11 Intra-arterial Radiopeptide Infusions: Identifying Anatomic Variants

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11.1 Normal, Variant, and Parasitized Extrahepatic Arterial Supply to the Liver

Standard hepatic arterial anatomy and its variants were first described by Michels as mentioned in Chaps. 9 and 10, based on his study of 200 cadavers [1], where he defined ten configurations of hepatic arterial variants. Of these, the most common one is the trifurcation of the celiac artery into the splenic (SA), the left gastric (LGA), and the common hepatic artery (CHA). Then, the CHA bifurcates into the proper hepatic (PHA) and gastro-duodenal artery (GDA). The PHA in turn bifurcates into the right hepatic (RHA) and the left hepatic artery (LHA). The segment IV artery that arises from the RHA is termed middle hepatic artery (MHA). The segment IV can also originate from the LHA.

Although the abovementioned configuration is called "standard" or "normal", this is the case in only 55% of subjects. Other common variants include a replaced left hepatic artery (rLHA) arising from the left gastric artery found in 11% of patients, a replaced right hepatic artery (rLHA) arising from the superior mesenteric artery (SMA) found in 10% of patients, and an accessory left hepatic artery (aLHA) arising from the LGA, observed in another 8% of patients. Table 11.1 shows a complete list of anatomic variants according to Michel's classification.

Special attention should be paid to several suspected vessels consisting the most common parasitized arterial source of tumor supply, observed in about 18% of patients. According to Chung et al. [2] the most common one used to be the

Table 11.1 Relevant anatomic variants of the hepatic artery according to Michels's classification [1]

Type I	Standard anatomy with right, middle, and left HA arising from the CA (55%)
Type II	Replaced LHA from the LGA (10%)
Type III	Replaced RHA from SMA (11%)
Type IV	Replaced RHA from SMA, LHA from LGA and MHA from CA (1%)
Type V	Accessory LHA from LGA (8%)
Type VI	Accessory RHA from SMA (7%)
Type VII	Accessory RHA from SMA (1%)
Type VIII	Accessory RHA and LHA and replaced RHA or LHA (2%)
Type IX	CHA replaced from SMA (2.5%)
Type X	CHA replaced from LGA (<1%)

HA hepatic artery, *CA* celiac axis, *LHA* left hepatic artery, *RHA* right hepatic artery, *LGA* left gastric artery, *SMA* superior mesenteric artery, *CHA* common hepatic artery

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G. S. Limouris (ed.), *Liver Intra-arterial PRRT with ^{111}In-Octreotide*,
https://doi.org/10.1007/978-3-030-70773-6_11

right inferior phrenic artery, which was found in almost 50% of patients. The same study found that the left and right gastric artery, the superior mesenteric, and pancreatic-duodenal arteries were much less frequent.

The importance of extrahepatic blood supply of the liver was noticed by Michels who categorized 16 different routes, apart from the hepatic arterial variants, from which blood could supply parts of the liver [1], including the inferior phrenic, internal mammary, and intra-costal arteries. Furthermore, according to Seki et al. [3] tumors near the surface of the liver are more likely to recruit extrahepatic blood supply. Also, parasitized extrahepatic arteries frequently supply tumors at the bare area of the liver, (Fig. 11.1) and according to Miyayama et al. [4] they consist a main cause of recurrence after treatment. Therefore, these potential routes require close attention and appropriate recognition in the evaluation of radio-infusion patients, since they can lead to incomplete treatment and recurrence after treatment.

Similar findings were reported by Covey et al. in 2002 in a study evaluating 600 patients that had undergone angiography, where the "standard" anatomy was observed in only 61.3% of cases [5]. He further found that the most common variant was a LHA arising from LGA in 10.7%, a rRHA originated from the SMA in 8.7% of patients and several other variants not mentioned in Michals's study as a CHA directly arose from the aorta, and a "double hepatic" artery, where

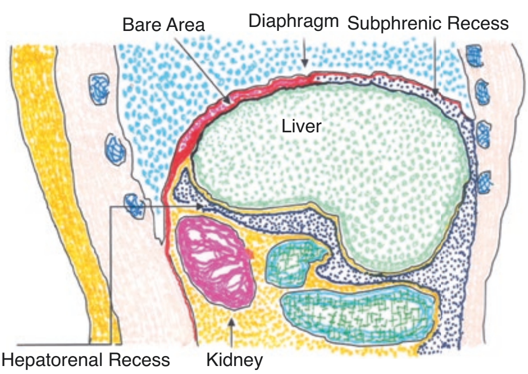

Fig. 11.1 Schematic sagittal section of the abdomen. Bare area in tight proximity to the diaphragm

one or both of the left and the right hepatic arteries originated directly from the aorta or from the celiac artery. Michals's and Covey's studies reflect the wide variability of the hepatic arterial anatomy.

According to Tohma et al. [6], the liver perihilar plexus includes arteries providing a communicating arcade between the right and left hepatic artery, connecting the segment IV branch or the main LHA with the main or anterior trunk of the RHA. Consequently, in cases where branch hepatic arteries are occluded, intrahepatic communications between segments are in existance, providing collateral flow. In studies of Mays and Wheeler in 1974 and Charnsangavej et al. in 1982 interruptions of any major hepatic artery, such as is the RHA or LHA, results in immediate filing via cross collaterals of the occluded branch [7, 8]. To be familiar and to appropriately evaluate these arcades, it is very important to expand options concerning catheter placement for radionuclide infusions [9].

11.2 Extrahepatic Arterial Anatomy: Identification and Treatment

Apart from the intrahepatic collateral vessels that supply arterial flow to tumors across segments or lobes, extrahepatic arteries, termed "parasitized", are found in about 17% of patients, either in cases undergoing chemo-embolization [2] or individuals undergoing radio-embo-lization [10]. Thus, they should be carefully screened in all diagnostic cross-sectional CT or MRI imaging required before treatment. Again, thin-section arterial phase breath-held images yield the useful information. All these variants of the hepatic arterial vasculature have to be identified during hepatic angiography before the PRRT treatment for two main reasons: (a) in case of vascular abnormalities, to prevent inappro-priate placement of the catheter into the hepatic artery, and (b) because if not identified properly may lead to radiopeptide temporary housing in excess amounts and burden the hepatic parenchyma or other neighboring to the liver organs. Superficial [3] or larger than 5 cm size tumors [2] or in contact with the bare area [4] (Fig. 11.1), the right or inferior border of the liver are prone to the aforementioned variants. Angiography is initiated with abdominal aortography with flush-injection of the mid- to lower-thoracic aorta (T8 to T11) to identify any extrahepatic vessel that could supply the liver tumor.

11.3 Conclusion

Variant hepatic arterial anatomy and parasitized extrahepatic arteries can guarantee for an intended sufficient degree of destruction of intrahepatic tumors. The carefully consecutive screening of the arterial extrahepatic anatomy on the course of the initial angiography, performed before each radiopeptide infusion, assesses the therapeutic efficacy of the radiopeptide treatment.

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