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REVIEW / *Gastrointestinal imaging*

Radioembolization with yttrium-90 microspheres work up: Practical approach and literature review

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Abstract Radioembolization (RE) is a selective internal radiotherapy technique in which yttrium-90 blended microspheres are infused through the hepatic arteries. It is based on the fact that primary and secondary hepatic tumors are vascularized mostly by arterial blood flow whereas healthy hepatocytes obtain their blood supply mostly from the portal network. This enables high radiation doses to be delivered, sparing the surrounding non-malignant liver parenchyma. Most of the complications are caused by unexpected particles passing into the gastrointestinal tract through branches originating from the main hepatic arterial supply. Knowledge of this hepatic arterial network and of its variations and the technical considerations this raises are required in preparation for treatment. This work describes the specific anatomical features and techniques for this anatomy through recent literature illustrated by cases from our own experience.

Abbreviations: CA, Celiac axis; SMA, Superior mesenteric artery; HA, Hepatic artery; CHA, Common hepatic artery; GDA, Gastroduodenal artery; APDA, Anterosuperior pancreaticoduodenal arcade; MHA, Main hepatic artery; RGA, Right gastric artery; LGA, Left gastric artery; CA, Cystic artery; FA, Falciform ligament artery; RHA, Right hepatic artery; aLHA, Left hepatic artery; PA, Phrenic artery; aLHA, Accessory left hepatic artery; aRHA, Accessory right hepatic artery; SDA, Supraduodenal artery; RE, Radioembolization; ^{90}Y, Yttrium-90; AMA, Albumin macroaggregates; CT, Computer tomography; HCC, Hepatocellular carcinoma; MIP, Maximum Intensity Projection; TACE, Transcatheter arterial chemombolization; CT, Computed tomography; rLHA, Replaced left hepatic artery; rRHA, Replaced right hepatic artery.

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Introduction

Hepatic radioembolization is a recent oncological interventional radiology technique reported for the first time in 1988 [1], and used to treat hepatocellular carcinoma and liver metastases. This technique involves administering glass or resin microspheres loaded with yttrium-90 through a catheter into the artery or arteries supplying target lesions. Yttrium-90 is a beta emitter with a half-life of 64.053 hours and disintegrates into zirconium-90, which is stable. The average penetration of the irradiation is 2.5 mm, reaching a maximum of 10 mm. By coming closer to the target lesions very high doses can therefore be delivered, reducing the toxicity to the adjacent liver parenchyma, unlike external radiotherapy [2]. Both the treatment itself and its success are governed by several stages:

- CT and MR for arterial mapping and to assess the hepatic lesions;
- arteriography, the purposes of which are to occlude the various arteries in the hepatic pedicle which run outside of the liver in order to reduce extrahepatic diffusion of the microspheres as the extent of embolization varies between groups and depending on the substances used for treatment [3—6]; to occlude accessory arteries supplying the liver, attempting to achieve arterial supply only from the hepatic artery or its variants. The use of computed tomography reconstruction mode, available on some angiography tables, or cone-beam CT is, in the opinion of some authors, a valuable aid to this stage [3,5,7,8];
- technetium 99 scintigraphy, which is used to quantify the hepatopulmonary shunt and confirm that no extrahepatic uptake is present.

Because of the risk of radiation damage, these factors may contraindicate treatment in some cases.

This report describes each stage from our own experience and from the literature, with particular attention to the technical points which need to be understood. Each artery is described in succession, explaining its anatomy, how to recognize it on computed tomography and how to manage it in the preoperative phase.

In some cases, occlusion of some arteries is a real technical challenge and we describe from our own experience the different technical options available, some of which are inspired from interventional neuroradiology techniques.

Extrahepatic branches of the hepatic pedicle

Gastroduodenal artery

The common hepatic artery (CHA) divides into the main hepatic artery (MHA) and the gastroduodenal artery (GDA). The GDA runs along the posterior aspect of the first part of the duodenum, giving rise to the anterosuperior pancreaticoduodenal artery, next to the upper part of the pancreas and divides into the inferior pancreaticoduodenal artery and the gastro-epiploic artery, running to the inferior edge of the duodenum. There are many anatomical variants, some of which may impact on the procedure. These include the origin of a cystic artery (Fig. 1b) and right gastric or right hepatic artery (single or accessory).

This artery is always present and it can be easily identified both on CT and on arteriography (Fig. 1).

Reflux of yttrium-90 (^{90}Y) loaded spheres into the GDA carries a risk of pancreatitis (ischemic or radiation-induced) and gastroduodenal ulceration, explaining why most authors agree that it should be occluded [3,9—13]. The risk of reflux is increased if the GDA arises distally from the MHA (and particularly if it arises from a trifurcation of the MHA into right and left branches of the hepatic artery and GDA) [3,5]. When the decision is made to occlude this artery, it should be occluded as proximally as possible as branches supplying extrahepatic regions commonly arise very early (Fig. 1b). Possible collateral branches should also be looked for and occluded [2,11] (Figs. 2 and 3).

Occlusion of this artery is debatable in two situations:

- in the presence of retrograde flow (hepatopetic), a situation usually seen in tight stenoses or obstruction of the celiac axis (CA), occluding the artery, is of no benefit and may even be potentially harmful in this situation [14—16];

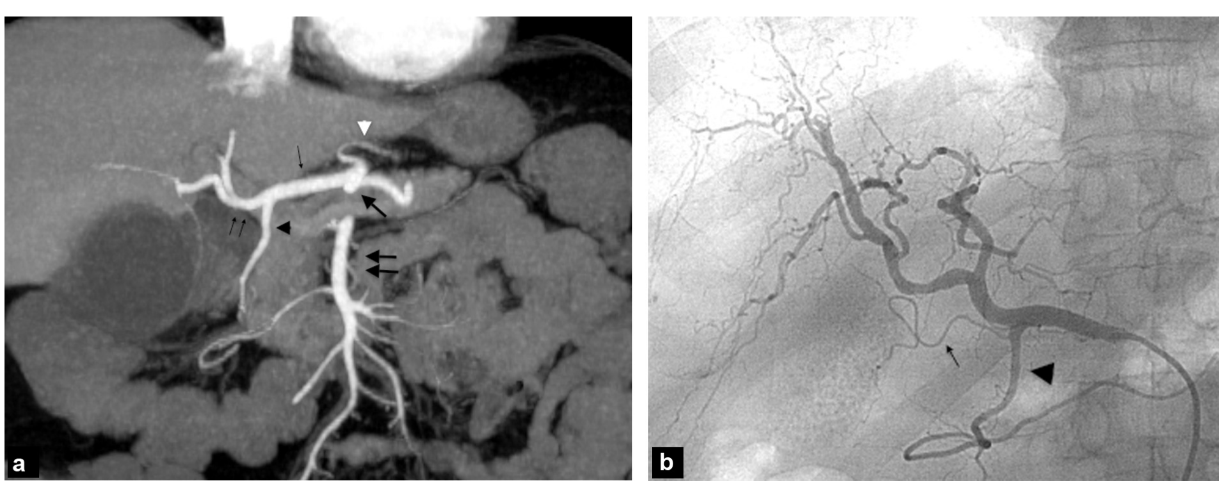

Figure 1. a: MIP coronal reconstruction of an abdominal CT in the arterial phase. Celiac axis (black arrow), superior mesenteric artery (double black arrow), common hepatic artery (small arrow), gastroduodenal artery (black arrowhead), main hepatic artery (double small arrow), left gastric artery (white arrowhead); b: hepatic arteriography with opacification of the common hepatic artery, showing the gastroduodenal artery (arrowhead) and cystic artery (arrow). Note the presence of many gallstones.