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Angiographic Branching Patterns of the Splenic Artery

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Abstract. Most previous studies of the splenic artery were cadaver dissections, and *in vivo* anatomical studies have been reported only rarely. Selective arteriography could be used as an *in vivo* study of the branching patterns of the splenic artery. Forty-three splenic arteriograms and seven celiac arteriograms were included in this study. There were 36 males and 14 females, aged 23–67 years (mean 48 years). The branching patterns of the splenic artery show 80% dorsal pancreatic, 98% pancreatic magna, 84% caudal pancreatic, 76% superior polar, 24% inferior polar, 46% left gastroepiploic, 28% accessory left gastric, 100% terminal superior and inferior, and 28% terminal media arteries. The branching patterns of the splenic artery were similar to the many reports of cadaver dissection in the Korean literature and there was a more frequent incidence of splenic arterial branches than in the reports from the study of Caucasians except for the accessory left gastric artery.

Introduction

The splenic artery is a major branch of the celiac artery and supplies the spleen, pancreas, stomach, and greater omentum. It is important for the radiologist, surgeons, and other clinicians to understand the variation of the course and branching patterns of the splenic artery. Surgical decisions regarding intervention in diseases of the stomach, pancreas, and spleen, and hypersplenism require analysis of splenic artery anatomy. Despite extensive work on postmortem studies of the anatomy of the splenic artery, only a few investigations have studied its anatomy in the live subjects. The anatomic study for the Korean population is rare. The purpose of this study was to analyze the variations of the splenic arterial anatomy seen on the selective arteriograms of the subpopulation of Korean adults.

Materials and Methods

We prospectively analyzed the splenic arteriograms of 43 patients and the celiac arteriograms of 7 patients, obtained when selective insertion of catheter into splenic artery was impossible because of anatomic variation of the celiac trunk. They showed no pathology in the pancreas, spleen, and other structures in the vicinity. The patients' age ranged from 23 to 67 years (mean 48 years). There were 36 males and 14 females.

The arteriography was performed through the right femoral arterial approach using the Seldinger technique in every case. For the selective splenic or celica arteriography, preshaped catheter (6 or 7 Fr Cobra type II or Sidewinder type I or II) was used, and 12–15 ml of contrast medium (lopamiro 300) was injected at a rate of 7 ml/second. All the arteriograms were obtained in the anteroposterior projection; two films per second for the first 1 second and one film per second for the subsequent 4 seconds. The oblique projection was not done because of the limitation of the angiographic unit. However, ordinary angiogram performs on anterior posterior projection. The splenic artery was divided into four segments: the suprapancreatic, pancreatic, prepancreatic, and prehilar segments [1] (Fig. 1). The suprapancreatic segment was defined as the first 3 cm of the splenic artery, the pancreatic segment as that lying along a groove in the upper surface of the body of the pancreas, the prepancreatic segment as that running obliquely along the anterior surface of the tail of the pancreas, and the prehilar segment as that located between the tail of the pancreas and the splenic hilum [2,3].

The distal small branches of caudal pancreatic artery, superior and inferior polar arteries, left gastroepiploic artery, accessory left gastric artery, or others were defined by the parts of the supplying organ, for example, pancreatic tail, splenic superior pole, splenic inferior pole, stomach or greater omentum, and with the formation of the transverse pancreatic artery of pancreatica magna or caudal pancreatic artery.

The branching pattern of the splenic artery seen on the arteriograms was analyzed in terms of the overall incidence of each branch that was visualized and the distribution of the site of its origin.

Results

Branches from the suprapancreatic segment were found in 41 instances (82%). The dorsal pancreatic artery originated from this segment in 40 patients (Figs. 2–5, 7), and the accessory left gastric artery in one patient (Table 1).

In the pancreatic segment, the pancreatic magna artery was the most common branch and was observed in 49 patients (98%) (Figs. 2–7). The superior polar artery was the next and was found in 32 patients (64%) (Figs. 2, 3, 6). The accessory left gastric artery was found in 13 patients: eight from the pancreatic segment of the splenic artery and five from the superior polar artery (Fig. 3). The caudal pancreatic artery was found in 10 patients, the short gastric artery was found originating from the superior polar artery in two patients, the inferior polar artery was observed in two patients (Table 1).

The most frequent branches originating from the prepancreatic segment were the terminal superior and terminal

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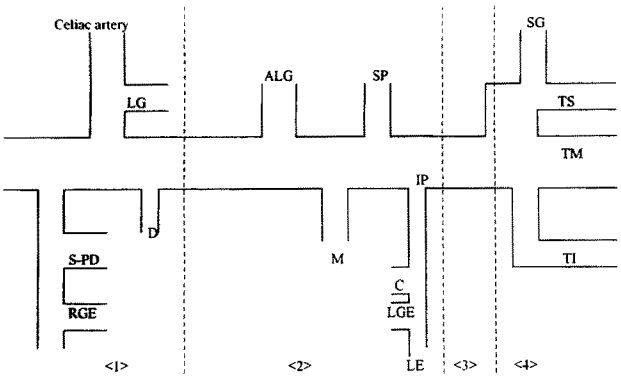

Fig. 1. Schematic diagram of four segmental divisions of splenic artery and the major splenic arterial branches and their usual origin sites. (1) suprapancreatic, (2) pancreatic, (3) prepancreatic, and (4) prehilar segment.

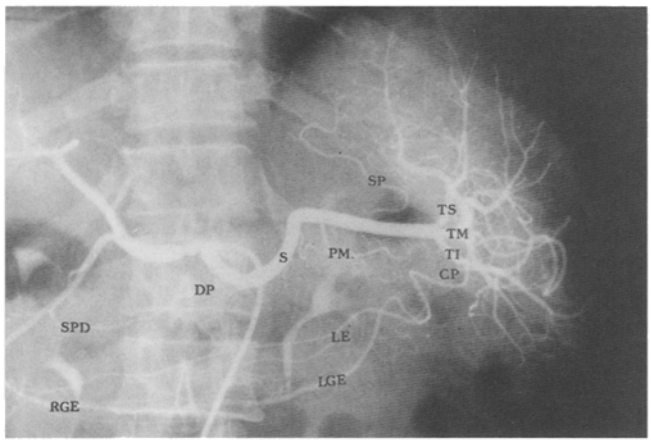

Fig. 2. Celiac arteriogram. The dorsal pancreatic (DP) artery arises from the suprapancreatic (SP) segment of the splenic (S) artery. Right branches of the dorsal pancreatic artery anastomose with the superior pancreaticoduodenal (SPD) artery. The pancreatic magna (PM) artery and superior polar (SP) artery arise from the pancreatic segment of the splenic artery. At the prepancreatic segment of the splenic artery, the splenic artery divides into the terminal superior (TS), terminal media (TM), and terminal inferior (TI) arteries. The left gastroepiploic artery arises from the terminal inferior (TI) artery, then subdivides into two branches. There is one anastomoses with the right gastroepiploic (RGE) artery to form the arcus arteriosus ventriculi inferior of Hyrtl; the other branch is the left gastroepiploic (LGE) artery. The caudal pancreatic (CP) artery arises from the left gastroepiploic artery to anastomose with the pancreatic magna artery.

inferior arteries and each branch was found in 42 patients. The terminal media artery was found in 10 patients (Fig. 2). The left gastroepiploic, caudal pancreatic, superior polar, and inferior polar arteries were found in eight, eight, two, and one patient, respectively.

The terminal superior and inferior arteries originated from the prehilar segment in eight patients each (16%), establishing these as the most constant branches (Fig. 6). The terminal media artery originated from the prehilar segment in four patients.

Branches arising from the terminal superior artery were the short gastric (nine patients), superior polar (five patients), caudal pancreatic (four patients), and left gastroepiploic artery (one patient) (Table 2) (Figs. 4, 7). Branches arising from the terminal inferior artery were the caudal pancreatic (15), left gastroepiploic (14), left epiploic (3), and inferior polar artery (1) (Table 2) (Figs. 2, 5, 6). Branches arising

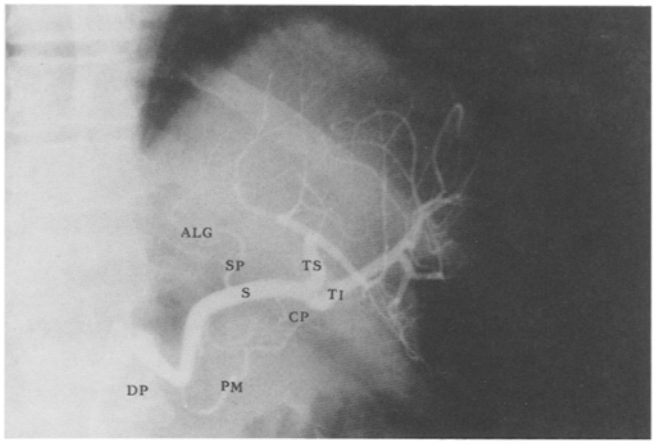

Fig. 3. Splenic arteriogram. The dorsal pancreatic (DP), pancreatic magna (PM), and caudal pancreatic (CP) arteries arise from the suprapancreatic (SP), pancreatic, and prepancreatic segments of the splenic (S) artery. The superior polar artery arises from the pancreatic segment of the splenic artery, then subdivides into the accessory left gastric (ALG) artery. The splenic artery divides into the terminal superior (TS) and terminal inferior (TI) arteries.

Fig. 4. Splenic arteriogram. The dorsal pancreatic (DP) and pancreatic magna (PM) arteries arise from the suprapancreatic (SP) and pancreatic segments of the splenic artery. At the prepancreatic segment, the splenic artery divides into the terminal superior (TS), terminal inferior (TI), and left gastroepiploic (LGE) arteries. The superior polar artery arises from the terminal superior artery. The caudal pancreatic (CP) artery arises from the left gastroepiploic artery, then anastomoses with the pancreatic magna artery.

from the left gastroepiploic artery were the left epiploic (11), caudal pancreatic (4), and inferior polar (3) (Table 2) (Figs. 4, 5).

The caudal pancreatic artery was found in 42 patients (84%). The artery originated from the pancreatic segment in 10 patients, the prepancreatic segment in 8, the terminal superior artery in 4, the terminal inferior artery in 15, the terminal media artery in 1, and the left gastroepiploic artery in 4 (Table 3).

The superior polar artery was found in 38 patients (76%). The artery originated from the pancreatic segment in 32 patients, the prepancreatic segment in 1, and the terminal superior artery in 5 (Table 4).

The inferior polar artery was found in 12 patients (24%).

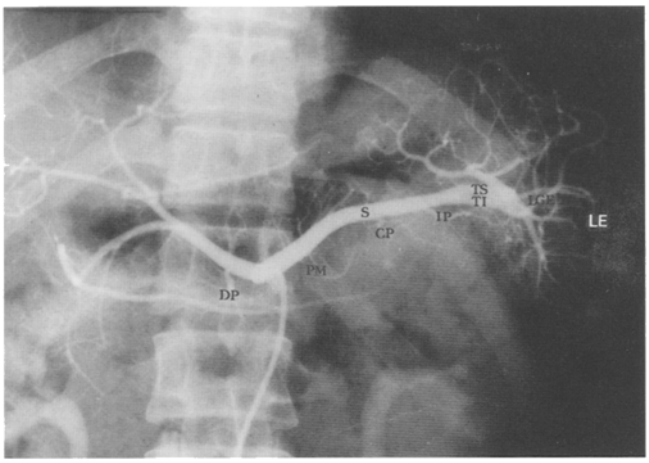

Fig. 5. Celiac arteriogram. The dorsal pancreatic (DP) artery arises from common hepatic artery. The pancreatic magna (PM) and caudal pancreatic (CP) arteries arise from the suprapancreatic, pancreatic, and prepancreatic segments of the splenic (S) artery. At the prepancreatic segment, the splenic artery divides into the terminal superior (TS), terminal inferior (TI), and inferior polar (IP) arteries. The left gastroepiploic (LGE) artery arises from the terminal inferior artery, then subdivides into the left epiploic (LE) artery.

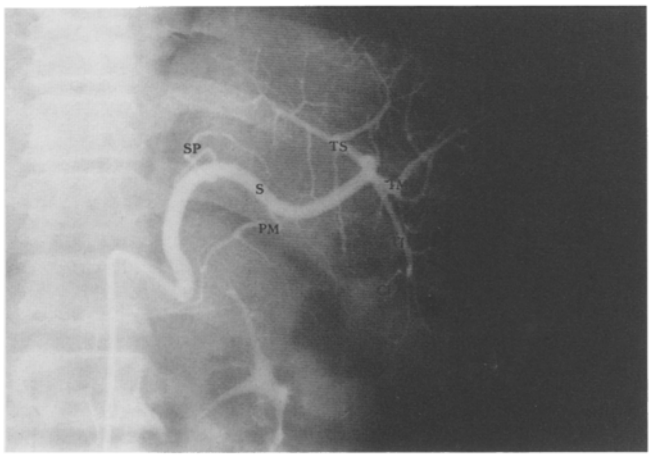

Fig. 6. Splenic arteriogram. The pancreatic magna (PM) artery arises from the pancreatic segment of the splenic (S) artery. It subdivides into two right branches. The left branch anastomoses with caudal pancreatic (CP) artery arising from terminal inferior (TI). Superior polar (SP) artery arises from the pancreatic segment of the splenic artery. At the prehilar segment, the splenic artery divides into the terminal superior (TS), terminal media (TM), and terminal inferior arteries. The dorsal pancreatic artery is not visualized.

The artery originated from the pancreatic segment in 2, the prepancreatic segment in 2, the terminal inferior artery in 1, the left gastroepiploic artery in 3, the caudal pancreatic artery in 3, and the left epiploic artery in 1 (Table 5).

The left gastroepiploic artery was found in 23 patients (46%). The artery originated from the prepancreatic segment in 8, the terminal superior artery in 1, and the terminal inferior artery in 14 (Table 6).

The accessory left gastric artery (posterior gastric artery) was found in 14 patients (28%). The artery originated from the suprapancreatic segment of the splenic artery in 1, the pancreatic segment in 8, and the superior polar artery in 5 (Table 7).

The overall incidence of some important individual

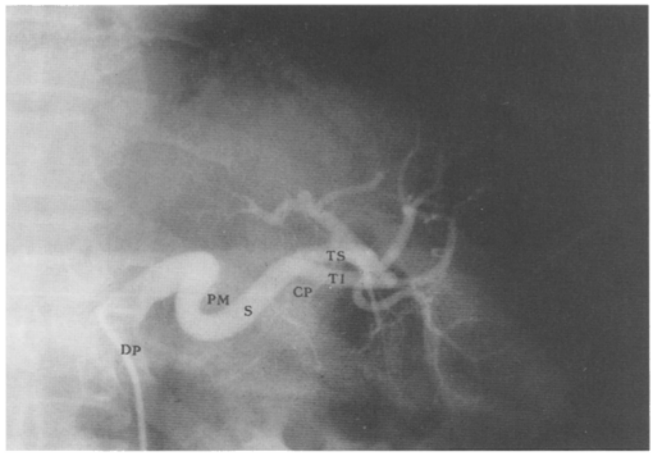

Fig. 7. Splenic arteriogram. The dorsal pancreatic (DP) and pancreatic magna (PM) arteries arise from the suprapancreatic and pancreatic segments of the splenic (S) artery. At the prepancreatic segment, the splenic artery divides into the terminal superior (TS) and terminal inferior (TI) arteries. The caudal pancreatic (CP) artery arises from the terminal superior artery.

Table 1. Origin and incidence of visualized branches of the splenic artery

Site (n = 50)	No.	%
Suprapancreatic segment		
Dorsal pancreatic	40	80
Accessory left gastric	1	2
Pancreatic segment		
Pancreatic magna	49	98
Superior polar	32	64
Caudal pancreatic	10	20
Accessory left gastric	8	16
Inferior polar	2	4
Other:		
SP-ALG	5	10
SP-SG	2	4
Prepancreatic segment		
Terminal superior	42	84
Terminal inferior	42	84
Terminal media	10	20
Left gastroepiploic	8	16
Caudal pancreatic	8	16
Inferior polar	2	4
Superior polar	1	2
Prehilar segment		
Terminal superior	8	16
Terminal inferior	8	16
Terminal media	4	8

branches and the distribution of their origins are listed together with the data from the other reports in Tables 8, 9, and 10.

Discussion

Recently, a transarterial interventional procedure of partial splenic arterial embolization was introduced to resolve the symptom of pancytopenia in certain leukemias instead of partial splenectomy by surgical intervention. However, the detailed surgical anatomy or surgical imaging is important to the surgeon or the interventional radiologist. The splenic artery has been the subject of numerous reports but most of the studies have been done through cadaveric dissections

Table 2. Branching patterns from splenic arterial branches

Site (n = 50)	No.	%
From terminal superior		
Short gastric	9	18
Superior polar	5	10
Caudal pancreatic	4	8
Left gastroepiploic	1	2
From terminal inferior		
Caudal pancreatic	15	30
Left gastroepiploic	14	28
Left epiploic	3	6
Inferior polar	1	2
From left gastroepiploic		
Left epiploic	11	22
Caudal pancreatic	4	8
Inferior polar	3	6

Table 3. Sites of origins of the caudal pancreatic artery

Site (n = 50)	No.	%
Pancreatic segment	10	20
Prepancreatic segment	8	16
Terminal superior	4	8
Terminal inferior	15	30
Terminal media	1	2
Left gastroepiploic	4	8
Total	42	84

Table 4. Sites of origins of the superior polar artery

Site (n = 50)	No.	%
Pancreatic segment	32	64
Prepancreatic segment	1	2
Terminal superior	5	10
Total	38	76

Table 5. Sites of origins of the inferior polar artery

Site (n = 50)	No.	%
Pancreatic segment	2	4
Prepancreatic segment	2	4
Terminal inferior	1	2
Left gastroepiploic	3	6
Caudal pancreatic	3	6
Left epiploic	1	2
Total	12	24

and only a few angiographic studies have been reported so far. We studied branching patterns of the splenic artery, the sites of origins of these branches, and the incidence of the splenic arterial branches on 43 selective splenic arteriograms and 7 celiac arteriograms.

In this study, the dorsal pancreatic artery was the most common branch of the suprapancreatic segment of the splenic artery with 80% incidence, in contrast to 42% in the study of Kupic et al. [1]. One accessory left gastric artery was found in this segment by the author but Kupic et al. described one left gastric artery and one inferior phrenic artery.

Table 6. Sites of origin of the left gastroepiploic artery

Site (n = 50)	No.	%
Prepancreatic segment	8	16
Terminal superior	1	2
Terminal inferior	14	28
Total	23	46

Table 7. Sites of origin of the accessory left gastric artery

Site (n = 50)	No.	%
Suprapancreatic segment	1	2
Pancreatic segment	8	16
Superior polar	5	10
Total	14	28

In the pancreatic segment, the pancreatic magna artery was the most common branch and was present in 98% of the patients but Kupic et al. reported it in only 55% of their patients. Other branches originating in this segment included the superior polar artery, the accessory left gastric artery, the caudal pancreatic artery and the inferior polar artery. The branches reported in Kupic et al.'s study were similar to this study and included the short gastric artery, the accessory left gastric artery, the left gastroepiploic artery, the superior polar artery, the terminal inferior artery, the inferior polar artery, and the middle polar artery.

In the prepancreatic segment, the terminal superior and inferior arteries were the most common branches and both branches were present in 84% of patients. Other branches found in this segment were the terminal media artery (20%), the left gastroepiploic artery (16%), and the caudal pancreatic artery (16%). These branches from the prepancreatic segment and their incidences were similar to the reports of Kupic et al.

The dorsal pancreatic artery originated from the splenic artery in 80% of the patients in this study. In the remaining 20%, the artery probably originated from either the celiac trunk or the common hepatic artery but these were not included in this study. Park et al. [4] reported the same 80% incidence but other authors reported much lower ones [1,5–7].

The pancreatic magna artery was found in 98% of the patients. The incidence of this artery was higher in studies using cadaveric dissections than angiographic studies [1,4–7].

The caudal pancreatic artery was seen in 84%, similar to most of the reports [4,5,7], but Kupic et al. reported only 16%, 13% of which arose from the splenic artery and 3% from the inferior polar artery.

The superior polar artery was found in 76%, 64% of which originated from the pancreatic segment of the splenic artery and 10% from the terminal superior artery and 2% from the prepancreatic segment of the splenic artery. Frequent branching of the superior polar artery from the pancreatic segment was also reported by others [1,8,9].

In this study, the inferior polar artery was seen in 24% but results from the literature varied from 8% in Kupic et al. [1] and 49% in Park [9] to 82% in Michels [8].

Table 8. Comparison of incidence of dorsal pancreatic (D), pancreatic magna (M), and caudal pancreatic (C) arteries

	Zeon et al (n = 50)	Kupic et al [1] (n = 38)	Park [9] (n = 45)	Park & Hong [5] (n = 94)	Suh [6] (n = 357)	Woodburne & Olsen [7] (n = 150)
D	80%	42%	80.0%	43.6%	29.13%	33.3%
M	98%	55%	95.6%	89.2%	85.43%	64.7%
C	84%	16%	82.2%	72.3%	79.83%	78.8%

Table 9. Comparison of incidence of superior polar (SP), inferior polar (IP), and left gastroepiploic (LGE) arteries

	Zeon et al (n = 50)	Kupic et al [1] (n = 38)	Michels [8] (n = 100)
SP	76%	16%	65%
IP	24%	8%	82% from S, 72% from T1 and its branches, 22%
LGE	46%	29%	

Table 10. Comparison of incidence of accessory left gastric artery

	Zeon et al (n = 50)	Didio et al [11] (n = 100)	Kim et al [12] (n = 50)	Kupic et al [12] (n = 38)
Percent	28%	46%	83%	36.8%

Kupic et al: pancreatic segment 13; prepancreatic segment 1.

The incidence of the left gastroepiploic artery was 46% and its most common site of origin was the terminal inferior artery. Michels reported that this artery originated from the splenic trunk in 72% of patients and from the terminal inferior artery and its branches in 22%. Park [9] reported that this arose from the splenic artery in 24% and from the terminal inferior artery and its branches in 76%.

The incidence of the dorsal pancreatic, pancreatic magna, and caudal pancreatic arteries was similar to the Korean reports [4,6,10], but it was higher than the reports from the study of Caucasians [1,8] (Table 8). The incidence of the superior polar, inferior polar, and left gastroepiploic arteries was also higher than in Kupic et al.'s [1] and Michels [8] studies (Table 9).

The surgical importance of the accessory left gastric artery (posterior gastric artery) derives from its relatively high incidence, from being another source of blood supply to the superior portion of the posterior gastric wall, and from having an almost hidden origin from the beginning of the splenic artery. Inadvertent transection of the posterior gastric artery during gastrectomy, especially high gastric resection with associated splenectomy, pancreatoduodenectomy or pancreatectomy, may cause postoperative bleeding or necrosis of the residual gastric stump. The accessory left gastric artery was found in 28% in this study, originating from the suprapancreatic segment in one patient, the pancreatic segment in eight patients, and the superior polar artery in five patients. DiDio et al. [11] and Kupic et al. [1] reported a slightly higher incidence rate than this study although all three studies were based on the angiographic analyses (Table 10). The difference in incidence in these three angiographic studies could be explained from the fact that DiDio et al. concentrated their study only on the accessory left gastric artery. The great difference between angiographic studies and Kim's report [12], which was based on operative dissection during gastrectomy, remains an enigma.

The differences in branching patterns of the splenic artery were noticed between this study and Kupic et al.'s. Selective splenic arteriograms were possible in 43 patients in this study but in the study of Kupic et al. the celiac arteriograms were used which probably caused some errors in the interpretation of the arteriograms from the superimposition of the major branches of the celiac trunk. Another reason why more precise and clear delineation of the splenic arterial branches was possible in this study was probably because there has been significant development in angiographic machines, film quality, and contrast media.

In conclusion, detailed surgical imaging of the splenic artery is very important to surgeons and interventional radiologist treating diseases of the stomach, pancreas, and spleen, and information obtained from this study could be utilized for surgical and/or radiologic interventional planning.

References

1. Kupic EA, Marchal WH, Abrams HL (1967) Splenic arterial pattern: Angiographic analysis and review. Invest Radiol 2:70.
2. Abrams HL (1983) Abrams Angiography: Vascular and Interventional Radiology, 3rd ed. Little, Brown and Company: Boston, pp 1531–1572.
3. Clemente CD (1985) Gray's Anatomy, 13th American ed. Lea & Febiger: Philadelphia, pp 733–739.
4. Park HJ, Lee KH, Hwang DH (1983) A study on the pancreatic arteries in Korea. Seoul J Med 24(2):165–174.
5. Park SY, Hong SW (1973) Study on the pancreatic arteries in Korean adults. Korean J Anat 6(1):101–106.
6. Suh SW (1965) Studies on the arteries of the duodenum and pancreas. New Med J 8:1235–1250.
7. Woodburne RT, Olsen LL (1951) The arteries of the pancreas. Anat Rec 111:255–270.
8. Michels NA (1942) The variational anatomy of the spleen and splenic artery. Am J Anat 70:21.
9. Park KB (1974) Anatomical studies on the splenic artery in Korean infants. J Busan Med Coll 14(1):159–164.
10. Hwang SY (1968) Anatomical studies on the celiac artery and its branches. J Busan Med Coll 8:49–59.
11. DiDio LJ, Christoforidis AJ, Chandnani PC (1980) Posterior gastric artery and its significance as seen in angiogram. Am J Surg 139:333–337.
12. Kim YS, Zeon SK, Yu W, Hwang IW (1994) Incidence and anatomy of the posterior gastric artery and its surgical importance. Mod Vasc Surg 6:132–137.
13. Johnsrude IS, Jackson DC, Dunnick NR (1983) A Practical Approach to Angiography, 2nd ed. Little, Brown and Company: Boston/Toronto, pp 3–70.