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Main Portal Vein Diameter Changes in Patients Undergoing Gastric Surgery for Malignancy: An Observational CT Study

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Abstract

Background In the follow-up computed tomography (CT) examinations of patients who had undergone gastrectomy for gastric malignancy in our center, we noticed by chance that there was an isolated increase in the diameter of the main portal vein (MPV) without other radiological findings of portal hypertension.

Objectives In this study, we aimed to evaluate whether the MPV diameter of patients who had gastric surgery for malignancy differed in the preoperative and postoperative periods and its change over time in patients who underwent postoperative follow-up examinations.

Materials and Methods The CT images of 240 patients who underwent abdomen CT for staging and follow-up gastric malignancy between January 2017 and September 2021 were evaluated retrospectively. The CT scans of the remaining 149 patients after the exclusion criteria were included in the study. All CT imaging was performed using multidetector CT (64 or 128 slice) in portal venous phases. The images were evaluated by two radiologists based on consensus. Maximum MPV diameter were measured outer wall to outer wall with calipers on axial images at the level of 1 cm distal to the portosplenic confluence.

Results One hundred forty-nine patients included in the study had preoperative CT examination. Eighty-three patients had follow-up CT examination at third month, 89 patients at sixth month, and 99 patients at first year. The MPV diameters differed significantly between preoperative CT and postoperative third month, sixth month, and first year CT ($p = 0.001$, $p = 0.001$, and $p = 0.001$, respectively). There was no difference in MPV diameter between postoperative third month CT and postoperative 6th month and 1st year CT ($p = 0.514$ and $p = 0.078$, respectively).

Keywords
- main portal vein diameter
- computed tomography
- gastric surgery

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Conclusion There is an increase in MPV diameter in the first 3 months postoperatively in patients undergoing gastric surgery for malignancy. This enlargement continues unchanged in the first 1 year follow-up. The radiologists' awareness of this situation may prevent the wrong diagnosis of portal hypertension, unnecessary concern, and further investigation.

Introduction

According to the Global Cancer Statistics 2020, stomach cancer was the fifth most commonly seen cancer and the fourth leading cause of cancer-related deaths worldwide in both sexes.[1] Surgery (total or subtotal gastrectomy) remains the main basic treatment method for patients with gastric cancer.[2,3] Computed tomography (CT) is used for evaluating the extent of the disease and staging preoperatively, and it is also the most important radiologic modality for follow-up postoperatively.[4]

The main portal vein (MPV) is formed as a portosplenic confluence with the union of the splenic vein and the superior mesenteric vein posterior to the neck of the pancreas, passes behind the duodenum and extends to the liver hilum in the hepatoduodenal ligament.[5,6] Normal MPV is about 8 cm long and 9 to 13 mm wide.[7] A large MPV diameter is accepted as one of the radiological indicators of portal hypertension.[8,9] In the follow-up CT examinations of patients who had undergone gastrectomy for gastric malignancy in our center, we noticed by chance that there was an isolated increase in the diameter of the MPV without other radiological findings of portal hypertension. These patients were routine follow-up patients due to malignancy and also there were no clinical signs of portal hypertension. We thought that the reason for the MPV enlargement we detected on CT might be previous gastric surgery. To the best our knowledge, there are no data on this subject in the literature. Therefore, in this study, we aimed to evaluate whether the MPV diameter of patients who had gastric surgery for malignancy differed in the preoperative and postoperative periods and its change over time in patients who underwent postoperative follow-up examinations.

Materials and Methods

The study was undertaken in a tertiary care hospital. It was approved by the Ethics Committee of the Faculty of Medicine of Eskişehir Osmangazi University (No: E-25403353-050.99-266327; date: October 26, 2021). The study was conducted in accordance with the principles of the Declaration of Helsinki. Datasets were evaluated retrospectively. Therefore, approval and informed consent were not necessary and were waived by our local Institutional Review Board.

All the CT imaging (preoperative staging and postoperative follow-up) and gastrectomy were done in the same hospital.

Study Participants

The CT images of 240 patients who underwent abdomen CT for staging and follow-up gastric malignancy between January 2017 and September 2021 were evaluated retrospectively. Patients with CT examinations in which it was not possible to evaluate portal venous system due to motion artifacts or an inappropriate contrast phase were not included in the study. Patients with portal venous thrombosis or absent of follow-up CT and patients who had historical or CT evidence of liver disease were excluded from the study. The patients were staged with CT in the perioperative period, and restaged according to the results of CT and pathology in the postoperative period. The patients who need neoadjuvant and adjuvant treatments received the necessary treatment. Since the aim of this study was to evaluate the effect of only surgery on portal vein diameter, patients with cirrhosis–pseudocirrhosis findings or CT findings that would increase portal vein diameter, such as congestive hepatopathy and portal thrombus, were also excluded from the study in this period. The CT scans of the remaining 149 patients were included in the study.

Image Acquisition

CT imaging was performed using 64-slice (Toshiba, Aquilion 64, Japan) or 128-slice (GE, Revolution EVO, United States) multidetector CT scanners with the following parameters: 1:1/1.35 pitch, 200 to 350 mAs, 120 kVp, and 05 to 0.625 mm isotropic spatial resolution. The subjects were examined in a supine position with their arms extended above their heads.

An iodinated intravenous contrast agent (1–1.5 mL/kg) was administered through the antecubital veins with an automatic injector at a rate of 3 mL/s; 20 mL saline was injected both prior to and following the injection of the contrast media with the same flow rate. Optimal scan time was detected by the automated bolus tracking method by placing the region of interest over the descending aorta and setting the trigger threshold to 100 HU and 40 seconds delay time. Images were obtained in portal venous phases.

Image Analysis and Interpretation

The images were evaluated by two radiologists, once experienced in abdominal radiology, using a workstation (Advantage WorkStation AW 4.7 software, GE Healthcare, Wisconsin, United States) based on consensus. Maximum MPV diameter were measured outer wall to outer wall with calipers on axial images at the level of 1 cm distal to the portosplenic confluence by a single radiologist. The measurements were performed twice and averaged. The diameter of MPV was recorded.

Statistical Analysis

SPSS software v. 22.0 (IBM Corp.) was used for statistical analysis. The normality analysis was performed with the

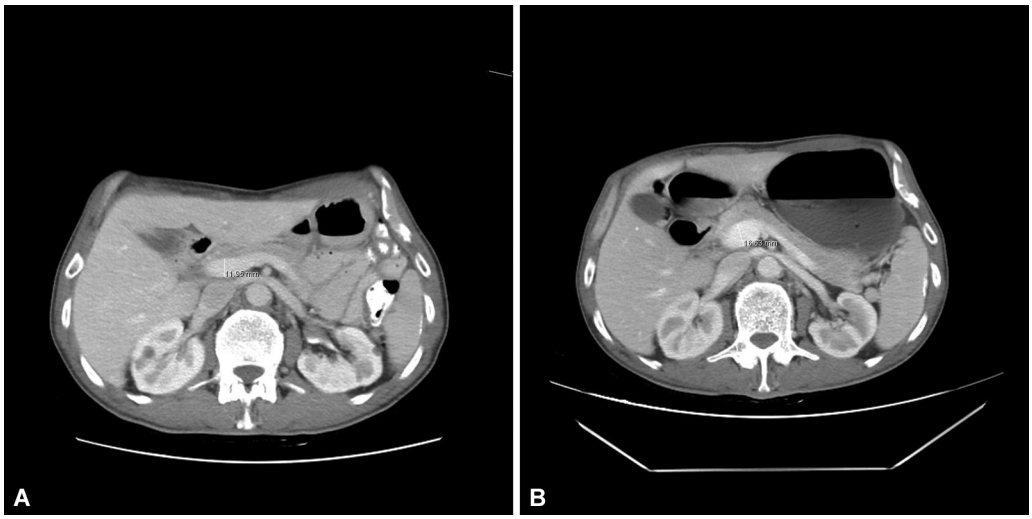

Fig. 1 A 56-year-old male patient; CT images in the axial plane showing (**A**) preoperative MPV diameter 11.95 mm and (**B**) postoperative third month MPV diameter 16.63 mm. CT, computed tomography; MPV, main portal vein.

Shapiro–Wilk's test. Descriptive statistics were presented as mean, standard deviation (SD) for the continuous data, and percentage values were used for discrete data. Preoperative and postoperative MPV diameters were compared using the paired samples *t*-test. A *p*-value of less than 0.05 was considered significant.

Results

The age of the 149 patients included in the study ranged from 28 to 89 years (mean ± SD, 61.16 ± 12.02 years). The sample consisted of 60 (40.26%) female and 89 male (59.73%) patients. None of the patients had a history of chronic liver disease. Portal hypertension findings were not detected in any of the patients in preoperative and follow-up CT examinations, except for portal vein enlargement.

Total gastrectomy was performed in 85 (57%) patients, subtotal distal gastrectomy in 52 (34.9%) patients, esophagogastrectomy in 7 (4.7%) patients, and wedge resection in 5 (3.4%) patients. Except for those who underwent wedge resection, the pathological diagnosis of all patients was adenocancer, and gastrectomy and D2 dissection were performed to them. The pathological diagnosis of all patients who underwent wedge resection were gastrointestinal stromal tumor, and lymph node dissection was not performed in these patients.

One hundred forty-nine patients included in the study had preoperative CT examination. Those with follow-up postoperative CT examinations at 3 months ± 15 days were classified as third month control, those with follow-up postoperative CT examinations at 6 months ± 15 days were classified as 6 months control, those with follow-up postoperative CT examinations at 1 year ± 15 days were classified as 1 year control. Eighty-three patients had follow-up control CT at postoperative third month, 89 patients at sixth month, and 99 patients at first year.

MPV diameters differed significantly between preoperative and follow-up postoperative CT at third month, sixth month, and first year ($p = 0.001$, $p = 0.001$, and $p = 0.001$, respectively). MPV diameters were larger than preoperatively on CT at third month, sixth month, and first year (►**Figs. 1** and **2**). The MPV diameters of the patients at the preoperative and postoperative third month, preoperative and postoperative sixth month, and preoperative and postoperative first year are given in ►**Table 1**.

There was no difference in MPV diameter between follow-up CT at third and sixth months and first year follow-up CT ($p = 0.514$ and $p = 0.078$, respectively). Follow-up MPV diameters of the patients at the postoperative third and 6th month, and postoperative third month and first year are given in ►**Table 2**.

Discussion

In this study, we found that MPV diameters in patients undergoing gastric surgery expanded at the postoperative third month, sixth month, and first year compared with preoperative CT, and this enlargement was statistically significant. We found no significant difference in portal vein diameters in postoperative third month CT and sixth month and first year CT examinations. According to these results, it is possible to say that the expansion in postoperative MPV occurs within the first 3 months, and continues without any change in the sixth month and first year CT examinations.

Although MPV dilatation is not specific, it is one of the most common radiological findings of portal hypertension. It is claimed that the patient's inspiratory depth, hydration, and contrast agent use may contribute to the factors affecting the portal vein diameter in CT examination.[10] However, dilatation of the MPV is usually a warning for the early phase of portal hypertension for radiologists, even in the absence of

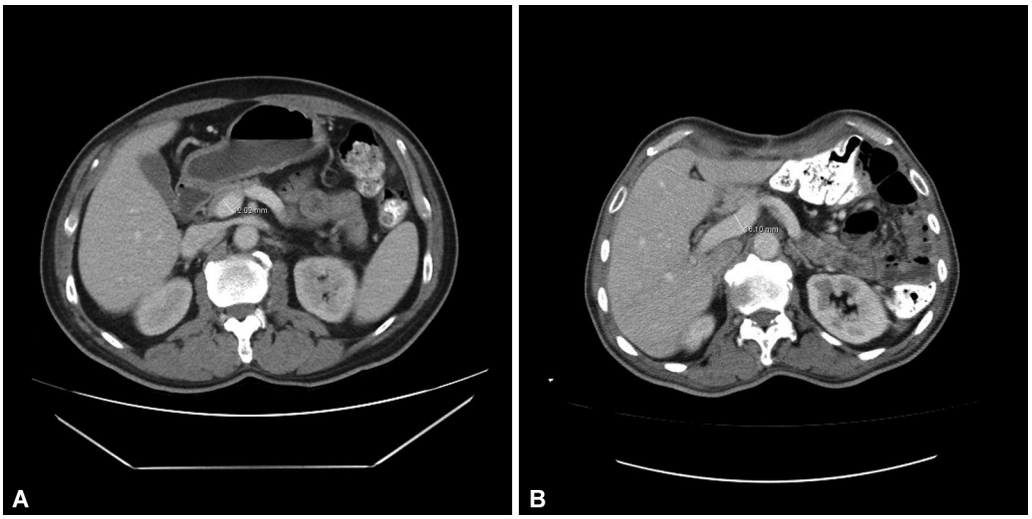

Fig. 2 A 63-year-old male patient; CT images in the axial plane showing (**A**) preoperative MPV diameter 12.02 mm and (**B**) postoperative sixth month MPV diameter 16.10 mm. CT, computed tomography; MPV, main portal vein.

Table 1 MPV diameters of the patients at the preoperative and postoperative third month, preoperative and postoperative sixth month, and preoperative and postoperative first year

	Number of patients (*n*)	Diameter (mm)	*p*-Value
Preoperative MPV diameter	83	12.82 ± 1.82	**0.001**
Postoperative third month MPV diameter	83	13.58 ± 2.16	
Preoperative MPV diameter	89	12.87 ± 1.86	**0.001**
Postoperative sixth month MPV diameter	89	13.61 ± 2.36	
Preoperative MPV diameter	99	12.71 ± 1.86	**0.001**
Postoperative first year MPV diameter	99	13.43 ± 1.82	

Abbreviation: MPV, main portal vein.
Note: Bold values are statistically significant.

Table 2 Follow-up MPV diameters of the patients at the postoperative third and sixth months, and postoperative third month and first year

	Number of patients (*n*)	Diameter (mm)	*p*-Value
Postoperative third month MPV diameter	44	13.95 ± 2.21	0.514
Postoperative sixth month MPV diameter	44	13.80 ± 2.52	
Postoperative third month MPV diameter	53	13.98 ± 1.96	0.078
Postoperative first year MPV diameter	53	13.56 ± 1.63	

Abbreviation: MPV, main portal vein.

other accompanying findings of portal hypertension (such as ascites, splenomegaly, chronic liver parenchymal findings, varicose veins, and collateral vascular structures). We observed an enlargement of MPV in CT examinations of patients who underwent gastric surgery for gastric malignancy in our tertiary center. In these patients, splenic vein enlargement or splenomegaly, which may suggest portal vein enlargement due to prehepatic reasons, were absent in preoperative CT examinations. When we compared the preoperative CT examinations of the patients, we found that enlargement of MPV was not present in the preoperative CT and developed in the first 3 months after the operation and remained unchanged during the first year follow-up. Based on our findings, it is not possible to clarify the underlying cause of MPV enlargement after gastric surgery, but we can speculate for some causes and mechanism.

D2 dissection was performed due to malignancy surgery in all patients in the current study, except for the patients who underwent wedge resection. D2 dissection, together with total or subtotal gastrectomy in the treatment of gastric cancer, is the standard lymph node dissection method in Japan and recommended in experienced centers in the

West.[3] It is the standard treatment method in our center also. According to the Japanese Classification of Gastric Carcinoma, lymph nodes no. 12 included in the D2 dissection are hepatoduodenal ligament lymph nodes.[11] The deterioration in the integrity of the hepatoduodenal ligament during the dissection of these lymph nodes may have caused enlargement in the structures inside by reducing or eliminating the sheath effect of the ligament. There was also another finding supporting this mechanism in our study. We did not detect MPV enlargement postoperatively in any of the five patients who underwent wedge resection and therefore did not undergo D2 dissection. Although the number of patients was not sufficient for statistical analysis, this result makes us think that D2 dissection with gastrectomy causes dilatation of the MPV diameter. We think that the portal vein which located with hepatic artery in the hepatoduodenal ligament is more affected and enlarged than hepatic artery due to the difference in the histological structures (thicker wall and strong media layer in the artery). We did not evaluate the hepatic artery in this study, as we did not have an observation for it. The common bile duct is another structure within the hepatoduodenal ligament. We did not notice this situation in our first observation, but in the retrospective examination, we noticed that there was an enlargement of the common bile duct compared with preoperative CT. This change in the diameter of the common bile duct may be a subject of separate evaluation for future studies.

Gastric surgery irreversibly changes the physiology of the digestive system, leading to the loss of capacitive function and the disappearance of the secretion of gastric digestive enzymes and hormones.[2] Functional elimination of one part of the gastrointestinal tract may cause a compensatory response in the remaining parts, involving some form of morphological adaptation.[2,12] Proliferation of enterocytes results in increased villi height, intestinal crypt depth, mucosal surface area, and small bowel mass.[13] Following adaptation, the intestinal enterocytes are more functional and more capable of digesting and absorbing nutrients.[2] As a second mechanism, we thought: the realization of these morphological and functional changes may be possible with an increase in blood flow to the intestines. Increased blood flow may also be the cause of increased venous outflow. Due to compliance, this may result in enlargement of the flexible vein walls and increase in vein diameter. Portal vein flow measurements are needed for the validity of this hypothesis. It is not possible to determine portal vein flow with CT, but it can be done with Doppler ultrasonography. This hypothesis can be evaluated with a prospectively planned study in the future.

The effect of gastric surgery on the liver is still controversial.[2] Puzio et al in their study on rats found that the number of total cells, hepatocytes, hepatocyte nuclei, and mononuclear hepatocyte nuclei increased significantly.[2] It is known that increased cell number in the liver and liver hypertrophy are partly related to a rise in portal pressure.[14] Increased pressure in the portal vein results in portal vein enlargement. The enlargement of the portal vein diameter in our study may also be a result of the proliferative effect of gastric surgery on liver cells.

One of the strengths of our study is that it was conducted in a large patient group. In addition, examining an observation that has not been mentioned in the literature before is important in terms of contributing to the literature. The first among the limitations of the study is its retrospective nature. In addition, due to this retrospective nature, it is also a limitation that the flow changes and characteristics in the portal vein are not examined by Doppler. Future prospective studies may allow the evaluation of Doppler findings. Another limitation is that all patients included in the study did not have a follow-up CT examination at third month, sixth month, and first year. However, sufficient number of patients in each group is a factor that partially prevents this limitation.

Conclusion

MPV enlargement occurs in the first 3 months postoperatively in patients undergoing gastric surgery. This enlargement continues irreversibly in the first 1 year follow-up. The radiologists' awareness of this situation can prevent the wrong diagnosis of portal hypertension, unnecessary concern, and further investigation.

Funding
None.

Conflict of Interest
None declared.

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