	
Total	71	0	1	14	55	1	

* *P*-value is significant. *P*-value achieved from Chi-square test.

A significant test was done for pre- and postoperative N staging of 71 patients, who had curative resections. Pre- and postoperative N staging were discordance in all stages. The result showed that the overall sensitivity of N staging in MDCT was 51% and specificity was 100%. P value was found <0.05 by Chi-square test revealing that the difference between pre- and postoperative N staging was statistically significant (table 5).

Table 5: Comparison of pre- and post-operative N stage between patients underwent curative surgery (*n*=71)

Pre-operative N stage	Post-operative N stage					*P* value
	Total	Stage 0	Stage 1	Stage 2	Stage 3	
Stage 0	41	13	18	4	6	0.003*
Stage 1	20	0	15	3	2	
Stage 2	7	0	2	4	1	
Stage 3	3	0	1	2	0	
Total	71	13	36	13	9	

* *P*-value is significant. *P*-value achieved from Chi-square test.

DISCUSSION

Accurate preoperative assessment of the local invasion and distant metastasis of gastric cancer is important for selecting appropriate management and determining prognosis. Gastric cancer preoperative staging is usually done with a combination of endoscopy, endoscopic ultrasonography, and computed tomography. Endoscopic ultrasonography is particularly useful for assessing the depth of tumor invasion, while CT is better for detecting lymph node and distant metastases [13]. However, studies have shown that preoperative staging may not always accurately reflect the true extent of disease. Preoperative imaging can underestimate the extent of disease, leading to under-staging, or overestimate the extent, leading to over-staging. Assessing lymph node involvement preoperatively is challenging because radiologically detected enlarged lymph nodes may not have metastasis, while small metastatic nodes can be missed on imaging. Similarly, peritoneal dissemination and small liver metastases may not be detected on preoperative scans [17]. This discordance between pre- and post-operative staging in gastric cancer has an important role in patient management.

In this study the overall mean age of enrolled patients was 54.30 ± 12.60 (Mean $\pm$ SD) years. The highest number of patients (30.4%) were found in the 41-50 years age group. Large number of patients (85.3%) age were more than 40 years. In relevant literature, the peak incidence for gastric cancer was found 65-74 years. Approximately 3%-10% of gastric cancers occur in patients younger than 40 years [18]. But in our study age group of peak incidences is a bit lower than the other study. The possible cause may be the lower life expectancy in our society. In our study male-female ratio was 1.37: 1. The GLOBOCAN 2022 reported that gastric cancer is most frequent in male [19]. A recent study from USA revealed that men had higher incidence of gastric cancer than women, regardless of race and ethnicity [20].

In this study, distribution of patients by risk factors showed that 48 patients (47.06%) had smoking history, 39 patients (38.24%) had history of taking extra salt, 28 patients (27.45%) had history of taking dry fish and 10 patients (9.80%) had family history of gastric cancer. Gastric cancer is a multifactorial disease, with both environmental and genetic factors having roles in it and its prevalence is more common in those with positive family history [21]. In addition, high-fat, high-salt and high-nitrogen diets, a history of infection with Helicobacter Pylori, EBV virus, genetic factors, pre-malignant stomach lesions and tobacco use have been reported as risk factors for gastric cancer [22]. So, the etiological factors of this study are almost similar with other studies.

Clinical signs of the patients showed that 99 patients (97.06%) were anemic, 28 patients (27.45%) had abdominal mass and 21 patients (20.59%) were dehydrated. All patients had multiple findings. Palpable abdominal mass indicates advanced disease [23]. Pre-operative T staging in MDCT scan showed that T0, T1, T2, T3 and T4 staging were 2.94%, 2.94%, 27.45%, 52.94% & 13.73% respectively. Preoperative N staging in CT showed N0, N1, N2 & N3 were 54.90%, 23.53%, 14.71% & 6.86% respectively. The highest number of patients were in T3 stage (54 patients, 52.94%) and N0 stage (56 patients, 54.90%). In our study peritoneal lavage cytology showed that 17.6% of patients had positive results and 82.4% of patients had negative results. The incidence of positive peritoneal cytology for patients with gastric cancer varies, in published reports, from 4% to 41% [24].

The diagnostic accuracy of MDCT for T1, T2, T3 & T4 staging are 20.8% 36.4%, 89.5% and 86.7% respectively [25]. The accuracy of N staging in MDCT is 44.6% [26]. The accuracy of MDCT for N0, N1, N2 and N3 staging are 61.1%, 48.5%, 38.9% and 8.4%, respectively [25]. So far, this study concerns T staging appears to be slightly varied with the other studies, but N staging appears to be similar. Disparity in T staging findings may be due to selection bias or inaccuracy of reporting. In this study significant tests were done for pre- and post-operative T staging in MDCT of 71 patients, who had done curative surgeries. CT scan failed to detect 17 (24%) stage T3 tumor and labeled those as stage T2 (under stage). Pre- and postoperative staging were discordance in all T stages. The result showed that for T staging in MDCT sensitivity was 97% and specificity was 100%. P value was found <0.001 by Chi-square test revealing that the difference between pre- and post-operative T staging in MDCT was statistically significant. In published literature, the overall diagnostic accuracy of MDCT for T staging was between 77.1% to 88.9%. Sensitivities and specificities for serosal invasion (T4a or T4b) was 82.8% to 100% and 80% to 96.8%, respectively [27]. In another literature, Chen *et al* [14] reported an improved T staging accuracy of 89% when using 2D and MPR images compared to 73% accuracy when using only 2D images. Kim *et al*. [28] also reported improved T staging of MDCT with MPR images in advanced GC. These results suggest that use of both MPR images and axial images improves the T staging accuracy, especially in advanced cases. The overall sensitivity of T staging of MDCT in our study was 97%, which is higher than many other studies. This may be due to the use of modern high quality upgraded versions of MDCT scan machine. The specificity was 100% in this study, maybe due to the small number of samples in the study.

In this study significant test was done for pre- and post-operative N staging of 71 patients. CT scan could not detect many stage N1 (18), N2 (4), N3 (6) tumor whom it reported as stage N0. Among the 41 N0 patients commented by CT scan only 13 were N0 in postoperative staging. However, among 20 patients of stage N1 commented on CT scan, 15 were stage N1 and

3 were stage N2 and 2 were stage N3 tumors. The result showed that for N staging in MDCT sensitivity was 51% and specificity was 100%. P value was found <0.005 by Chi- square test which revealed that the difference between pre- and post-operative N staging in MDCT was statistically significant. The result showed that pre- and postoperative staging were discordant in all N stages of gastric cancer. The results of other studies evaluating the accuracy of MDCT N-staging are somewhat poor. The sensitivity and specificity of N staging in MDCT were between 62.5% to 91.9% and 50.0% to 87.9%, respectively in published literatures [29], [30]. These variability in results may be due to lack of standard CT criteria and guidelines for diagnosing metastatic lymph nodes. The sensitivity of N stage in MDCT was 51% in our study. This may be because the reports were provided by different radiologists. It may be possible that they missed some mildly enlarged lymph nodes away from the stomach. Focused searching for LN with zoom view on CT software might detect more lymph nodes. The specificity of N stage in MDCT was 100% in this study, which may be due to the small number of samples.

This study has several limitations. This is a longitudinal observational study that has been done in a single center with a limited number of samples within a short period of time. All investigations, especially MDCT scans, were not done from single center rather those were done in different centers that may affect preoperative image-based staging. Post-operative histopathology report varies from center to center and person to person that may be a limitation in terms of homogeneity of reporting.

CONCLUSION

Our study highlights the importance of accurately staging gastric cancer preoperatively to guide appropriate management. While MDCT provided valuable information about the depth of tumor invasion, lymph node involvement and distant metastases, they may not always accurately reflect the true extent of disease. To improve the accuracy of preoperative staging, clinicians should consider combining multiple imaging techniques and incorporating relevant clinical and pathological factors, such as peritoneal cytology, into the staging process. By achieving more accurate preoperative staging, surgeons can make more accurate decisions about the management for each individual patient with gastric cancer and thus improve morbidity and mortality.

REFERENCES

1. H. Sung *et al.*, "Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries," *CA. Cancer J. Clin.*, vol. 71, no. 3, pp. 209–249, May 2021, doi: 10.3322/caac.21660.
2. E. Morgan *et al.*, "The current and future incidence and mortality of gastric cancer in 185 countries, 2020–40: A population-based modelling study," *eClinicalMedicine*, vol. 47, p. 101404, May 2022, doi: 10.1016/j.eclinm.2022.101404.
3. M. Arnold *et al.*, "Global Burden of 5 Major Types of Gastrointestinal Cancer," *Gastroenterology*, vol. 159, no. 1, pp. 335-349.e15, Jul. 2020, doi: 10.1053/j.gastro.2020.02.068.
4. J. Ferlay *et al.*, "Cancer statistics for the year 2020: An overview," *Int. J. Cancer*, vol. 149, no. 4, pp. 778–789, Aug. 2021, doi: 10.1002/ijc.33588.
5. Md. Habibullah Talukder, Md Johirul Islam, Md. Mostafa Kamal, Nausheen Laila, and Dr. Md. Shihabuddin, "Hospital Cancer Registry Report, NICRH, Dhaka 2015-2017," 2020, doi: 10.13140/RG.2.2.10796.08320.
6. E. C. Smyth, M. Nilsson, H. I. Grabsch, N. C. Van Grieken, and F. Lordick, "Gastric cancer," *The Lancet*, vol. 396, no. 10251, pp. 635–648, Aug. 2020, doi: 10.1016/S0140-6736(20)31288-5.
7. B. W. Feig, *The MD Anderson Surgical Oncology Handbook*, 6th edition. Wolters Kluwer, 2018.
8. S. Oka *et al.*, "Advantage of endoscopic submucosal dissection compared with EMR for early gastric cancer," *Gastrointest. Endosc.*, vol. 64, no. 6, pp. 877–883, Dec. 2006, doi: 10.1016/j.gie.2006.03.932.
9. Royal College of Nursing, *A framework for adult cancer nursing / RCN.* London: Royal College of Nursing, 2003.
10. R. Seevaratnam *et al.*, "How useful is preoperative imaging for tumor, node, metastasis (TNM) staging of gastric cancer? A meta-analysis," *Gastric Cancer*, vol. 15, no. 1, pp. 3–18, Sep. 2012, doi: 10.1007/s10120-011-0069-6.
11. H. Cho *et al.*, "Long-term Survival Outcomes of Advanced Gastric Cancer Patients Who Achieved a Pathological Complete Response with Neoadjuvant Chemotherapy: A Systematic Review of the Literature," *Ann. Surg. Oncol.*, vol. 22, no. 3, pp. 787–792, Mar. 2015, doi: 10.1245/s10434-014-4084-9.
12. J. A. Ajani *et al.*, "Gastric Cancer, Version 2.2022, NCCN Clinical Practice Guidelines in Oncology," *J. Natl. Compr. Cancer Netw. JNCCN*, vol. 20, no. 2, pp. 167–192, Feb. 2022, doi: 10.6004/jnccn.2022.0008.
13. A. A. Zytoon, S. I. B. El-Atfey, and S. A.-H. Hassanein, "Diagnosis of gastric cancer by MDCT gastrography: diagnostic characteristics and management potential," *Egypt. J. Radiol. Nucl. Med.*, vol. 51, no. 1, p. 30, Dec. 2020, doi: 10.1186/s43055-020-0148-y.
14. J. Chen *et al.*, "Improvement in preoperative staging of gastric adenocarcinoma with positron emission tomography," *Cancer*, vol. 103, no. 11, pp. 2383–2390, Jun. 2005, doi: 10.1002/cncr.21074.
15. R. E. Schwarz, "Factors influencing change of preoperative treatment intent in a gastrointestinal cancer practice," *World J. Surg. Oncol.*, vol. 5, no. 1, p. 32, Dec. 2007, doi: 10.1186/1477-7819-5-32.

16. S. Cieśla *et al.*, "Clinical Significance of Peritoneal Fluid Examination for Free Cancer Cells in Patients Qualified for Surgery for Gastric Cancer," *Front. Surg.*, vol. 8, p. 685868, 2021, doi: 10.3389/fsurg.2021.685868.

17. J. Zhao, H. Zhao, T. Jia, S. Yang, and X. Wang, "Combination of Changes in CEA and CA199 Concentration After Neoadjuvant Chemoradiotherapy Could Predict the Prognosis of Stage II/III Rectal Cancer Patients Receiving Neoadjuvant Chemoradiotherapy Followed by Total Mesorectal Excision," *Cancer Manag. Res.*, vol. Volume 14, pp. 2933–2944, Sep. 2022, doi: 10.2147/CMAR.S377784.

18. J. Y. Seo *et al.*, "Clinicopathologic and molecular features associated with patient age in gastric cancer," *World J. Gastroenterol.*, vol. 21, no. 22, pp. 6905–6913, Jun. 2015, doi: 10.3748/wjg.v21.i22.6905.

19. F. Bray *et al.*, "Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries," *CA. Cancer J. Clin.*, vol. 74, no. 3, pp. 229–263, May 2024, doi: 10.3322/caac.21834.

20. L. Lou *et al.*, "Sex difference in incidence of gastric cancer: an international comparative study based on the Global Burden of Disease Study 2017," *BMJ Open*, vol. 10, no. 1, p. e033323, Jan. 2020, doi: 10.1136/bmjopen-2019-033323.

21. P. Karimi, F. Islami, S. Anandasabapathy, N. D. Freedman, and F. Kamangar, "Gastric cancer: descriptive epidemiology, risk factors, screening, and prevention," *Cancer Epidemiol. Biomark. Prev. Publ. Am. Assoc. Cancer Res. Cosponsored Am. Soc. Prev. Oncol.*, vol. 23, no. 5, pp. 700–713, May 2014, doi: 10.1158/1055-9965.EPI-13-1057.

22. C. A. González and A. Agudo, "Carcinogenesis, prevention and early detection of gastric cancer: where we are and where we should go," *Int. J. Cancer*, vol. 130, no. 4, pp. 745–753, Feb. 2012, doi: 10.1002/ijc.26430.

23. S. Mukkamalla, A. Recio-Boiles, and HM. Babiker, "Gastric Cancer," in *StatPearls*, Treasure Island (FL): StatPearls Publishing, 2023. Accessed: Jan. 01, 2024. [Online]. Available: http://www.ncbi.nlm.nih.gov/books/NBK459142/

24. S. Jamel, S. R. Markar, G. Malietzis, A. Acharya, T. Athanasiou, and G. B. Hanna, "Prognostic significance of peritoneal lavage cytology in staging gastric cancer: systematic review and meta-analysis," *Gastric Cancer Off. J. Int. Gastric Cancer Assoc. Jpn. Gastric Cancer Assoc.*, vol. 21, no. 1, pp. 10–18, Jan. 2018, doi: 10.1007/s10120-017-0749-y.

25. X. Feng *et al.*, "Comparison of Endoscopic Ultrasonography and Multislice Spiral Computed Tomography for the Preoperative Staging of Gastric Cancer - Results of a Single Institution Study of 610 Chinese Patients," *PLoS ONE*, vol. 8, no. 11, p. e78846, Nov. 2013, doi: 10.1371/journal.pone.0078846.

26. L. Sobin, M. Gospodarowicz, and C. Wittekind, *TNM classification of malignant tumours*, 7th ed. New York: John Wiley & Sons, 2009.

27. J. Hur *et al.*, "Diagnostic accuracy of multidetector row computed tomography in T- and N staging of gastric cancer with histopathologic correlation," *J. Comput. Assist. Tomogr.*, vol. 30, no. 3, pp. 372–377, 2006, doi: 10.1097/00004728-200605000-00005.

28. J. W. Kim *et al.*, "Diagnostic performance of 64-section CT using CT gastrography in preoperative T staging of gastric cancer according to 7th edition of AJCC cancer staging manual," *Eur. Radiol.*, vol. 22, no. 3, pp. 654–662, Mar. 2012, doi: 10.1007/s00330-011-2283-3.

29. R. M. Kwee and T. C. Kwee, "Imaging in assessing lymph node status in gastric cancer," *Gastric Cancer Off. J. Int. Gastric Cancer Assoc. Jpn. Gastric Cancer Assoc.*, vol. 12, no. 1, pp. 6–22, 2009, doi: 10.1007/s10120-008-0492-5.

30. J.-I. Choi, "State-of-the-art preoperative staging of gastric cancer by MDCT and magnetic resonance imaging," *World J. Gastroenterol.*, vol. 20, no. 16, p. 4546, 2014, doi: 10.3748/wjg.v20.i16.4546.