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The Capabilities of Ultrasound Diagnosis in Assessment of Gastric Carcinoma of Different Localization and Stage

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Abstract: *Objective:* To evaluate the diagnostic possibilities of transabdominal ultrasonography for various localizations of gastric carcinoma (GC). *Materials and Methods:* The study included 101 patient with GC, the stage T1 in 5, the stage of T2 – in 12, the stage of T3 – in 39 and the stage of T4 – in 45 cases respectively. The stomach tumor in 37 (36.6%) cases was localized mainly in the antrum, 35 (34.6%) – in the body, 12 (11.9%) in the cardia and fundus, in 13 (12.9%) cases it had a total, in 4 (4.0%) - subtotal character. Ulcerating infiltrating forms (UIF) of GC was diagnosed in 71 cases, diffuse infiltrating forms (DIF) in 23 cases. All patients underwent preoperative X-ray, virtual gastroscopy techniques, multidetector computed tomography and transabdominal ultrasonography (USG). *Results:* The intestinal histological form of GC was detected in 7 cases – with USG in 6 cases. The UIF of GC with the help of USG was diagnosed in 69 (97,2%) cases, DIF – in 23 (100%) cases of T2-T4 stages. The results of USG and CT was coincided in all cases of T3 and in 92,7% of T4 stages of GC. *Conclusions:* The combined use of ultrasonography and gastroscopy will increase the detection of early intestinal type of GC. USG is the best, cheap, independent method for diagnosing a diffusely infiltrative form of GC, especially of the antrum. At stage T3, he is not inferior to CT in assessing the localization and prevalence of GC, and at stage T4, the difference between them is negligible.

Keywords: Gastric Carcinoma, Localization, Transabdominal Ultrasonography

1. Introduction

Gastric carcinoma (GC) is the fourth most common cancer worldwide and the second most common cause of cancer-related death. Though a marked reduction has been observed in the incidence of gastric carcinoma in North America and Western Europe in the last 50 years, 5-year survival rates are less than 20%, as most patients present late and are unsuitable for curative, radical surgery. That is an aggressive carcinoma with 5-year survival rates ranging from 3% in the case of stage IV tumors to 85–90% in the case of stage I tumors. The most commonly used staging system for GC was developed by the American Joint Committee on Cancer (AJCC) [1, 2].

The occurrence of GCs in the stomach is relatively evenly distributed with 30% occurring in the antrum, 30% in the body and 40% in the fundus and cardia. Gastric adenocarcinoma has shown a marked decline in the last decades. Nevertheless, there seems to be an increase in carcinomas localized to the cardia, especially in younger women and older men [3]. However, other studies have failed to demonstrate such an increase [4, 5].

Adenocarcinomas account for 95% of all GCs. Most GCs are polypoid or ulcerated. Based on the level of invasion, GCs are divided into early gastric cancer and advanced gastric cancer. EGC or the superficial form is limited to the mucosa and submucosa, regardless of the presence or absence of lymph

node metastases and can appear as a small circumscribed, sometimes ulcerated thickening of the gastric wall. AGC involves the muscularis propria or beyond and can be polypoid, ulcerating, ulcerating infiltrating and diffusely infiltrating. Histologically, GC is usually classified into intestinal or diffuse histologic forms. The intestinal type is presumed to arise from intestinalized gastric mucosa and they are usually nodular, polypoid, or fungating. The diffuse type is grossly ill defined and may have the appearance of a plaque or linitis plastica [6].

Diagnosis of stomach cancer in the early stages makes survival very favorable. In most cases, because of the absence of specific symptoms, patients consult a doctor at inoperable stages with a locally advanced or metastatic lesion. It is known that surgical removal of the tumor remains the only way available and depending on the stage of the disease. The stage of the tumor is determined by the degree of invasion of the stomach wall, spreading to the lymph nodes and the presence of distal metastases of the organs.

For a long time, fibrogastroscopy and x-ray of the stomach with double contrast were the main methods of diagnosing stomach cancer. With the introduction of computer tomography, it became possible to determine the degree of invasion of the tumor process. C. Y. Chen et al. (2007), on the basis of revealing the thickening of the wall of the stomach and "strengthening" the image of its layers, claim that the accuracy of their diagnosis in determining early gastric cancer is 96% [7]. S. Kumano et al. (2007) indicate the possibility of computed tomography in the diagnosis of directly tumor wall infiltration of the stomach [8].

Upper gastrointestinal endoscopy is the preferred technique for detection of GC which is also useful in obtaining histological confirmation of suspicious gastric lesions. However, up to 6.7% of GCs may be missed when an endoscopy shows no initial cancer findings [9]. Imaging techniques are useful for staging the already detected GC but can also occasionally detect unsuspected cancers. Routine clinical ultrasonography can detect liver metastases; however, its use for detection and overall staging of GC is limited as the gastric wall cannot be evaluated adequately except in dedicated research studies. Several studies have reported accuracy up to 90% or more with multidetector computed tomography (MDCT) for detection of GC with the use of multiplanar reconstruction (MPR) and virtual gastroscopy techniques [10, 11]. However, MDCT detection of early gastric cancer is

moderate with accuracies ranging from 44% to 70% [12].

Currently, ultrasonography for the study of the stomach is not yet used in connection with a skeptical attitude to the possibilities of the method. However, in separate publications, the role of transabdominal ultrasonography in the visualization of the stomach walls, the differentiation of wall layers and the diagnosis of adenocarcinoma of the antrum by gastric cancer is shown [13-15].

Objective: To evaluate the diagnostic possibilities of transabdominal ultrasonography for various localizations of gastric cancer.

2. Materials and Methods

An analysis of transabdominal ultrasonography of one hundred and one patients with gastric carcinoma was performed. Sixty-nine cases were males (mean age 56.4 years) and thirty two females (mean age 59.3 years). All patients were on surgical treatment at the Kharkov Regional Oncology Center (Ukraine).

Histologically, in 97 (96%) cases adenocarcinoma, in 4 (4%) – ring-cell carcinoma (cricoidal) gastric cancer was established. In 5 (5%) cases early gastric cancer (EGC) and in 96 (95%) advanced gastric cancer (AGC) was diagnosed. Intestinal histologic forms in 7 (6,9%) cases, diffuse forms – in 94 (93,1%) was diagnosed. Among the advanced gastric cancer ulcerating infiltrating forms in 71 cases and diffusely infiltrating – in 23 cases was diagnosed.

According to the classification of the American Joint Committee on Cancer (AJCC) [2], the stage T1 of gastric cancer in 5 cases, the stage of T2 – in 12 cases, the stage of T3 – in 39 cases and the stage of T4 – in 45 cases were identified. The stomach tumor in 37 (36.6%) cases was localized mainly in the antrum, 35 (34.6%) – in the body, 12 (11.9%) in the cardia, in 13 (12.9%) cases it had a total, in 4 (4.0%) – subtotal character. In 28 cases pylorostenosis and in 7 cases – the stenosis of abdominal part of esophagus was diagnosed (table 1).

All patients underwent preoperative X-ray, virtual gastroscopy techniques and multidetector computed tomography with the use of multiplanar reconstruction.

Normal ultrasound semiotics was studied in 36 patients without gastric pathology. Ultrasound was carried out in the frequency range 4-7 MHz in B and color Doppler in the patient's position lying on his back, on his side, standing, on an empty stomach and after filling 500 ml with warm boiled water.

Table 1. Localization and stage of gastric cancer.

Stage of carcinoma	Antrum 37 (36,6±4,8%)	Body 35 (34,6±4,7%)	Cardia and fundus 12 (11,9±3,2%)	Total and subtotal 17 (16,9±3,7%)
T1	3 (3,0±1,7%)	1 (1,0±1,0%)	1 (1,0±1,0%)	–
T2	6 (5,9±2,3%)	4 (3,9±1,9%)	2 (2,0±1,4%)	–
T3	17 (16,8±3,7%)	18 (17,8±3,8%)	4 (3,9±1,9%)	–
T4	11 (10,9±3,1%)	12 (11,9±3,2%)	5 (5,0±2,2%)	17 (16,9±3,7%)

3. Results

After contrasting, the unchanged stomach wall has a layered structure 2.5 mm thick in the body, up to 4-5 mm in the

antrum. In the anterior wall of the abdominal part of the esophagus, there is also a false "thickening" caused by projection distortion. At the time of peristaltic waves, there is also a thickening of the wall, which disappears after a few seconds. The layered structure of the stomach in the antrum

and the body was noted in all cases. In the fundus and greater curvature, due to the projection distortion and the depth of the object's location, the layers of the stomach wall were not differentiated, at the same time there was no local thickening (Figures 1, 2).

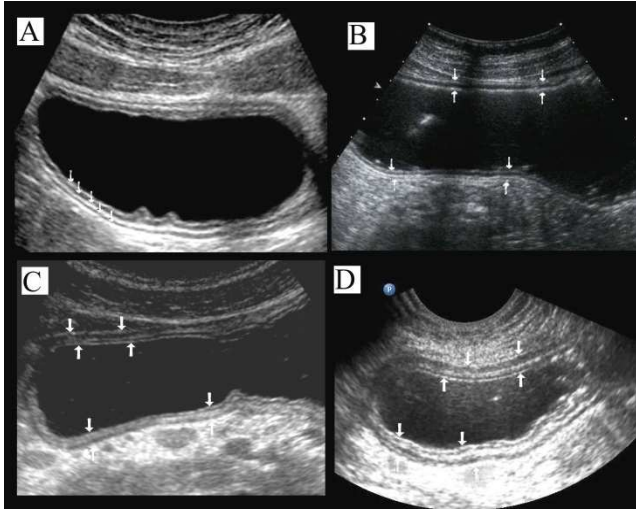


Figure 1. Ultrasonogram of the stomach for various projections of scanning and degree of filling. A – the arrows show all layers of the stomach wall at the body level in the transverse section; B - at the level of the small and greater curvature in the longitudinal section; C - at the antrum; D - with partial emptying. All layers of the stomach wall are clearly differentiated.

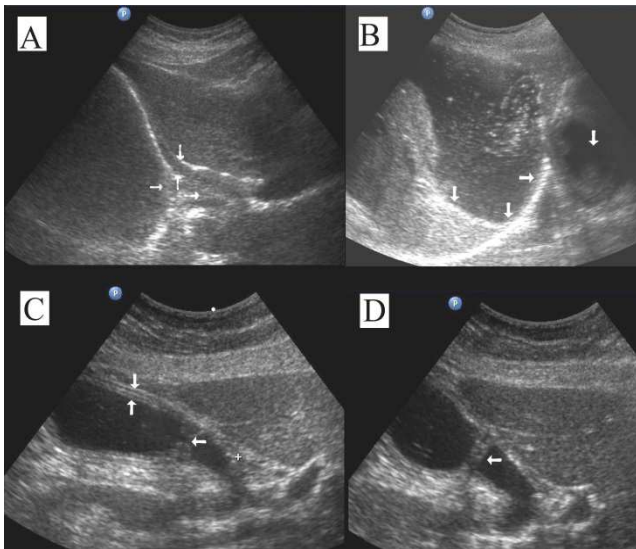


Figure 2. Ultrasonography of the cardia and atrium. A – Vertical arrows show the mucosa of the walls of the abdominal part of the esophagus, vertical - a false projection thickening of its anterior wall; B – The left three arrows show the fundus of the stomach, the right one - the left ventricle of the heart with papillary muscles; C – The vertical arrows show the anterior wall of the antrum; the horizontal arrows – pyloric, which is not fully open; D – the same, pyloric is closed.

To identify areas suspected of hyperplastic process in the stomach, the following echographic symptoms were used:

1. presence of parietal formations protruding into the cavity

2. deterioration or absence of differentiation of the layers of the stomach wall;
3. local thickening of the stomach wall more than 6 mm;
4. local reduction or absence of peristaltic waves;
5. if there is a peptic ulcer presence of color vascular signals;
6. The location and extent of the thickened wall of the stomach were determined.

The intestinal histological form of gastric cancer was detected in 7 cases (Table 2). At the same time, this group did not include cases when the exophyte component of the diffusely infiltrative form of the carcinoma of the stomach was formed in the late stages of the tumor process. In 3 cases, the early cancer of the antrum was first detected ultrasonographically and in 2 cases endoscopically in the body and fundus of the stomach. On the echogram, the tumor was visualized as a polypoid formation on a wide base above the gastric mucosa of a non-uniform structure, a rough surface, less than 15 mm in length and 3-7 mm in thickness (Figure 3). In one case, a small tumor (7x3 mm) on a large curvature was not detected ultrasonographically. In two cases, the intestinal form of stomach cancer had a second stage, in one case - the third stage of the tumor process (Figures 4, 5).

Table 2. Ultrasonographic and Gastroscopic diagnosis of intestinal forms of gastric canceromas.

Stage of carcinoma	Intestinal forms (n=7)	
	Ultrasonography	Gastroscopy
T1	3 (3,0±1,7%)	4 (1,0±1,0%)
T2	2 (5,9±2,3%)	2 (3,9±1,9%)
T3	1 (16,8±3,7%)	1 (17,8±3,8%)
T4	-	-

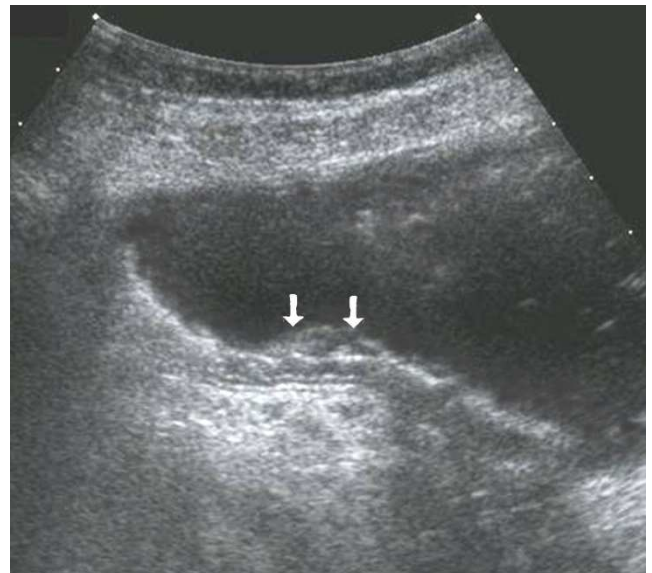


Figure 3. Early gastric carcinoma of intestinal – exophytic form (arrows). On the posterior wall of the antrum, polypoid formation is visualized on a wide base.

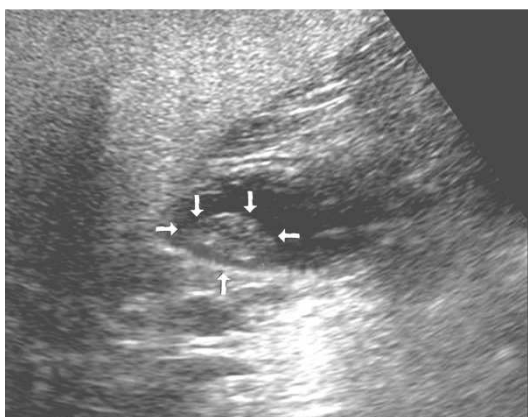


Figure 4. The intestinal – exophytic form of gastric carcinomas for T2 stage. On the posterior wall of the antrum, small polypoid formation, with the not a clear contour, intermittent mucosal membrane image is visualized (arrows). Lower arrow shows the integrity of the serosa.

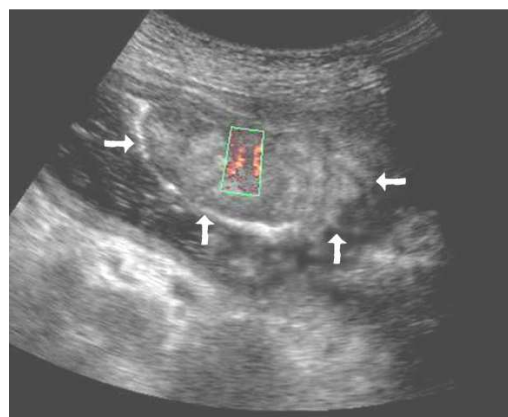


Figure 5. The intestinal – exophytic form of gastric carcinomas for T3 stage. On the anterior wall of the stomach body, large polypoid formation, with the rough contour, intermittent mucosal and absence of serous membrane image is visualized (arrows). Inside the formation, increased blood flow is recorded in color Doppler mode.

Table 3. Ultrasonographic and Gastroscopic diagnosis of different histological forms and stage of gastric carcinomas.

Stage of carcinomas	Diffuse forms (n=94)			
	Ulcerating infiltrating forms (n=71)		Diffuse infiltrating forms (n=23)	
	Ultrasonography	Gastroscopy	Ultrasonography	Gastroscopy
T1 (n=1)	-	1 (1,4±1,4%)	-	-
T2 (n=10)	5 (7,0±3,0%)	6 (8,4±3,1%)	4 (17,4±7,9%)	-
T3 (n=38)	30 (42,3±5,9%)	30 (42,3±5,9%)	8 (34,8±9,9%)	8 (34,8±9,9%)
T4 (n=45)	34 (47,9±5,9%)	29 (40,8±5,7%)	11 (47,8±10,4%)	9 (39,1±10,2%)

In 94 cases, progressive gastric carcinoma was recorded – among them in 71 cases - ulcerative infiltrative, in 23 cases - diffuse infiltrative form. We compared the possibilities of ultrasonography and gastroscopy in the diagnosis of these forms of carcinoma (Table 3). T1 stage of carcinoma was recorded in one case and diagnosed gastroscopically. T2 stage of diffuse carcinoma was recorded in 10 cases – among them 6 cases of ulcerating infiltrating forms and 4 cases of diffuse infiltrating forms. Gastroscopically diagnosis was established in all 6 cases of ulcerating infiltrating forms of gastric carcinomas, but ultrasonographically – in 5 cases. T2 stage of diffuse carcinoma was recorded gastroscopically in one case, ultrasonographically – in 3 cases.

In two cases, the thickness of the wall varied within 6-8 mm, the length of the affected area from 12 to 18 mm, the mucosa, the muscle and serous layers are differentiated (Figures 6, 7). There was a decrease in the amplitude of the peristalsis of the affected area. Endoscopically, there were no obvious changes on the mucous membrane. After histological examination of the biopsy material, adenocarcinoma was established. In one case, endoscopically on the anterior wall of the stomach revealed a superficially ulcerating changes on the mucosa with a length of about 3 cm. Ultrasonographically, there was a local thickening of the stomach wall up to 8 mm, the length of the affected area about 32 mm. The serous membrane was intact. Histological diagnosis of adenocarcinoma of the stomach and the second stage is established (Figure 8). In one case, ultrasonographically on

the posterior wall of the stomach revealed a thickening of the wall up to 1,09 cm with the length of the affected area until 6,89 cm. Endoscopically, there were no obvious changes on the mucous membrane. The serous membrane was intact. Histological diagnosis of adenocarcinoma of the stomach and the second stage is established (Figure 9).

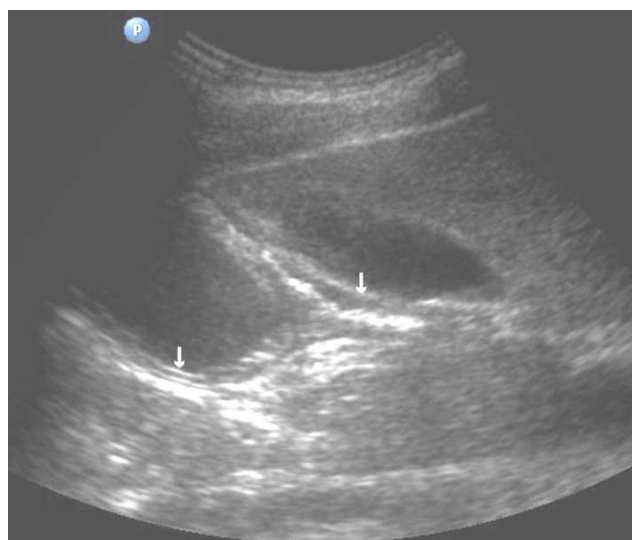


Figure 6. The gastric carcinoma of diffuse form. An area with a local thickening up to 6 mm, a length of about 15 mm, is visualized on the anterior wall of the antrum (upper arrow). Mucous, muscular and serous membranes are differentiated. The lower arrow shows a clear differentiation of all layers of the posterior wall of the intact antrum.

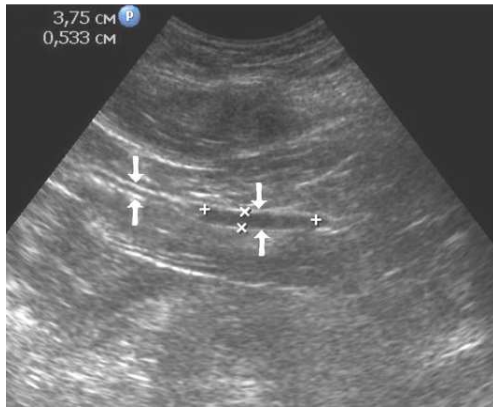


Figure 7. The gastric carcinoma of diffuse form. An area with a local thickening up to 5 mm, a length of about 37 mm, is visualized on the anterior wall of the stomach. The left arrows show the differentiated intact wall layers, the right arrows – local thickening hypoechoic of the anterior wall. Mucous, muscular and serous membranes are differentiated.

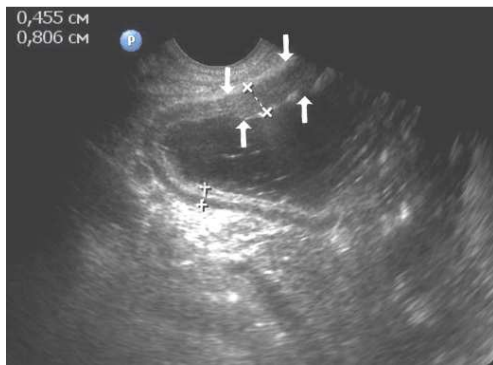


Figure 8. The gastric carcinoma of diffuse form. The region with a local thickening up to 8 mm, a length of about 32 mm, is visualized on the anterior wall of the stomach. The thickening of intact posterior wall is 0,455 cm, the all layers are differentiated well. The upper arrows show the intact serosa and the lower arrows – intermittent imaging of the mucosa.

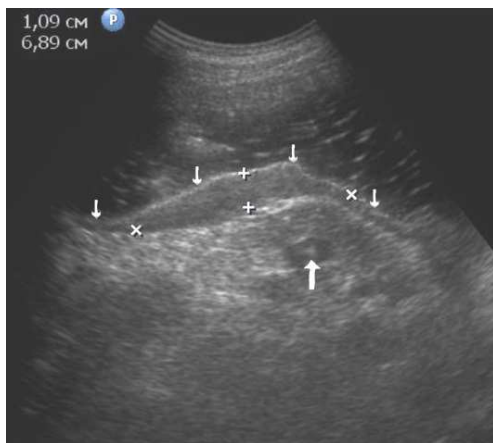


Figure 9. The gastric carcinoma of diffuse form. An area with a local thickening up to 1,09 cm, a length of about 6,89 cm, is visualized on the posterior wall of the stomach (arrows). The lower arrow shows the lymphatic node.

In two cases, superficial ulceration on the mucosa was primarily endoscopically detected on the anterior wall of the cardia and in the fundus of the stomach. At a biopsy the adenocarcinoma is established. The thickness and extent of

the affected wall are determined echographically. The serous membrane was intact. The second stage of gastric carcinoma is established (Figures 10, 11). In 59 cases of a ulcerative infiltrative form of gastric carcinoma of T3 and T4 stages the gastroscopic and ultrasonographic diagnoses was coincided (Figures 12–14). In 5 cases of gastric carcinomas of ulcerative infiltrative form and in 2 cases of a diffuse infiltrative form of the fourth stage of the tumor, due to stenosis of the esophagus, gastroscopy was not performed (Figure 15). In three cases of a diffuse infiltrative form of gastric cancer of T3 and T4 stages, a large exophytic component of the tumor was recorded, which is not related to the intestinal type (Figure 16).



Figure 10. The gastric carcinoma of the cardia of diffuse form. The horizontal arrows show the thickening (1,16 cm) anterior wall of the stomach cardia. The vertical arrows show the intact abdominal esophagus with well differentiated layers.

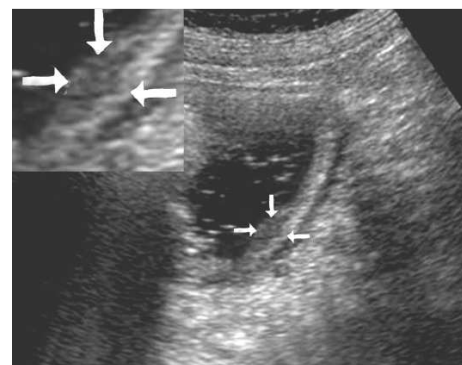


Figure 11. The gastric carcinoma of the fundus. The tumor primarily was detected endoscopically. On the echogram the left arrows show a small hypoechoic formation in the fundus of the stomach. The right arrow show the intact serous membrane.

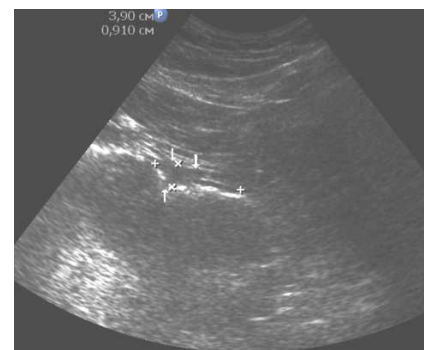


Figure 12. Gastric carcinomas of ulcerating infiltrating forms in the anterior wall of the stomach body of stage T3.

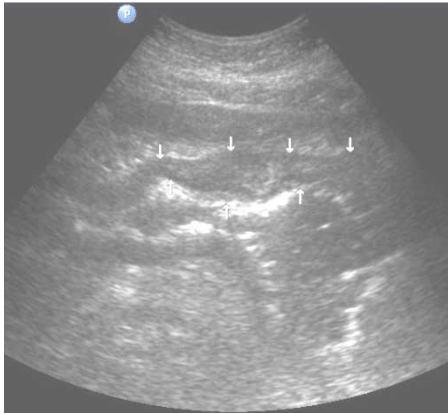


Figure 13. Gastric carcinomas of ulcerating infiltrating forms in the lesser curvature of the stomach of stage T3.

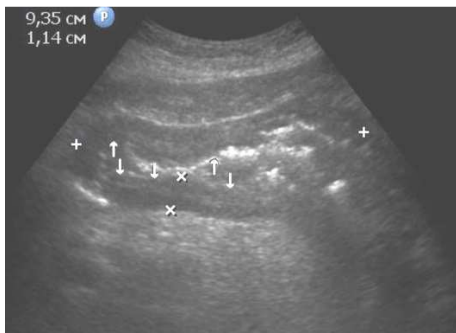


Figure 14. Gastric carcinomas of ulcerating infiltrating forms in the antrum and anterior wall of the body of stage T3.

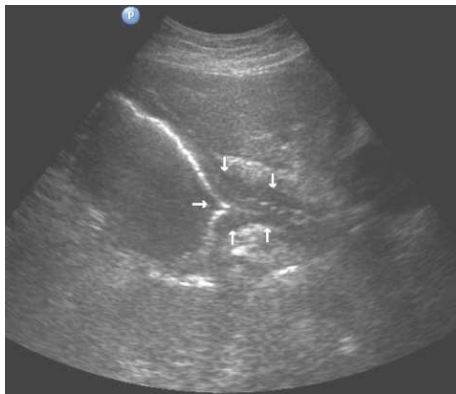


Figure 15. Gastric carcinoma of the cardia with the expansive to the esophagus. Severe stenosis of the abdominal part of the esophagus (arrow).

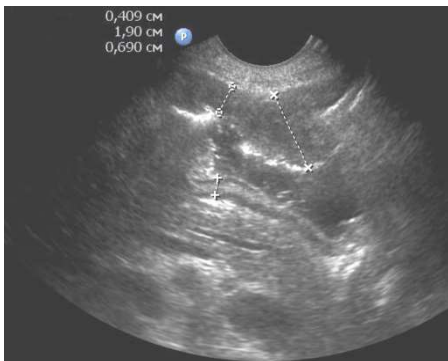


Figure 16. Exophytic component of the diffuse infiltrating form of gastric carcinoma of the anterior wall.

The results of ultrasonography and computed tomography are compared in the evaluation of localization, prevalence, and distant manifestations of gastric carcinoma. Both methods were used in 3 cases of gastric carcinoma stage of T1, in 7 cases of T2, in 36 cases of T3 and in 41 cases of T4 (Table 4). In two cases, the intestinal type of carcinomas was diagnosed by both methods, and in one case, superficial ulceration was not determined. Diagnosis of carcinoma was carried out only gastroscopically. In one case, the localization of carcinoma in the region of the stomach bottom ultrasonographically and tomographically the tumor was not visualized. In the other case, in the antrum the layers of the stomach wall were not differentiated at CT. At the third stage of the carcinoma of the stomach, the results of ultrasonography and computed tomography fully coincided (Figure 17 – 24).

Table 4. Comparison of results of ultrasonography and computed tomography in the diagnosis of gastric carcinoma.

Stage of gastric carcinoma	Ultrasonography	Computed tomography
T1 (n=3)	2 (66,7±27,2%)	2 (66,7±27,2%)
T2 (n=7)	6 (85,7±13,2%)	5 (71,4±17,1%)
T3 (n=36)	36 (100,0±1,7%)	36 (100,0±1,7%)
T4 (n=41)	38 (92,7±4,1%)	41 (100,0±1,6%)



Figure 17. T3N2M1 - visualization of gastric carcinoma of cardia with computer tomography.

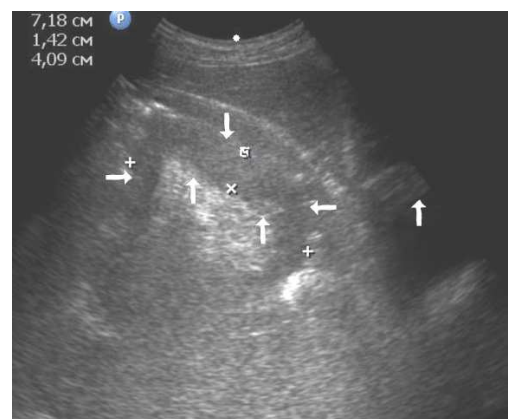


Figure 18. T3N2M1 - visualization of gastric carcinoma of cardia ultrasonographically. Left arrows show the carcinoma, right arrow shows the interventricular septum.

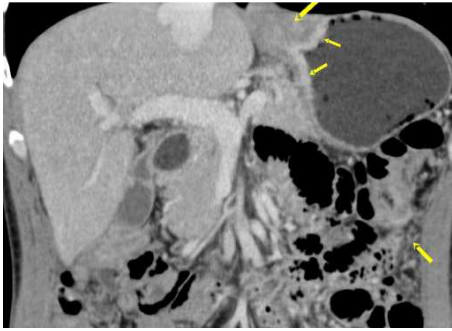


Figure 19. T3N2MO - visualization of gastric carcinoma of antrum with computer tomography. Pyloric stenosis.

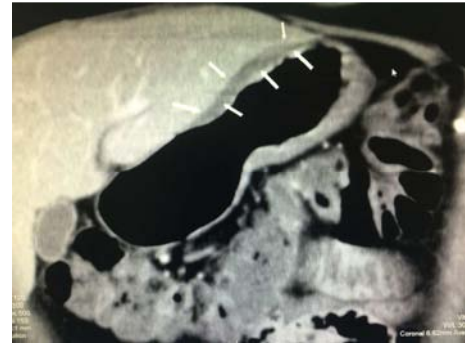


Figure 23. T4N3M1 - visualization of gastric carcinoma of body of diffuse infiltrative type with computer tomography (arrows). Tumor invasion of the liver.

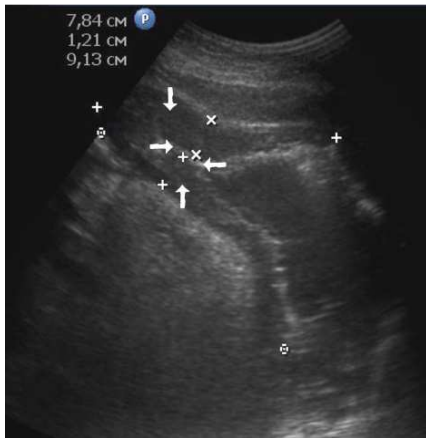


Figure 20. T3N2MO - visualization of gastric carcinoma of antrum ultrasonographycalli. Pyloric stenosis (horizontal arrows).

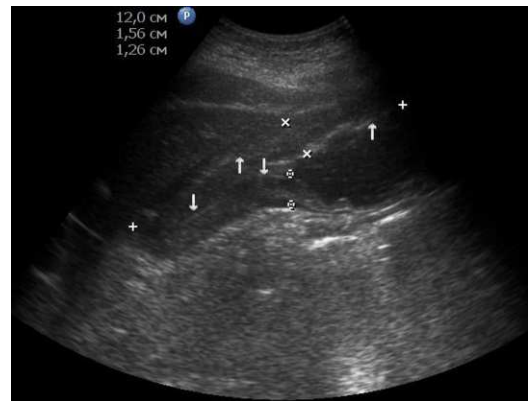


Figure 24. T4N3M1 - visualization of gastric carcinoma of body of diffuse infiltrative type ultrasonographycalli (arrows). Tumor invasion of the liver.



Figure 21. T4N2M1 - visualization of gastric carcinoma of body and antrum of diffuse infiltrative type with computer tomography (arrows).

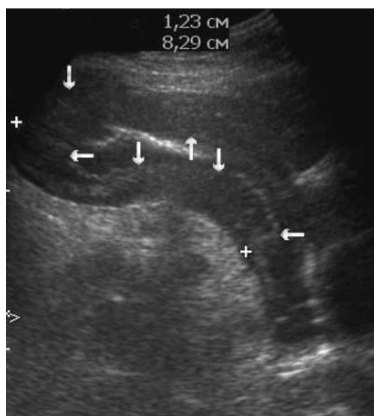


Figure 22. T4N2M1 - visualization of gastric carcinoma of body and antrum of diffuse infiltrative type ultrasonographycalli (arrows).

4. Discussion

Gastroscopy is a method of choosing a diagnosis of gastric carcinoma [16]. However, the method does not allow visualizing the layers of the stomach wall, which is necessary for determining the stage of the tumor process. Computed tomography or CT scanning of the abdomen may reveal gastric cancer. It is more useful to determine invasion into adjacent tissues or the presence of spread to local lymph nodes. Wall thickening of more than 1 cm that is focal, eccentric and enhancing favours malignancy [17]. Recent studies show that in the differentiation of the layers of the wall of the stomach, ultrasonography has a sufficient resolution, especially of the antrum and the body of the stomach. Despite the fact that in the fundus and greature curvature of the stomach wall layers are not ultrasonographically differentiated, an increase in the wall thickness of more than 5 mm is suspicious for the hyperplastic process [15]. In recent years, the number of cases of adenocarcinoma of the stomach, localized in the cardia, is increasing [18]. Unlike the fundus of the stomach, the layers of the wall of the abdominal part of the esophagus and cardia during ultrasonography are well differentiated. This allowed us to identify the spread of cardiac cancer to the abdominal part of the esophagus and to diagnose its stenosis.

Using USG was particularly effective in diffusely infiltrative forms of stomach cancer. Comparison of CT and

SSG data with the results of surgical intervention showed the accuracy of the DSC in 92.7% of cases.

5. Conclusions

The combined use of ultrasonography and gastroscopy will increase the detection of early intestinal type of gastric carcinoma. USG is the best, cheap, independent method for diagnosing a diffusely infiltrative form of gastric carcinoma, especially of the antrum. At stage T3, he is not inferior to CT in assessing the localization and prevalence of gastric carcinoma, and at stage T4, the difference between them is negligible.

Conflict of Interest

The authors declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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