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Measurement of Postoperative Liver Volume Changes In Patients With Gastric Cancer By Computed Tomography

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ABSTRACT

One of the most prevalent cancer worldwide is gastric cancer. Surgical treatment is the only curative method. In this study, we aimed to investigate the changes in liver volume before and after open gastrectomy in patients diagnosed with gastric cancer.

We retrospectively analyzed the computed tomography scans of 70 patients who underwent gastric cancer surgery between June 2013 and December 2020. Preoperative and postoperative total liver volume, the volume of segments II-III, and segment IV were measured. The data obtained from volume measurements were compared statistically.

Of the 70 subjects included in the study, 48 were male and 22 were female, with an average age of 64.2±11.8 years. In the postoperative phase, the volume of segments II-III and IV dropped significantly compared to the preoperative period ($p=0.001$ for both). Total liver volume exhibited a mild decrease in the postoperative period, but the total volume loss was not statistically significant ($p=0.744$).

In this study, we detected significant volume loss in segments II-III and segment IV after open gastrectomy. However, the total liver volume reduction was less.

Keywords: Gastric cancer, Open gastrectomy, Volume change, Liver segments, Computed tomography

Introduction

Gastric cancer is one of the most frequent types of malignancy and one of the leading causes of cancer-related morbidity and mortality worldwide. Surgical excision of gastric cancer is the only curative treatment, therefore the diagnosis of the disease at an early stage is important. The tumor stage varies depending on gastric wall invasion, lymph node dissemination, and the existence of distant organ metastases (1). Preoperative tumor staging is important for choosing the appropriate surgical method. The most commonly used effective modality for gastric cancer staging is contrast-enhanced computed tomography (CT). In addition, CT is an effective method to assess the treatment response and follow-up in the postoperative period (2).

It has been reported that liver function tests deteriorate after laparoscopic gastrectomy in patients with gastric cancer (3). Furthermore, it has been reported that ischemia developed in the left lobe of the liver following laparoscopic operations (2). These laparoscopy-related conditions were primarily attributed to long-term Nathanson surgical retractor compression (2,3). After open surgeries, these conditions have not been reported much.

When we searched in the literature, we encountered only one study reporting volume reduction in liver segments II and III after open gastrectomy (2). However, the volume of segment IV was not measured in this study. The fact that there is only one study in the literature requires contribution in this field.

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In this retrospective study, we aimed to examine the volume changes in the liver total parenchyma, segments II-III and segment IV by evaluating preoperative and postoperative CT examinations in patients who had undergone open gastrectomy.

Materials and Methods

Patients: Preoperative and postoperative contrast-enhanced CT images of adult patients who have undergone open total or subtotal gastrectomy for gastric carcinoma in our hospital between June 2013 and December 2020 were analyzed retrospectively. The study excluded individuals with liver or other distant organ metastases, patients without preoperative or postoperative contrast-enhanced CT images, patients with other organ malignancies, patients with hepatic cirrhosis, and patients receiving neoadjuvant chemotherapy or radiotherapy. CT scans of 70 participants who met the inclusion criteria were analyzed retrospectively. The study was started after the approval of the institutional ethics committee.

CT Examination: Abdominal CT examinations were performed using a 16-detector multislice computed tomography scanner (Somatom Emotion 16-slice; CT2012E-Siemens AG Berlin and München-Germany). Arterial phase and portal venous phase images were obtained by administering 80-100 mL of intravenous non-ionic contrast agent via an infusion pump in accordance with the abdominal CT protocol. Arterial phase imaging was aimed at the upper abdomen, from the dome of the diaphragm to the upper border of the sacroiliac joint, while the portal venous phase was aimed at the entire abdomen, from the dome of the diaphragm to the symphysis pubis. In addition, an oral negative contrast agent was given to the patients. The scanning parameters of CT were as follows: 120 kVp, 512x512 matrix, 35-50 cm FOV, 3 mm slice thickness, 0.8 pitch factor, and 0.6 sec rotation time.

On preoperative and postoperative CT images, the hepatic arteries, veins, and portal veins were examined. The integrity of the vessels was checked. Although the postoperative CT time interval is different for each patient, the CT images performed within the first 12 months after the surgery and which were most appropriate for the acquisition protocol were analyzed. Postoperative CT scans were carried out to evaluate response to treatment, recurrence and distant organ metastases.

Volume Measurement: Images of the subjects were transmitted to CT volume software (Elektra, XİO-Release 4.34.02, Stockholm AB, Sweden) in order to determine the total volume of the liver, as well as the volume of segments II-III and IV. A radiologist with 7 years of experience in abdominal radiology analyzed preoperative and postoperative CT scans. Total liver volume, the volume of segments II-III and the volume of segment IV measurements were performed by tracing contours in each section and applying the interactive volumetric method. The inferior vena cava, portal veins, hepatic veins, and gallbladder were not included in the volume measurement. The measurement time took approximately 30-40 minutes for each case.

The liver segment boundaries were defined based on the Couinaud classification (4). The line passing through the middle hepatic vein, inferior vena cava, and gallbladder fossa was used to separate the liver into the right and left lobes. The segments II-III of the left lobe were defined as the medial area of the falciform ligament and the left hepatic vein, while segment IV was defined as the area lateral to them.

Surgical Approach: Patients underwent open total gastrectomy or open distal subtotal gastrectomy. Histopathologically, the diagnosis of "gastric adenocarcinoma" was verified. The surgical method was explained in detail in the previous study, and the same surgical approach was applied in our study (2). Classic abdominal retractors were used during open gastrectomy operations. Nathanson retractors, which are generally effective in the laparoscopic approach, were not used.

Statistical Analysis: The mean, standard deviation, minimum, and maximum values are the descriptive statistics for continuous variables in our study. Paired t-test was used to evaluate the difference between liver volume measurements obtained before and after the gastrectomy operation. To compare all continuous measurements across groups, an independent t-test was performed. The association between age, gender, post-operative time, and volume change was determined using Pearson correlation analysis. The statistical significance level was set at 5%. The statistical software SPSS (version 24) was utilized for the analysis.

Results

The study comprised a total of 70 patients, 48 (68.6%) of whom were male and 22 (31.4%) of

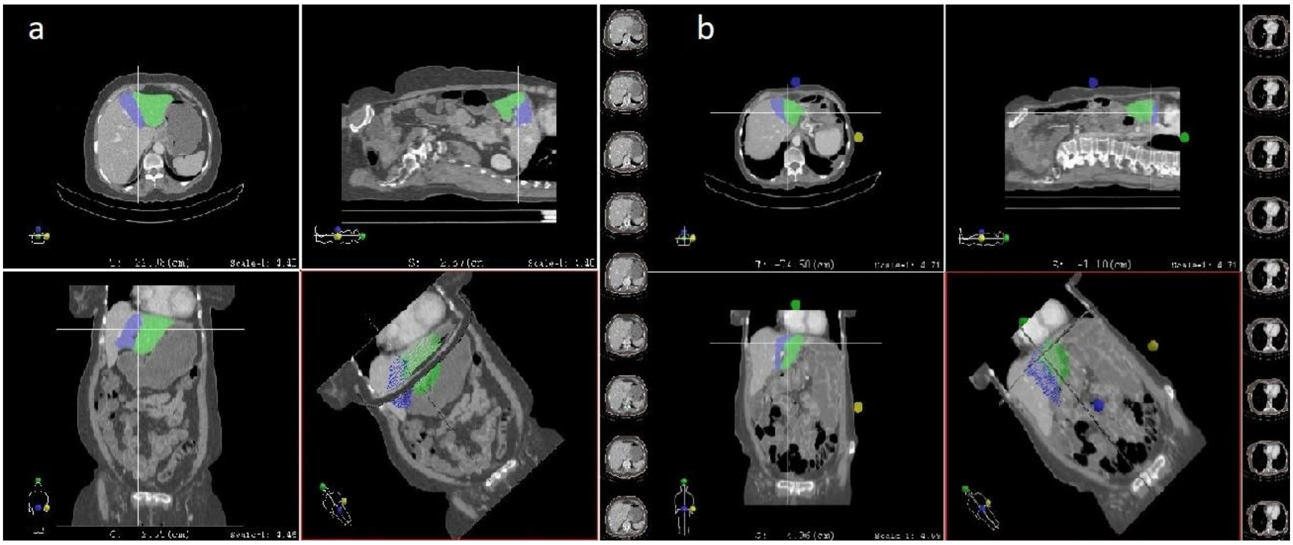

Fig. 1 a, b: Preoperative (a) and postoperative (b) multiplanar CT images. A 69-year-old female patient with gastric cancer. The volume of segments II-III and IV on preoperative CT was 179 mL and 102 mL, respectively. On postoperative CT, the volume of segments II-III and IV had decreased to 69 mL and 67 mL, respectively, after around 6 months.

whom were female, with a mean age of 64.2±11.8 years and a range of 19-81 years. Fifty-seven patients underwent total gastrectomy, and 13 patients underwent distal subtotal gastrectomy. The date range from the day of the gastrectomy surgery to the day of the postoperative CT scan was at least 4 months, at most 12 months, with a mean of 8 months. The mean size of the gastric tumor was calculated as 5±1.8 cm. TNM staging revealed that 27 subjects were T1 or T2, and 43 subjects were T3 or T4. On the postoperative CT scans, it was observed that the left hepatic artery, left hepatic vein, and left portal vein were intact in all patients.

Preoperative and postoperative segments II-III, segment IV and total liver volume measurements and paired t-test results are summarized in Table 1. In the postoperative period (figure 1), the volumes of segments II-III and IV decreased dramatically compared to the preoperative period ($p=0.001$ for both). Total liver volume exhibited a slight decrease in the postoperative period, but the difference was not statistically significant ($p=0.744$).

According to the correlation analysis, no significant correlation was found between age, gender, operation time and volume change ($p>0.05$).

Discussion

In our study, a significant volume loss was detected in segments II-III and segment IV in the postoperative period. However, the decrease in total liver volume was not statistically significant. Ozutemiz et al. (2) found a statistically significant decrease in the volume of segments II-III in their study. When segments II-III were excluded, a decrease was found in the volume of the rest of the liver, but it was not statistically significant. In our study, we determined a decrease in the volume of segment IV as well as segments II-III. The results of our study were in accordance with the findings of Ozutemiz et al (2).

The lack of significant reduction in total liver volume is probably due to the fact that the right lobe volume did not alter much. Although the reason for the decrease in the volume of the left lobe of the liver has not been fully elucidated, different causes and possible mechanisms are considered in the etiology (2). In some studies, elevations in liver enzymes have been detected after surgeries involving the upper gastrointestinal tract. In their study, Jeong et al.(3) reported hepatic enzymes elevation in patients who underwent open and laparoscopic gastrectomy, however, they did not detect enzyme elevation in patients who underwent open and laparoscopic colectomy. They attributed the enzyme elevation to liver traction and direct damage to the parenchyma during the operation. After both open gastrectomy and laparoscopic gastrectomy operations, focal wedge-shaped, rectangular or oval-shaped hypodensities with the subcapsular location were detected in the left lobe of the liver on postoperative CT images. These findings were attributed to parenchymal damage and necrosis

Table 1. Comparison of Preoperative and Postoperative Liver Volume Measurements

	Preoperative Volumes		Postoperative Volumes		P
	Mean±SD	Min.-Max.	Mean±SD	Min.-Max.	
Segments II-III	177.29±53.07	87.6-363.6	130.00±63.39	30.0-326.0	0.001
Segment IV	156.92±37.40	75.3-256.2	121.76±46.48	43.0-217.0	0.001
Total liver	1114.76±137.40	757.0-1555.6	1108.19±224.49	466.0-1596.3	0.744

secondary to the use of surgical retractors. It has been shown that these injuries result in capsular retraction, hypovascular scarring and left lobe atrophy in the late period (5,6). In addition, it has been reported that liver enzyme elevations and parenchymal damage are more common in laparoscopic surgeries using Nathanson retractors compared to open surgeries. Excessive parenchymal retraction due to the prolongation of the operation time was considered as the reason (7).

The subjects in our study had undergone open gastrectomy, and classical abdominal retractors were used instead of Nathanson retractors. In the postoperative CT images, we did not encounter hypodense lesion areas adjacent to the liver border, which may be compatible with damage secondary to the retractor. However, it has been reported in the literature that the aforementioned lesions can disappear in the late period (5). Since the postoperative CT scans were performed after 4-12 months in our study, the acute findings and injuries may have disappeared. Therefore, we speculate that retractor usage may be one of the causes of atrophy in the left lobe of the liver and volume loss in segments II-III and IV.

Various structural variations have been reported in the angiographic studies performed on the hepatic arterial system, and the most frequently detected variations are the replaced right hepatic artery, the replaced left hepatic artery, and the accessory left hepatic artery (8). In our study, replaced right and left hepatic arteries were not observed in the preoperative CT images. In the postoperative CT images the common, right, and left hepatic arteries were intact. In addition, no complications related to hepatic arteries developed during surgery. Accessory hepatic arteries with a diameter of less than 1 mm can not be visualized on CT and can not be seen during surgery, so they can be ligated (2). It can be thought that these accessory arteries support the nutrition of segments II, III and IV, and their ligation may contribute to left lobe atrophy. Furthermore, the arterial supply of the liver segment IV may exhibit variation. In angiographic studies, it has been reported that segment IV can be fed from the right hepatic artery at a rate of 9-35% (8,9). In the preoperative arterial phase CT images, we did not see a vascular structure that is compatible with the middle hepatic artery (segment IV artery) originating from the right hepatic artery. However, since CT scans are not specific for arterial angiography, the origin of the arteries feeding segment IV may not be clearly evaluated.

The vascularization of the liver parenchyma is mainly provided by the hepatic artery and portal vein. Besides, different venous systems have been described that contribute to the vascularization of the left lobe of the liver. The main ones are aberrant gastric veins, paraumbilical veins, cholecystic veins and the parabiliary venous system. It has been reported that these venous structures play a critical role in the etiopathogenesis of pseudolesions, such as focal fatty infiltration and focal fatty sparing, which are frequently encountered in segments II, III and IV (10,11). In particular, it has been emphasized that the parabiliary venous system directly supplies the inferior component of segment IV (12). Under normal circumstances, these venous structures are not often visible on portal phase-contrast CT, but they become dilated and visible during diseases that cause portal hypertension. During the gastrectomy operation, these venous structures are often ligated. Due to this reason, venous ischemia may develop in segments II, III and IV, and may contribute to volume loss (2,12).

Patients undergoing surgery for gastric cancer with the addition of chemotherapy, are encountered with nutritional deficiency. Therefore, severe weight loss and cachexia can occur (2). Nutritional deficiency and weight loss may be possible causes of volume loss in segments II, III, and IV. However, the lack of volume loss at the same rate in total liver volume indicates that this condition is not the only effective factor. Since we do not know the weight of the patients at the time of preoperative and postoperative CT scans, we could not evaluate the correlation between the percentage of weight loss and liver volume loss.

Limitations: Our study has some limitations. First of all, our study is a retrospective study with a limited number of patients. In addition, the association between laboratory testing, particularly liver enzymes, and volume changes was not examined. Comprehensive prospective studies with larger sample sizes may provide additional data on this issue. Moreover, the association between nutritional deficiency, weight loss rate, chemotherapy regimen and liver volume loss can be clearly demonstrated in prospective studies. The fact that the measurements were performed by a single radiologist is another limitation as it may cause bias.

In this retrospective study, we detected that in gastric cancer patients who underwent total and distal subtotal open gastrectomy, segments II, III, and IV of the liver exhibited significant volume reduction. However, the reduction of total liver volume was not significant. In prospective studies, volume changes can be better evaluated in the early and late postoperative periods. In addition, the relationship between the percentage of volume change and survival can be assessed by observing the patients. In other organ malignancies involving the upper abdomen such as esophagus and pancreas, liver volume changes in the postoperative period can be compared with gastric adenocarcinoma patients.

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