

Right Gastric Venous Drainage: Angiographic Analysis in 100 Patients

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Objective: To evaluate the pattern of right gastric venous drainage by use of digital subtraction angiography.

Materials and Methods: A series of 100 consecutive patients who underwent right gastric arteriography during transcatheter arterial chemoembolization for hepatocellular carcinoma were included in this study. Angiographic findings were retrospectively analyzed with respect to the presence or absence of the right and aberrant gastric veins, multiplicity of draining veins, aberrant right gastric venous drainage sites, and the termination pattern of aberrant right gastric veins (ARGVs). We also compared the relative size of the right and left gastric veins.

Results: A total of 49 patients collectively had 66 ARGVs. The common drainage sites for the ARGVs included the hepatic segment IV (n = 35) and segment I (n = 15). The termination pattern of ARGV could be classified into 4 different types. The most common type was termination as a superficial parenchymal blush formation in small areas without demonstrable portal branches. A statistically significant difference was found for the dominance of the right gastric vein in gastric venous drainage between the two groups with or without ARGV ($p < 0.05$, Fisher's exact test). In the group of patients without ARGV (n = 51), the right gastric vein was equal to (n = 9) or larger than (n = 17) the left gastric vein in 26 patients (26 of 51, 51%).

Conclusion: The incidence of ARGV is higher than expected with four distinct types in its termination pattern. The right gastric vein may play a dominant role in gastric venous drainage.

Index terms: Aberrant gastric vein; Gastric vein; Angiography

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INTRODUCTION

The right gastric vein has been reported to drain into the portal vein trunk or the splenic vein along the lesser curvature of the stomach (1). There have been reports about aberrant gastric venous drainage into the liver (2-5). An aberrant right gastric vein (ARGV) is a well-known cause of pseudo tumors in the liver because it can produce focal fatty infiltration or a focal sparing lesion in the fatty infiltrated liver (6-8). Few case reports exist on the study of aberrant gastric venous drainage as depicted on computed tomography (CT) or ultrasonography (US) (3, 6, 9-12). In addition, the

ARGV can play an important role in cavernous transformation due to thrombosis in the portal vein trunk (2, 9, 10).

However, the incidence of ARGV is also unclear because there are large variations, ranging from 0% to 34% in the literature including an unpublished cadaveric study (2, 3, 6, 9, 13).

The left gastric vein has been well recognized as a preferential route of the portosystemic shunt in patients with portal hypertension, and is easily traced on an enhanced CT of the upper abdomen. Therefore, radiologists are familiar with its anatomy and pathologies. However, the right gastric vein or right gastric venous drainage is difficult to trace on routine enhanced CT of the upper abdomen and the pattern of right gastric venous drainage has not been systematically investigated.

The purpose of this study was to investigate the pattern of right gastric venous drainage by use of digital subtraction angiography in a large study population.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board, and informed consent was waived.

Patients

This study included consecutive 100 patients who underwent right gastric arteriography during transcatheter arterial chemoembolization of hepatocellular carcinoma over the past six month period at the Seoul National University Hospital. During this period, 685 patients underwent transcatheter arterial chemoembolization. Patients with tumors in the left hepatic lobe or in the caudate lobe, portal vein thrombosis, an arteriportal shunt, and severe liver cirrhosis with reversed portal flow were excluded from the study. Also we excluded patients who did not undergo right gastric angiography because it was not necessary for their particular tumor treatment. The patient population consisted of 73 men and 27 women ranging in age from 15 to 80 years of age (mean age, 56.2 years).

Angiography

To obtain indirect gastric venograms, celiac arteriography and selective arteriography of the right and left gastric arteries were performed with digital subtraction angiographic equipment (Angiostar; Siemens, Erlangen, Germany or V-3000; Philips Medical Systems, Eindhoven, The Netherlands). A celiac arteriography was performed

with a 6.5-Fr or 5-Fr Rösch hepatic catheter (Cook, Bloomington, IN). Selective arteriography of the right gastric and left gastric arteries was performed with use of a 3-Fr microcatheter (Microferret; Cook). An experienced interventional radiologist performed all of the angiographic procedures. A nonionic contrast agent (iopromide, Ultravist 370; Schering, Berlin, Germany) was used for the angiography. The injection rate and total volume of the contrast medium used were 6-7 mL/sec and 42-49 mL, respectively for celiac arteriography, 1.0-2.0 mL/sec and 10-14 mL, respectively for selective arteriography of the right or left gastric arteries

Imaging Interpretation

Angiographic findings for the 100 patients were retrospectively analyzed in consensus by two radiologists with respect to the presence or absence of the right gastric vein and aberrant gastric veins, multiplicity of draining veins, aberrant right gastric venous drainage sites, and the termination pattern of ARGVs. When it was difficult to determine the drainage site, CT images were referenced. We also compared the relative size of the right and left gastric veins.

The right gastric vein was defined as a vein which runs rightward along the lesser curvature of the stomach in parallel with the right gastric artery, and drains into the main portal vein or the left portal vein trunk. The ARGV was defined as a vein which takes off from the right side of the lesser curvature of the stomach and drains into the superficial liver parenchyma or peripheral portal branches.

Aberrant right gastric venous drainage sites were classified by hepatic segments based on the Couinaud classification (Couinaud C. *Le foie: etudes anatomiques et chirurgicales*. Paris, France: Masson, 1957).

RESULTS

Presence or Absence of the Right Gastric Vein and Aberrant Gastric Veins

Of the 100 patients evaluated, only forty eight patients had the right gastric vein draining into the main portal vein ($n = 43$) or into the left portal vein trunk ($n = 5$) without aberrant right gastric venous drainage (Fig. 1). Eleven patients had aberrant right gastric venous drainage in addition to the right gastric vein draining into the main portal vein. Thirty eight patients had aberrant right gastric venous drainage without the right gastric vein (Fig. 2).

Right Gastric Venous Drainage Patterns on Angiography

In the remaining three patients, the right gastric vein or aberrant gastric venous drainage was not demonstrated at all. In six of the fifty nine patients with right gastric vein drainage, the left gastric vein was not identified. The conjunction of the right and left gastric vein just before entering the main portal vein trunk was noted in one patient (Fig. 3).

Multiplicity of Aberrant Gastric Veins

Among the forty nine patients with aberrant gastric venous drainage, thirteen patients had two ARGVs and two patients had three. Therefore, a total of 66 ARGVs were demonstrated in forty nine patients.

Aberrant left gastric venous drainage was found in four patients; three of which had aberrant right gastric venous drainage without the right gastric vein (Fig. 2) and one

which had aberrant gastric venous drainage in addition to the right gastric vein draining into the main portal vein. The aberrant left gastric vein was drained into the portal vein of the hepatic segment II.

Aberrant Right Gastric Venous Drainage Sites

The most common drainage site of the 66 ARGVs is hepatic segment IV (n = 35) followed by segment I (n = 15). The 12 ARGVs were drained into the umbilical segment of the left portal vein or adjacent liver parenchyma. The uncommon drainage sites included the hepatic segment II (n = 3) and hepatic segment III (n = 1).

Termination Pattern of Aberrant Right Gastric Veins

The termination pattern of ARGV could be classified into 4 different types which were illustrated on Figure 4. Type I

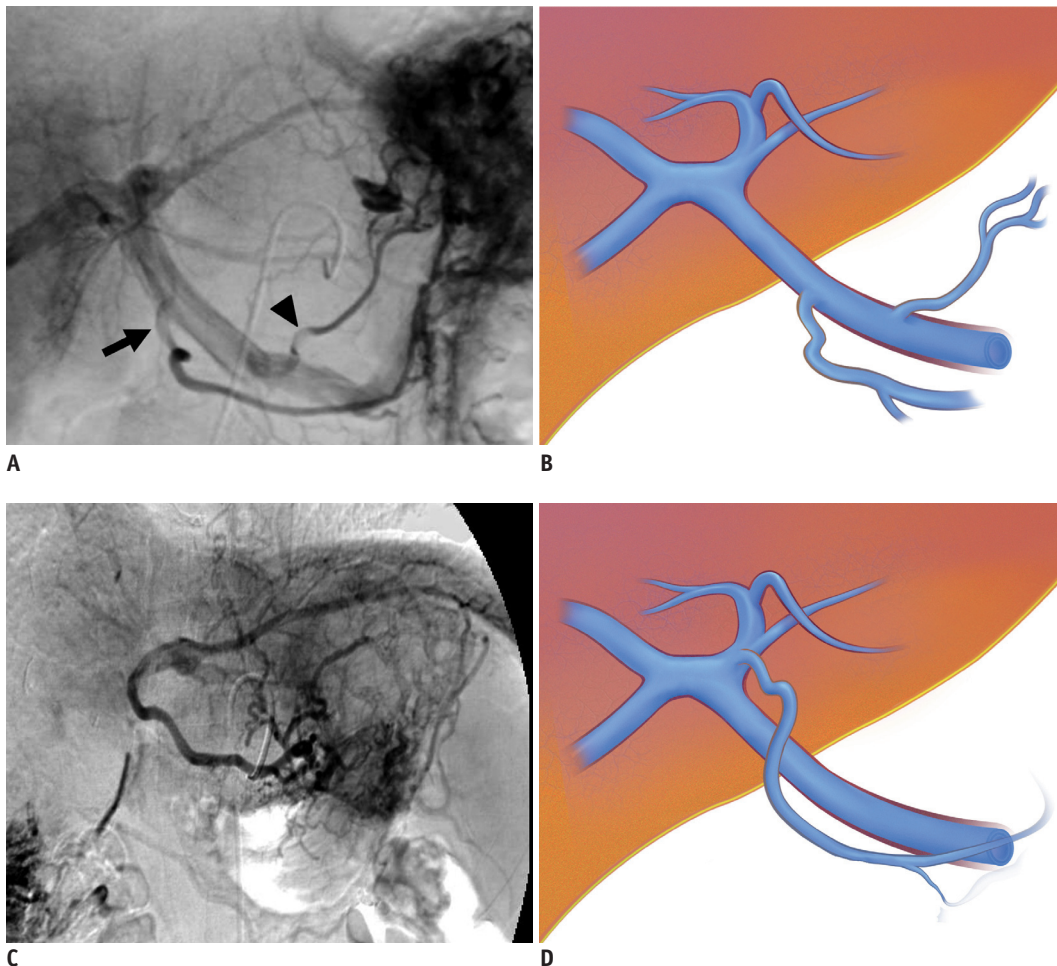


Fig. 1. Normal venous drainage of stomach.

A. Right gastric vein draining into main portal vein in 72-year-old man. Right gastric vein drains into main portal vein (arrow), while left gastric vein drains into splenic vein (arrowhead). **B.** Schematic diagram of right gastric vein draining into main portal vein. Right gastric vein drainage site is more distal to left gastric vein drainage site and on right side of main portal vein. **C.** Right gastric vein draining into left portal vein trunk in 43-year-old woman. Right gastric vein runs parallel to main portal vein and drains into left portal vein trunk. **D.** Schematic diagram of right gastric vein draining into left portal vein trunk.

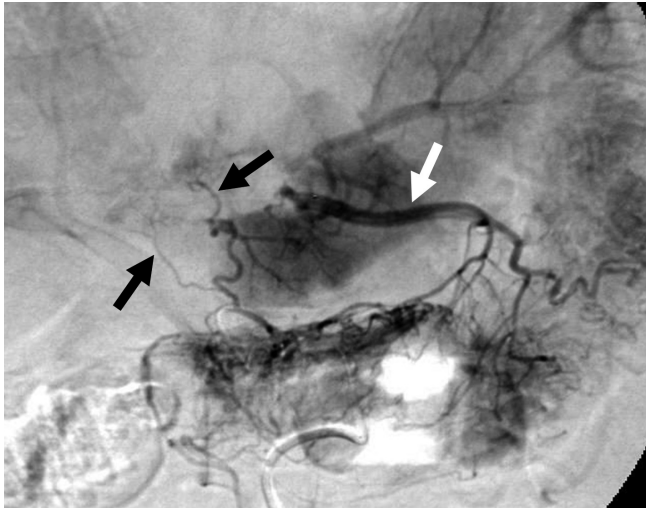


Fig. 2. Coexisting aberrant right and left gastric venous drainage in 46-year-old man. Aberrant right gastric vein drains into superficial areas of hepatic segment IV (black arrows) and aberrant left gastric vein drains into segment II portal branches (white arrow).

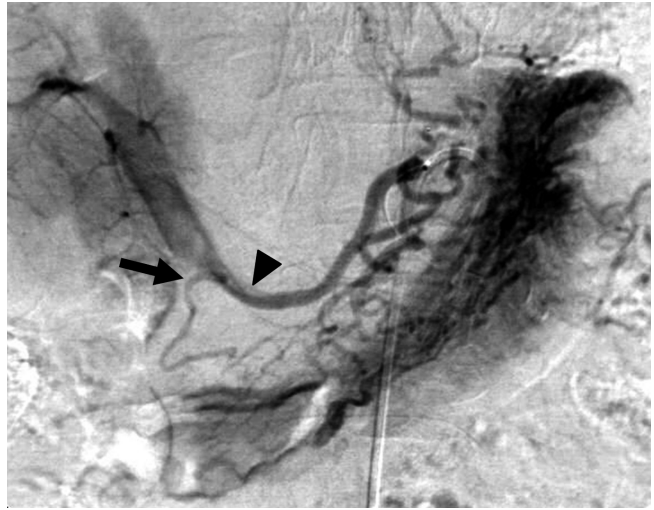


Fig. 3. Conjunction type of gastric venous drainage in 60-year-old woman. Right gastric vein (arrow) anastomose with left gastric vein (arrowhead) just before entering main portal vein.

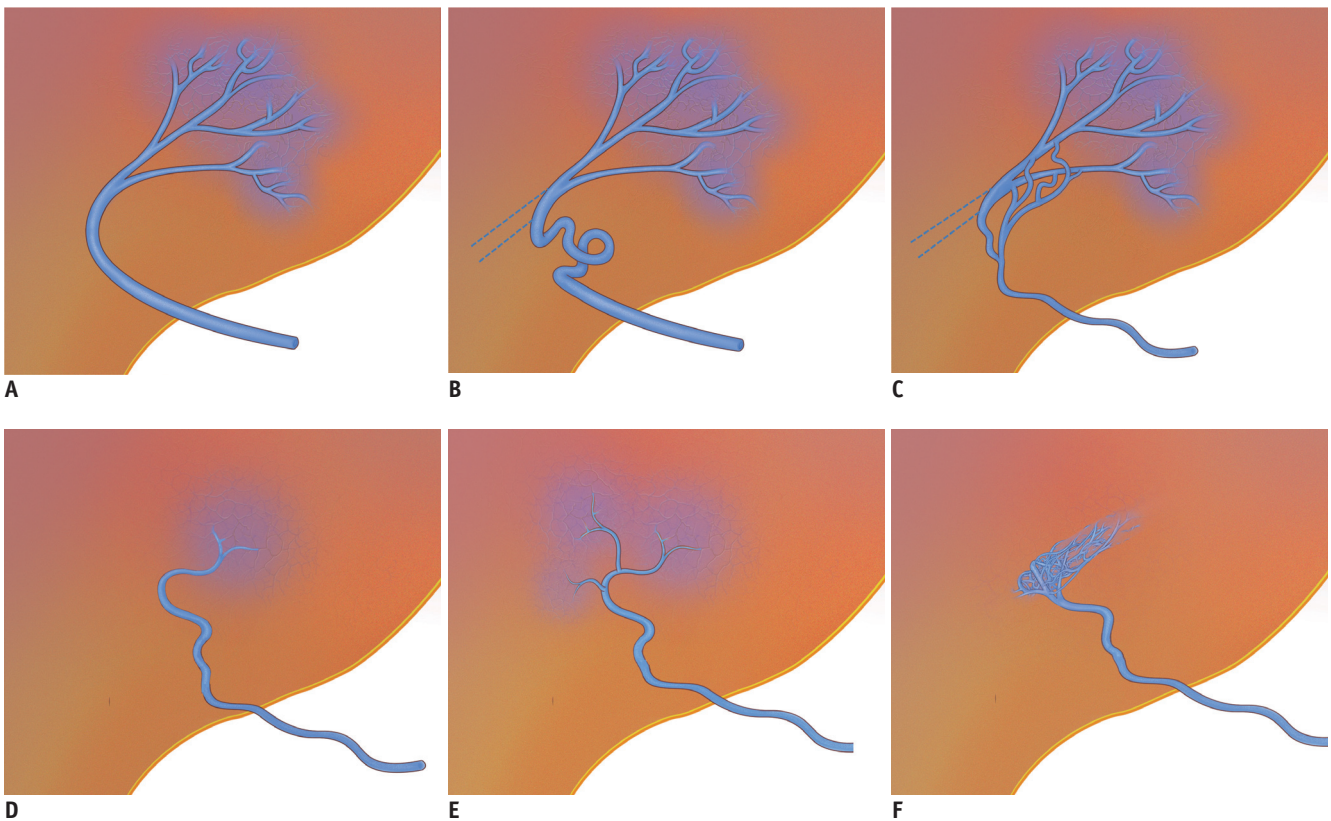


Fig. 4. Termination patterns of aberrant right gastric vein.

A. Type I. Aberrant right gastric vein continues smoothly into peripheral portal vein as single channel, hence sequestering territory supplied by aberrant right gastric vein from normal portal supply. **B.** Type IIa. Aberrant right gastric vein is connected to peripheral portal vein in end-to-end or end-to-side (dotted line) fashion via single collateral channel. **C.** Type IIb. Aberrant right gastric vein is connected to peripheral portal vein in end-to-end or end-to-side (dotted line) fashion via multiple collateral channels. **D.** Type IIIa. Aberrant right gastric vein is terminated as small superficial parenchymal blush formation without demonstrable portal branches. **E.** Type IIIb. Aberrant right gastric vein branches in extrahepatic location and branches are terminated as multifocal small superficial parenchymal blush formation without demonstrable portal branches. **F.** Type IV. Aberrant right gastric vein forms network around sectional or segmental portal vein, and subsequently drains into it.

Right Gastric Venous Drainage Patterns on Angiography

is the smooth continuation of ARGV as a single channel into the peripheral portal vein (Fig. 5). Type II is the collateral connection of ARGV into the peripheral portal vein (Fig. 6). Type III is the superficial parenchymal blush formation in a small area without demonstrable portal branches. Type IV is the network connection to the sectional or segmental portal vein (Fig. 7). For type II and III, subclassifications are made according to the multiplicity of channels.

The most common termination pattern of ARGV was type III (n = 38, 58%) (Table 1). Sixteen of the 38 type III ARGVs branched into the extrahepatic location, and the branches terminated as multifocal small superficial parenchymal blush without demonstrable portal branches (Fig. 7). Twelve ARGVs showed a type II termination pattern. They were connected to the peripheral portal vein in an end-to-end or end-to-side (dotted line, Fig. 4) fashion via single or multiple collateral channels (Fig. 6). Nine



Fig. 6. Type IIb aberrant right gastric vein in 69-year-old man. Aberrant right gastric vein (arrow) is connected to segment I portal vein in end-to-side fashion via multiple collateral channels.



Fig. 5. Type I aberrant right gastric vein in 58-year-old woman. Venous phase image of selective right gastric arteriography shows two aberrant right gastric veins, one in type I (arrow) and other in type IIIb (arrowhead).

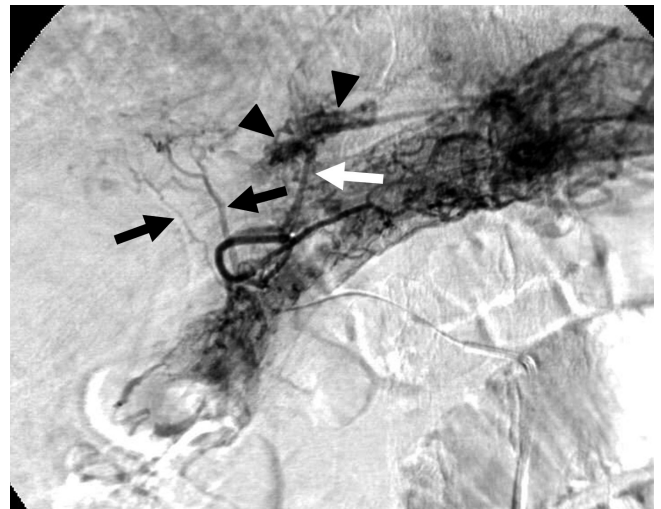


Fig. 7. Type IV aberrant right gastric vein in 53-year-old man. Three aberrant right gastric veins are seen; one in type IV (white arrow) and two in type III (black arrows). Network formation around umbilical segment of left portal vein is clearly demonstrated (arrowheads).

Table 1. Termination Pattern of Aberrant Gastric Vein

Type	Termination Pattern	Subtotal	Total
I	Smooth continuation as single channel into peripheral portal vein		9
II	Collateral connection into peripheral portal vein		12
IIa	Single collateral channel	3	
IIb	Multiple collateral channels	9 (6*)	
III	Superficial parenchymal blush formation in small areas without demonstrable portal branches		38
IIIa	Unifocal	22	
IIIb	Multifocal	16	
IV	Network formation around sectional or segmental portal vein		7

Note.— *In six patients, connection between peripheral portal vein and aberrant right gastric vein was proven to be in end-to-side fashion.

Table 2. Relative Size of Right and Left Gastric Veins Depending on Presence or Absence of Aberrant Right Gastric Vein

	Aberrant Right Gastric Vein	
	+	-
RGV \geq LGV	7	26
RGV < LGV	42	25

Note.— **P* value is 0.001. LGV = left gastric vein, RGV = right gastric vein

ARGVs showed a type I termination pattern. The territory supplied by the type I aberrant right gastric vein was considered to be sequestered from the normal portal supply. The seven remaining ARGVs showed a type IV termination pattern.

Relative Size of the Right and Left Gastric Veins

In the group of patients with ARGV ($n = 49$), the right gastric vein was equal to ($n = 5$) or larger than ($n = 2$) the left gastric artery in seven patients (7 of 49, 14%) (Table 2). However, in the group of patients without ARGV ($n = 51$), the right gastric vein was equal to ($n = 9$) or larger than ($n = 17$) the left gastric vein in 26 patients (26 of 51, 51%). A statistically significant difference was found for the relative size of the right and left gastric veins (dominance of the right gastric vein in gastric venous drainage) between the two groups ($p < 0.05$, Fisher's exact test).

DISCUSSION

Based on previous studies, the incidence of an ARGV variable from 2% to 14%; angiographic studies have reported ARGV incidence as 2% and the assumption from the lesion study at hepatic segment IV was 14% with the CT during arterial portography (3, 14). An unpublished cadaver study showed an incidence as high as 34% for ARGV prevalence (2, 9, 14). An aberrant left gastric vein (ALGV) is a very rare variation, having an incidence of 0.8% (2 of 245 cadavers) (15). However, in our study, the prevalence of an ARGV was 49% and the prevalence of an ALGV was 4%; both frequencies being higher than the frequencies in autopsy reports or angiographic reports previously published. Usually, aberrant gastric veins are slender and may be missed on an autopsy or radiological imaging such as CT, MRI or US. However, with angiography, the presence of aberrant gastric veins is more readily visualized. We performed a selective arteriography of the right and left gastric artery, but a previous angiographic study was

performed at the celiac artery. This is the one reason for a large discrepancy between previous studies and our study.

The most common drainage site was hepatic segment IV (35 out of 66 ARGVs) and hepatic segment I (15 of 66 ARGVs). Our results support the previous study about aberrant gastric venous drainage on the basis of CT arterial portography (CTAP) (9). When the incidence (12 out of 66 ARGVs) of drainage to the left portal vein or around the portal vein is included, almost all ARGVs drained into or adjacent to the medial segment of the left hepatic lobe, including the caudate lobe (62 out of 66 ARGVs, 94%). The reason for the difference between hepatic segments IV/I and the other hepatic segments is the following. Although the major portion of the liver and portal venous system develops at approximately days 26-28 of gestation, the bile ducts, parabiliary venous system, hepatic artery, and segment I and IV of the liver develop later, at approximately days 32-34 of gestation. The parabiliary venous system extends along the hepatic artery and bile duct, and finally directly supply the liver in the later stage, after the intrahepatic distribution of the portal veins is established (16).

This is the first report to describe the termination pattern of ARGVs. We classified the ARGVs based on the extrahepatic ramification and portal vein connection in the liver. Type I is the smooth continuation of ARGV into the intrahepatic portal vein as a single channel (Fig. 4A), which means that type I ARGV is the only source of portal venous supplies in the drainage territory. Type II is the single or multiple collateral connection of the ARGV to the peripheral portal vein in an end-to-end or end-to-side fashion (Fig. 4B, C), which suggests that type II ARGV may not be the only source of portal venous supply to the drainage territory because normal portal venous connection can be patent. Type III is the superficial parenchymal blush formation in a small area without demonstrable portal branches, which suggests that type III ARGV supplies only the superficial capsular or subcapsular areas without penetrating into the deeper portion of the liver (Fig. 4D, E). Type IV is the network connection to the sectional or segmental portal vein, which suggests that type IV ARGV contributes little to the portal venous supply of the section or segment. Therefore, we theorize that a relatively large type I and type II ARGV without normal portal venous connection can result in a pseudo lesion on imaging studies. In this study, the incidence of type I and II ARGVs without a normal portal venous connection (10 of 100, 10%) is very similar to the incidence of a pseudo lesion of the liver as reported

in 6-14% of cases (14, 17, 18). The termination pattern of ARGVs explain why the incidence of pseudo lesions in the clinical setting is much lower than the true incidence of ARGVs.

Of the 94 patients evaluated for left gastric veins, 47 left gastric veins drained into the splenic vein, 30 drained into the main portal vein and 13 drained into the portal confluence. Only four patients had an ALGV which drained into hepatic segment II and all these patients (n = 4) also had an ARGV. We found only one case of conjunction between the right and left gastric vein drained into the main portal vein (Fig. 3). To our knowledge, this is a unique report of the conjunction type involving the right and left gastric vein.

Aberrant gastric venous drainage is important to both the radiologist and clinician because of the pseudo lesion formation in the portal phase of CT angiography or CTAP (9, 14), one route of cavernous transformation in the main portal thrombosis, and unexpected hemorrhage during hepatobiliary surgery due to a missed aberrant gastric vein by the surgeon (19). It is also probable that the ARGV provides a direct metastatic pathway for gastric cancer in the lesser curvature and a potential route of hepatofugal arteriportal shunt in a case of main portal vein tumor thrombosis (19-21). It can be used as the alternative route for placing a stent in a transjugular intrahepatic portosystemic shunt with main portal thrombosis (20).

First a limitation of our study is the absence of secondary confirmative modality for the exact frequency of aberrant gastric venous drainage. Even an autopsy could not confirm the exact frequency (2). Secondly, most of the patients in this study had liver cirrhosis, which elevates portal venous pressure. In turn, liver cirrhosis and portal hypertension may alter hemodynamics in the portal system, which may affect angiographic visualization of aberrant gastric venous drainage. Further study is necessary in the population with a non-cirrhotic normal liver.

In conclusion, aberrant right gastric venous drainage was found in almost half of the patients. The main venous drainage site was hepatic segment IV, and I around the umbilical segment of the left portal vein in descending order. The termination pattern of ARGV could be divided into four different types.

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