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COMPARATIVE ANALYSIS OF COMPUTER TOMOGRAPHIC STAGING AND POSTOPERATIVE PATHOMORPHOLOGICAL STAGING IN STOMACH CANCER

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Abstract

Introduction. Gastric cancer remains one of the leading causes of malignant mortality worldwide and occupies a significant place in the oncological morbidity structure in Kazakhstan. Accurate preoperative assessment of the extent of the disease is essential for choosing the optimal treatment strategy. Computed tomography (CT) is widely used for gastric cancer staging, but its accuracy can vary depending on the stage of the disease, the biological characteristics of the tumor, and the technical parameters of the examination.

Aim. To evaluate the concordance between the results of CT staging and the final pathological conclusion in patients with gastric cancer in the clinical practice of Kazakhstan.

Materials and methods. A retrospective analysis of CT scans was conducted in patients with histologically confirmed gastric cancer referred from various regions of the country and operated on at the National Research Oncology Center. All CT scans were performed before surgery. Staging results were compared with postoperative pathological data. Sensitivity, specificity, accuracy, and the Kappa coefficient of agreement were calculated.

Results. The study included 42 patients. The accuracy of CT based on the T-score ranged from 73.2% (T3) to 95.1% (T4a), with the highest concordance for T4a (κ=0.72). For N-stage, the accuracy was 78.6% (κ=0.46). When assessing M-stage, the overall accuracy reached 87.8%, but the kappa coefficient was negative (κ=–0.06), which is associated with the rarity of M1 detection. The rate of understaging exceeded the rate of overstaging, especially at early stages T1–T2.

Conclusion. CT demonstrates high diagnostic efficacy in assessing late T-stage disease and distant metastases, but its capabilities in early stages and in detecting lymph node metastases are limited. Optimization of protocols and integration of CT with endoscopic ultrasound and staging laparoscopy can improve staging accuracy and clinical outcomes in patients with gastric cancer.

Keywords: *Gastric cancer, computed tomography, staging, accuracy, Kazakhstan.*

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Резюме

СРАВНИТЕЛЬНЫЙ АНАЛИЗ КОМПЬЮТЕРНО-ТОМОГРАФИЧЕСКОГО СТАДИРОВАНИЯ И ПОСЛЕОПЕРАЦИОННОЙ ПАТОМОРФОЛОГИЧЕСКОЙ СТАДИИ ПРИ РАКЕ ЖЕЛУДКА

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Введение. Рак желудка остаётся одной из ведущих причин смертности от злокачественных новообразований во всём мире и занимает значимое место в структуре онкологической заболеваемости Казахстана. Точная предоперационная оценка распространённости процесса необходима для выбора оптимальной тактики лечения. Компьютерная томография (КТ) широко используется для стадирования рака желудка, однако её точность может варьировать в зависимости от стадии заболевания, биологических особенностей опухоли и технических параметров исследования.

Цель. Оценить соответствие между результатами КТ-стадирования и окончательным патоморфологическим заключением у пациентов с раком желудка в условиях клинической практики Казахстана.

Материалы и методы. Проведён ретроспективный анализ КТ-исследований у пациентов с гистологически подтверждённым раком желудка, направленных из различных регионов страны и прооперированных в Национальном научном онкологическом центре. Все КТ выполнялись до хирургического вмешательства. Результаты стадирования сопоставлялись с послеоперационными патоморфологическими данными. Рассчитывались чувствительность, специфичность, точность и коэффициент согласия Каппа.

Результаты. В исследование включены 42 пациента. Точность КТ по Т-критерию варьировала от 73,2% (Т3) до 95,1% (Т4а), с наибольшим уровнем согласия при Т4а (к=0,72). Для N-стадии точность составила 78,6% (к=0,46). При оценке М-стадии общая точность достигала 87,8%, однако коэффициент Каппа был отрицательным (к=–0,06), что связано с редкостью выявления М1. Частота недооценки (understaging) превышала частоту переоценки (overstaging), особенно на ранних стадиях Т1–Т2.

Заключение. КТ демонстрирует высокую диагностическую эффективность при оценке поздних Т-стадий и отдалённых метастазов, однако её возможности при ранних формах и определении лимфогенного метастазирования ограничены. Оптимизация протоколов и интеграция КТ с эндоскопическим ультразвуком и стейджинговой лапароскопией могут повысить точность стадирования и улучшить клинические результаты у пациентов с раком желудка.

Ключевые слова: *рак желудка, компьютерная томография, стадирование, точность, Казахстан.*

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Түйіндеме

АСҚАЗАН ОБЫРЫ КЕЗІНДЕ КОМПЬЮТЕРЛІК ТОМОГРАФИЯ НЕГІЗІНДЕГІ САТЫЛАУ МЕН ОПЕРАЦИЯДАН КЕЙІНГІ ПАТОМОРФОЛОГИЯЛЫҚ САТЫЛАУДЫҢ САЛЫСТЫРМАЛЫ ТАЛДАУЫ

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Кіріспе. Асқазан обыры әлем бойынша қатерлі ісіктерден өлім-жітімнің негізгі себептерінің бірі болып қала береді және Қазақстандағы онкологиялық аурушаңдық құрылымында да айтарлықтай орын алады. Үдерістің таралуын дәл операцияға дейінгі бағалау емдеудің оңтайлы тактикасын таңдау үшін қажет. Компьютерлік томография (КТ) асқазан обырын кезеңдеу үшін кеңінен қолданылады, алайда оның дәлдігі ауру сатысына, ісіктің биологиялық ерекшеліктеріне және зерттеу техникасының параметрлеріне байланысты өзгеруі мүмкін.

Мақсаты. Қазақстандағы клиникалық тәжірибе жағдайында асқазан обыры бар науқастарда КТ арқылы жүргізілген сатылаудың нәтижелерін түпкілікті патоморфологиялық қорытындымен салыстырып, олардың сәйкестігін бағалау.

Материалдар мен тәсілдер. Гистологиялық тұрғыда расталған асқазан обыры бар және елдің әртүрлі өңірлерінен жолданған, Ұлттық ғылыми онкология орталығында ота жасалған науқастардың КТ-зерттеулеріне ретроспективті талдау жүргізілді. Барлық КТ операцияға дейін орындалды. Сатылау нәтижелері отадан кейінгі патоморфологиялық деректермен салыстырылды. Сезімталдық, ерекшелік, дәлдік және Каппа келісім коэффициенті есептелді.

Нәтижелері. Зерттеуге 42 науқас енгізілді. Т-критерий бойынша КТ дәлдігі 73,2% (Т3)-тен 95,1% (Т4а)-ға дейін өзгерді, ең жоғары келісім деңгейі Т4а кезінде байқалды (к=0,72). N-стадия үшін дәлдік 78,6% құрады (к=0,46). М-стадияны бағалауда жалпы дәлдік 87,8%-ға жетті, алайда Каппа коэффициенті теріс болды (к=–0,06), бұл М1 жағдайларының сирек анықталуымен байланысты. Кем бағалау (understaging) жиілігі артық бағалаудан (overstaging) жоғары болды, әсіресе Т1–Т2 ерте сатыларында.

Қорытынды. КТ кеш Т-сатыларын және метастаздарды бағалауда жоғары диагностикалық тиімділікті көрсетеді, алайда оның ерте формаларды және лимфогенді метастазданудыанықтаудағы мүмкіндіктері шектеулі. Протоколдарды оңтайландыру және КТ-ны эндоскопиялық ультрадыбыспен, стейджингтік лапароскопиямен біріктіру стадиялау дәлдігін арттырып, асқазан обыры бар науқастардың клиникалық нәтижелерін жақсарта алады.

Түйінді сөздер. *Асқазан обыры, компьютерлік томография, стадиялау, дәлдік, Қазақстан.*

Дәйексөз үшін:

Сапаев М.Н., Байнаева Б.С., Джакипов М.А., Кожахметов А.М., Мамлин М.А., Керимкулов А.К., Усипбеков Б.Н., Болсынбекова С.О., Манатова А.М., Буркитбаев Ж.К. Асқазан обыры кезінде компьютерлік томография негізіндегі сатылау мен операциядан кейінгі патоморфологиялық сатылаудың салыстырмалы талдау // Ғылым және Денсаулық сақтау. 2025. Vol.27 (5), Б. 56-62. *doi 10.34689/SH.2025.27.5.007*

Introduction

Gastric cancer is one of the leading causes of cancer-related mortality worldwide, ranking fourth among causes of death from malignant neoplasms and fifth among all cancers [1]. Although advances in multimodal management, particularly the introduction of neoadjuvant and adjuvant chemotherapy, have improved outcomes, the overall 5-year survival remains limited at approximately 35–45% [2]. Accurate clinical staging is essential for treatment planning, prognosis assessment, and optimizing healthcare resources. In particular, computed tomography (CT) has become the most widely used imaging modality for preoperative staging of gastric cancer. Contrast-enhanced computed tomography (CT) remains the primary imaging modality for initial assessment of the tumor (T), nodal (N), and metastatic (M) status. One of the major radiologic challenges is achieving precise TNM staging to minimize the likelihood of under- or overstaging [3]. Therefore, evaluating the concordance between CT staging and final pathological findings is of major clinical importance.

In Kazakhstan, gastric cancer ranks among the top four most common cancers, accounting for 7.4% of all new cases, and remains the second leading cause of cancer mortality (12.0%), after lung cancer (16.3%) [4]. Despite advances in oncology care, the proportion of patients diagnosed at advanced stages (III–IV) remains high, which negatively affects survival outcomes and increases the burden on the healthcare system. For example, regional disparities in early detection rates are observed: in the Aktobe, Atyrau, and Turkestan regions, early diagnosis remains below 20%, far behind national targets [4]. This reflects persistent difficulties in timely identification of gastric cancer cases, which directly influences the reliability of preoperative staging.

Computed tomography (CT), particularly multidetector scan (MDCT), plays a key role in preoperative staging of gastric cancer. High-quality thin-slice CT with water filling allows for the reliable detection of advanced forms of the disease, assessment of the depth of invasion, and visualization of the histological features of the tumor, including the mucinous component and the degree of infiltration. However, this method has limitations such as difficulties in visualizing flat mucosal cancer and differentiating between stages T2 and T3 [5].

To improve the accuracy of clinical staging, a combination of imaging techniques is used. Endoscopic ultrasound has traditionally been considered the "gold standard" for assessing T and N parameters, but the role of CT has expanded significantly: it is used both to detect distant metastases and to clarify the local stage. Magnetic resonance imaging provides high soft tissue contrast and is sensitive to small foci in the liver, while positron emission tomography is effective in detecting lymph node metastases and peritoneal carcinomatosis. The integration of multiple methods improves the accuracy of TNM staging and optimizes treatment strategies [6].

However, in Kazakhstan, the diagnostic performance of CT may be affected by several factors, including heterogeneous equipment quality, variability in protocols, and unequal regional access to advanced imaging technologies. These limitations contribute to discrepancies between CT-based staging and postoperative pathological findings. Such discrepancies may lead to suboptimal treatment decisions, highlighting the need for systematic evaluation of CT accuracy in local practice. Thus, the aim of this study is to assess the concordance between CT staging results and final pathological findings in patients with gastric cancer in Kazakhstan.

Materials and methods:

Study design and population

A retrospective single-center study was conducted at the National Research Oncology Center (NROC, Astana, Kazakhstan) between January 2024 and August 2025. The study included patients with pathologically confirmed gastric adenocarcinoma who had undergone CT scans of the chest and abdomen prior to treatment and had available postoperative pathology reports. Patients were excluded from the analysis if reliable histological data were not available, if CT scans were performed without intravenous contrast, or if the contrast agent administration technique was improper.

Visualization methods

Computed tomography was performed using 16-, 64-, and 128-slice scanners. The reconstructed slice thickness was 1–3 mm. Oral contrast was used sparingly, primarily to improve visualization of the gastric lumen.

Staging assessment

CT images were interpreted by blinded radiologists at the Scientific Research Center of Cancer Research. Tumor staging was performed according to the TNM classification (8th edition, AJCC, 2017). The CT staging results were compared with the final postoperative pathology report.

Statistical analysis

To evaluate the diagnostic efficacy of CT, sensitivity, specificity, overall accuracy, and the kappa agreement coefficient (κ) were calculated. Statistical processing was performed using SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Values of $p < 0.05$ were considered statistically significant.

Results

The study included 42 patients with verified gastric adenocarcinoma. The average age was 56 years (range, 38-74 years), with a predominance of men (71.4%). According to the final pathological report, the majority of patients were at stage III of the disease (47.6%), while stages I and II were detected less frequently (14.3% and 26.2%, respectively), and stage IV was recorded in 11.9% of patients (Table 1). All patients underwent preoperative computed tomography of the abdominal organs with intravenous contrast, the results of which were compared with postoperative histological data.

Table 1.

General characteristics of patients.

Variable	n=42
Average age (years)	56
Men	30 (71.4%)
Women	12 (28.6%)
Stage I	6 (14.3%)
Stage II	11 (26.2%)
Stage III	20 (47.6%)
Stage IV	5 (11.9%)

The analysis showed that the overall concordance between clinical CT staging and pathological results was

65.8% for the T parameter, 60.9% for the N parameter, and 87.8% for the M parameter (Table 2). CT demonstrated the highest diagnostic accuracy in detecting distant metastases, owing to the method's high sensitivity for liver, lung, and peritoneal lesions. However, the kappa agreement coefficient was low, which is explained by a significant sample imbalance: the vast majority of patients had stage M0, while M1 cases were rare. Thus, the high concordance rate is primarily due to the sample structure, rather than solely to the method's performance.

Table 2.

Diagnostic efficacy of CT in staging gastric cancer.

Stage	Sensitivity	Specificity	Accuracy	Kappa
T1	00.0	92.5	90.2	-0.038
T2	33.3	94.3	85.4	0.32
T3	73.3	72.7	73.2	0.40
T4a	75.0	97.3	95.1	0.72
T4b	—	87.8	87.8	00.0
N0	63.6%	83.9%	78.6%	0.47
N1	60.0%	74.1%	69.0%	0.38
N2	66.7%	90.0%	83.3%	0.56
N3	25.0%	94.7%	88.1%	0.15
M0	94.74	0.00	87.80	-0.062
M1	0.00	94.74	87.80	-0.062

When analyzing the accuracy of CT in determining the depth of invasion (T-stage), significant differences were revealed. The most reliable results were achieved for T4a diagnosis, where sensitivity and specificity were high, and the level of concordance with pathology was the most significant (κ = 0.72). At the same time, the greatest difficulties were observed in assessing early stages. For T1 tumors, sensitivity was 0%, indicating the limited ability of CT to detect superficial forms of the disease. For T2 tumors, a tendency to underestimate the depth of invasion was also observed, while for T3 tumors, in contrast, cases of both overestimation and underestimation of the stage were recorded. Overall, this reflects the difficulty of differentiating between adjacent stages, especially in infiltrative tumor growth.

CT demonstrated moderate accuracy in assessing regional lymph node involvement (N stage). The highest results were obtained for N2 (sensitivity 66.7%, specificity 90.0%, accuracy 83.3% (κ = 0.56)), whereas both false-positive and false-negative results were observed for N0 and N1. The greatest difficulties arose in determining the N3 stage, where diagnostic sensitivity was minimal. These results indicate that CT's capabilities in assessing lymph node metastasis remain limited, particularly in the presence of micrometastases that cannot be visualized by this method.

Thus, the study demonstrated that CT remains highly informative in detecting distant metastases and is relatively reliable in diagnosing widespread forms of local invasion (T4a). However, the method's accuracy significantly decreases when assessing early stages and lymph node metastases, confirming the need for a comprehensive approach to staging that includes additional imaging techniques and morphological verification.

Discussion

Staging gastric cancer using computed tomography (CT) remains one of the most challenging tasks in clinical oncology. Its accuracy is determined by many factors, including tumor morphological features, standardization of imaging protocols, and the experience of specialists [7]. These problems are particularly relevant for developing countries, where the proportion of patients with locally advanced tumors at the time of presentation remains high and diagnostic capabilities are limited [8]. Our study adds new evidence from Kazakhstan, where CT staging has not been systematically validated against pathology despite the high national burden of gastric cancer. This local context is important, because healthcare systems with limited access to advanced imaging technologies face unique challenges in ensuring staging accuracy.

Our study demonstrated that the accuracy of CT depends on the stage of the disease. The most pronounced limitations of the method are associated with early stages (T1–T2). Not a single T1 case was correctly identified, which confirms the literature data on the extremely low sensitivity of CT in detecting tumors limited to the mucosa and submucosa [9, 10]. Even at T2, accuracy remained limited and concordance with histology was poor, which is explained by the difficulty in differentiating between T2 and T3, where inflammatory or fibrotic changes can mimic tumor invasion. These results are consistent with the work of *Yan C. et al.* (2009) *and Makino T. et al.* (2011), who showed similar difficulties in distinguishing adjacent stages [11, 12].

Unlike early forms, CT has demonstrated high diagnostic value in late stages. For T4a, high sensitivity and specificity were achieved, comparable to data from international studies [8, 12]. Visualization of signs of serous invasion, such as irregularity of the serous surface or the presence of ascites, makes the method particularly useful for surgical planning. These findings are of practical importance, as the extent of surgery is determined at stage T4a. In T4b, CT also demonstrated high specificity, which is critical for assessing tumor resectability. Thus, CT remains an indispensable tool for identifying advanced forms of the disease, although its role in early diagnosis remains limited.

A similar situation is observed in the assessment of regional lymph node metastasis. In our study, the diagnostic accuracy of the N stage was 60.9%, which is consistent with the results of *Gundavda K. et al. (*2025), who reported a range of 60.8–63.7% [13]. The classical criteria—the size and morphological structure of the lymph nodes—proved to be insufficiently reliable, which is confirmed by earlier data [14, 15, 16]. Enlarged lymph nodes can be caused by inflammation, while normal-sized nodes may contain

micrometastases, significantly reducing the accuracy of staging. Currently, there are no generally accepted CT criteria for characterizing a lymph node as malignant, including size, round shape, central necrosis, enhancement, and clustering of 3 or more lymph nodes [17]. This highlights the need to develop new assessment criteria, including functional and textural parameters, as well as the combined use of CT with endoscopic ultrasound or PET/CT.

The determination of the M stage deserves special attention. CT has traditionally demonstrated high accuracy in detecting distant metastases in the liver and lungs, which is confirmed by our results (accuracy of 87.8%). However, the method remains insufficiently sensitive to small peritoneal implants. In our sample, three patients were misclassified as M0, although peritoneal metastases were histologically confirmed. This result is consistent with the data of *Zviniene K. et al.* (2015), who also noted a decrease in the sensitivity of CT in carcinomatosis, especially in cases of minimal implants [18]. The presence of ascites, as shown by the works of *Choi K. et al.* (2018) and *Xu M. et al. (*2024), can serve as an indirect predictor of carcinomatosis, but even in this case the accuracy of the method remains limited [19, 20]. In clinical practice, in such situations, the use of PET/CT or diagnostic laparoscopy is justified, which allows for increased detection of hidden metastases.

Thus, the results of our study confirm the strengths and limitations of CT staging. The method is highly accurate in diagnosing late stages (T4 and M0), but its capabilities in early stages and lymph node assessment are limited. The main problem remains the tendency to underestimate the stage, which can lead to suboptimal treatment decisions. To improve the informativeness of staging, standardization of CT protocols, the implementation of new technologies, and the integration of CT with other imaging modalities and morphological verification are necessary.

Limitations of our study include its retrospective design, small sample size, and single-center nature, which limit the generalizability of our findings. However, the findings are consistent with the results of international studies and highlight the need for prospective, multicenter projects. Looking ahead, a combined approach including CT, EUS, MRI, and laparoscopy appears to be the most rational for optimizing gastric cancer staging, particularly in resource-limited settings.

Conclusion

Computed tomography remains a reliable method for assessing advanced gastric cancer, particularly stage T4, where the results directly influence the extent of surgical intervention. However, its diagnostic accuracy is significantly reduced in early stages and in detecting regional metastases, requiring careful interpretation of data and mandatory combination with other imaging modalities. A promising direction is the standardization of CT protocols, as well as the integration of this method with endoscopic ultrasound, PET/CT, and laparoscopy, which will improve staging accuracy and clinical outcomes, even in resource-limited settings.

Ethical approval

The study was approved by the Institutional Review Board of the National Cancer Research Center. The institutional review board waived the requirement for written informed consent because this retrospective study was conducted using anonymized data obtained from the hospital's electronic medical records and physical examination database.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors' contributions

All authors have made equal contributions to this publication. The conception and design of the study, data collection and analysis, statistical processing, writing, and critical revision of the manuscript were performed collaboratively by all authors. All authors read and approved the final version of the manuscript.

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Data Accessibility Statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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