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Surgical Anatomy of the Hepatic Arteries in 1000 Cases

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Objective
Anatomic variations in the hepatic arteries were studied in donor livers that were used for orthotopic transplantation.

Summary Background Data
Variations have occurred in 25% to 75% of cases. Donor livers represent an appropriate model for study because extrahepatic arterial anatomy must be defined precisely to ensure complete arterialization of the graft at time of transplantation.

Methods
Records of 1000 patients who underwent liver harvesting for orthotopic transplantation between 1984 and 1993 were reviewed.

Results
Arterial patterns in order of frequency included the normal Type 1 anatomy (n = 757), with the common hepatic artery arising from the celiac axis to form the gastroduodenal and proper hepatic arteries and the proper hepatic dividing distally into right and left branches; Type 3 (n = 106), with a replaced or accessory right hepatic artery originating from the superior mesenteric artery; Type 2 (n = 97), with a replaced or accessory left hepatic artery arising from the left gastric artery; Type 4 (n = 23), with both right and left hepatic arteries arising from the superior mesenteric and left gastric arteries, respectively; Type 5 (n = 15), with the entire common hepatic artery arising as a branch of the superior mesenteric; and Type 6 (n = 2), with the common hepatic artery originating directly from the aorta.

Conclusions
These data are useful for the planning and conduct of surgical and radiological procedures of the upper abdomen, including laparoscopic operations of the biliary tract.

Patterns of arterial blood supply to the liver are variable. Modifications of the dominant scheme, in which the liver receives its total inflow from the hepatic branch of the celiac axis, occur in 25% to 75%[1] of cases. Under variant patterns, the lobes may receive blood supply from the superior mesenteric artery, left gastric artery, aorta, or other visceral branches. These vessels may be accessory, occurring in addition to the normal arterial supply, or replaced, representing the primary arterial supply to the lobe.

Orthotopic liver transplantation represents an ideal opportunity to study the surgical anatomy of the blood supply to the liver. The extrahepatic arteries must be identified with precision at the time of liver harvest, to

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Table 1. CLASSIFICATIONS OF HEPATIC ARTERIAL TYPES

	Type	Description	Percent
Michels[3] (n = 200)	1	Normal	55
	2	Replaced LHA from LGA	10
	5	Accessory LHA	8
			18
	3	Replaced RHA from SMA	11
	6	Accessory RHA	7
			18
	4	Replaced RHA + LHA	1
	7	Accessory RHA + LHA	1
	8	Replaced RHA + Accessory LHA or Replaced LHA + Accessory RHA	2
			4
	9	CHA from SMA	2.5
	10	CHA from LGA	0.5
Current Series (n = 1000)	1	Normal	75.7
	2	Replaced or Accessory LHA	9.7
	3	Replaced or Accessory RHA	10.6
	4	Replaced or Accessory RHA + Replaced or Accessory LHA	2.3
	5	CHA from SMA	1.5
	6	CHA from aorta	0.2

LHA—left hepatic artery; LGA—left gastric artery; RHA—right hepatic artery; SMA—superior mesenteric artery; CHA—common hepatic artery.

avoid injuries that might compromise complete arterialization of the graft. Thus, the presence of all arteries that are accessory or replaced must be demonstrated. Whether an individual vessel is accessory or replaced is not always determined, because the intrahepatic branches are not dissected. We studied variations of extrahepatic arterial anatomy in 1000 donor livers.

MATERIALS AND METHODS

The records of 1000 patients who underwent liver harvesting for orthotopic transplantation by the UCLA Liver Transplant Service between 1984 and 1993 were reviewed. The first 172 of these patients were reported previously.[2] Donor arterial anatomy was recorded as it was described in operative notes of both the donor harvest and the recipient transplantation procedures. A modification of Michels'[3] classification scheme was used (Table 1).

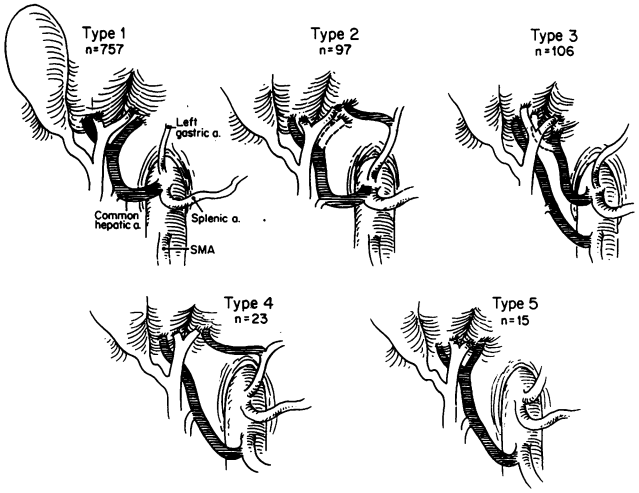

Figure 1. Hepatic arterial anatomy in 998 cases. Dotted lines indicate that the variant artery may be accessory (if branch shown by dotted line is present) or replaced (if absent). Type 1—normal; Type 2—replaced (accessory) left hepatic artery from left gastric; Type 3—replaced (accessory) right hepatic artery from superior mesenteric (SMA); Type 4—double replaced system; Type 5—common hepatic artery (CHA) from SMA. In two patients (not shown), the CHA arose directly from the aorta.

RESULTS

Arterial variations in 1000 organs could be classified as one of six types (Fig. 1):

Type 1 (n = 757). In this normal pattern, the common hepatic artery arose from the celiac axis to form the gastroduodenal and proper hepatic arteries; the

Table 2. HEPATIC ARTERIAL TYPES (%)—COLLECTED SERIES

Type	Current series (n = 1000)	Michels[3] (n = 200)	Rong[4] (n = 120)	Kemeny[5] (n = 100)	Rygaard[6] (n = 216)	Daly[7] (n = 200)	Niederhuber[8] (n = 111)
1	75.7	55	51	59*	75.5	76	73†
2	9.7	18	12	17	4.6	7.7	10
3	10.6	18	21	18	13.4	12	11
4	2.3	4		2	1.9		2
5	1.5	2.5	5	3	1.4		
Other	0.2	0.5	11	1	3.2	6	5

Trifurcation: *9%; †14%.

proper hepatic artery divided distally into right and left branches.

Type 2 (n = 97). A replaced or accessory left hepatic artery arose from the left gastric artery.

Type 3 (n = 106). A replaced or accessory right hepatic artery originated from the superior mesenteric artery.

Type 4 (n = 23). In this double-replaced pattern, the right hepatic artery arose from the superior mesenteric artery, and the left hepatic artery was a branch of the left gastric artery.

Type 5 (n = 15) The entire common hepatic artery originated as a branch of the superior mesenteric artery.

Type 6 (n = 2) The common hepatic artery took direct origin from the aorta.

DISCUSSION

Michels'[3] classic autopsy series of 200 dissections, published in 1966, defined the basic anatomic variations in hepatic arterial supply and has served as the benchmark for all subsequent contributions in this area (Table 1). Variant patterns occurred in 45% of cases, and arteries could be defined as accessory or replaced because dissection was carried into the liver substance. Michels' motivation, similar to our own, was to maximize the database of the surgeon performing procedures in and around the *porta hepatis*, to avoid injury to vascular and ductal structures.

In a previous report from our group, Brems[2] described arterial anatomy of the first 172 of the liver donors reported herein. A modification of the Michels' classification was developed to reflect the presence of vessels that were either accessory or replaced (Table 1), so that Michels' original ten groups could be reduced to five major types and a most rare sixth variant. Comparison of Michels' data with the current series (Table 1) shows a somewhat higher incidence of variant patterns in Michels' patients, primarily Types 2 and 3. We did not observe Michels' Type 10 (common hepatic artery from left gastric artery), whereas he did not observe our Type 6 (common hepatic artery from aorta).

A number of large series,[4-8] most from the surgical oncology literature, are based on arteriographic data, which also give information about the intrahepatic branches. The major experiences are compared in Table 2, using the modified classification that is shown in Table 1. Both Kemeny[5] and Niederhuber[8] describe a pattern termed "trifurcation" (common hepatic divides to form gastroduodenal, right and left hepatic arteries), which we have regarded as a subtype of the normal scheme. It is of interest that the least common variants are not seen in every series. Additional very rare patterns also have been described.[9]

The introduction of laparoscopic cholecystectomy has stimulated a renewed interest in anatomy of the hepatic arteries and bile ducts. Variations in the origin and course of the cystic artery are of particular importance to the laparoscopic surgeon.[10] The variant patterns of the major vessels also are relevant because they will affect the laparoscopic appearance of the *porta hepatis*.[11]

Hepatic arterial anatomy represents one of many "lessons for the general surgeon" that have emerged from the development of liver transplantation.[12] These arterial patterns are of importance in the planning and performance of all surgical and radiological procedures in the upper abdomen.

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