Work-up of Liver radioembolization with Yttrium-90 microspheres: practical approach and literature review

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Learning objectives

This poster provide a practical approach of the radioembolization (RE) work-up with detailed:

- Liver arterial vasculature and main variations;
- How to identify those arteries on preprocedure CT-scan and during arteriography
- Main issues related to those arteries and practical management
- Technical tips and tricks
- Recent literature review and personal experience confrontation

This educational exhibit is addressed to:

- novice RE practitioners: vascular liver variations, problems encountered and their technical management, step by step detailed RE proceeding.
- to advanced practitioners: recent literature review illustrated with personal cases. The interest of the interventional neuroradiology devices are underlined.

Background

Liver selective internal radiotherapy technique (SIRT) is an oncologic interventional radiology technique, first reported in 1988, dedicated for hepatocarcinoma and secondary lesions. The method consists in infusion of Yttrium-90 blended microspheres through hepatic arteries. This radioelement undergoes Beta minus decay to Zirconium-90 with a half-life of 64 hours. The mean rays penetration is 2.5 mm for a maximum of 10 mm. High radiation doses are delivered, sparing surrounding non neoplastic liver parenchyma [1][2][3].

This treatment is made of several steps:

1) Hepatic CT-scan and MRI to assess hepatic arterial anatomy and malignant liver lesions.
2) arteriography, realized for :
- occlude extrahepatic vessels originating from the hepatic vasculature to avoid extra-hepatic non target Y-90 administration
- occlude parasitic arteries (extrahepatic arteries feeding hepatic lesions)

3) Technetium-99 scintigraphy to assess hepato-lung shunt and identify potential extra-hepatic uptake.

4) Treatment : Yttrium-90 administration

Through personnal experience and litterature review, this work will give a practical approach of the two first steps, focusing on the major technical points to know. Each hepatic vessel anatomy, recognition and management will be detailed.

**Findings and procedure details**

Contents:

I) Extrahepatic arteries originating from the hepatic vasculature:
- Gastroduodenal artery (GDA)
- Right gastric artery (RGA)
- Cystic artery (CA)
- Falciform artery (FA)
- Supraduodenal and retroduodenal artery (SDA, RDA)

II) "Parasitic arteries" : extrahepatic arteries feeding hepatic lesions:
- Phrenic artery (PA)
- Others (omental artery, internal mammary artery...)

III) Main anatomical variants:
- Replaced right hepatic artery and accessory right hepatic artery
- Replaced left hepatic artery and accessory left hepatic artery

RE = radioembolization; DSA = digital subtraction angiography; CHA = common hepatic artery; GDA = gastroduodenal artery; PHA = proper hepatic artery; RHA = right hepatic artery; LHA = left hepatic artery; RGA = right gastric artery; LGA = left gastric artery; FA = falciform artery; CA = cystic artery; PA = phrenic artery; MIP = maximum intensity projection; Y-90 = Yttrium-90

I) Extrahepatic arteries originating from the hepatic vasculature

a) Gastroduodenal artery

- Main hepatic common artery branch
- Role: pancreas, duodenum and gastric blood supply
- Always and easily identifiable on CT-scan and DSA (Fig. 1 & 2)
- Issues if non targeted microspheres get through: ischemic pancreatitis, duodenal ulcer,..
- Management: occlusion recommended for most authors [3] [9-13]. Exceptions: 1) Retrograde flow: occlusion or coeliac axis stenosis and rare cases of retrograde flow by highly vascular tumors 2) Distal injection of microspheres (reflux risk is very low)
- Occlusion: as proximal as possible. Mostly by coils but can be difficult due to packing migration when the GDA diameter is large. It can require many coils. Solutions: "anchor technique" (Fig. 3), plug occlusion (Fig. 4) or temporary balloon occlusion

b) Right gastric artery

- Role: lesser curvature and pylorus vascularization (with the left gastric artery).
- Originates from proper hepatic artery (45 - 57%) or left hepatic artery (23%) and sometimes gastroduodenal artery (3 - 12%), common hepatic artery (2.7 - 5%) and right hepatic artery (4%) [20][21].
• Most of the time visible on pretherapeutic CT scan (Fig. 5) and always identified on DSA in literature. Its characteristic curvature (Fig. 6) makes it easy to recognize.

• Issues: from epigastric transient pain to antrum or pylorus giant ulcer which may require surgical treatment (2.9 - 4.8% in a large study) [24].

• Occlusion recommended by most authors [2][3][10][21].

• Technetium-99 scintigraphy is useful to check a potential gastrointestinal uptake (Fig. 7).

• Catheterism: sometimes difficult due to proximal angulation and anatomic variations. Can require 2.1 - 1.7 microcatheter with 0.014 inches microwire. Usefulness of multiplanar CT-scan reformations to assess angulation before DSA (Fig. 8).

• Occlusion: mostly by coils (1.5 - 2mm) with proximal occlusion (collaterals, proximal divisions). If failure to embolize, the left gastric artery route can be used to reach the origin of RGA (successfully catheterized up to 89%) (Fig. 9) [31]. Another possibility is its temporary occlusion by remodeling balloon (Fig. 10) [18].

c) Cystic artery

• Role: supplies blood to gallbladder and extrahepatic biliary tract.

• Origins: RHA in 64% of cases (proximal or close to anterior and posterior sectorial arteries fork), CHA in 26.7%, LHA in 5.5% and GDA in 2.6%. Accessory cystic artery: 2 - 25% [34-36].

• Typical "Y" shaped. Most of the time noticeable on CT-scan and DSA (Fig. 11).

• Issues: complications are infrequent, sometimes transient right upper abdominal pain. Radiation induced cholecystitis reported up to 23% in series.

• How to manage CA? Distal injection when possible (up to 30%). Gelfoam pledges occlusion is recommended by numerous authors. Coil occlusion needs to be as proximal as possible to allow development of collateral arteries. Temporary balloon occlusion is also possible (Fig. 12) [37][38].

• High clinical and radiologic discordances with frequent wall thickening of the gallbladder on CT scan but without pejorative evolution [37][39][40].

d) Falciform artery
Role: occasional terminal branch of the left or middle hepatic artery and is part of the communicating arcade between distal superior and inferior epigastric branches.

Origins: S4 (68%), S3 and S23 [7][42].

Almost never seen on CT. Typical "L" shaped artery with cranio-caudal direction towards abdominal anterior wall sometimes seen with adequate output injection. Identified in anatomical series up to 70% but only 10% on DSA due to its thin diameter (0.7 mm). Better seen with high flow in LHA and during venous phase (Fig. 13) [43][44].

Issues: Rare, benign and mostly transient. When occurs, some kind of wall abdominal pain is the most common presentation but some cases of skin necrosis have been described.

Tc99 scintigraphy analysis for subtle abdominal wall uptake is required.

Management: Occlusion only when abdominal wall uptake is noticeable for most authors (with 0.018 coils).

c) Supraduodenal artery

Role: proximal horizontal segment of duodenum.

Origins: GDA (27%), CHA and PHA (20%), LHA (20%) or RHA (13%) [35][50].

Found in 93% of surgical series. Thin artery sometimes seen in arteriography.

Issues: same as RGA.

Management: occlusion by coils if identified [3][9]

II) "Parasitic arteries": extrahepatic arteries feeding hepatic lesions

Extrahepatic supplies to hepatocarcinoma is well known and concern up to 30.8% of patients. Several factors lead to the development of those afferences like previous chemoembolization procedure, tumor size (63% of tumors > 6cm), exophytic tumors, surface location tumors, bare area contact, ....

Although numerous chemoembolization procedures through those arteries have been reported so far, very little cases of similar approach with radioembolization have been described [51].
The development of intrahepatic shunts after occlusion of those arteries and restoration of intrahepatic blood supply is well-known. The successful reestablishment of this anterograde blood flow through intrahepatic collateral vessels can be confirmed by DSA, Tc99 Scintigraphy or tumor response in those territories [51].

a) Inferior phrenic artery

- **Role:** Supplies most of the diaphragm.

- **Most common extrahepatic collateral vessel** that supplies hepatocarcinoma (up to 37%). Important factors: large tumor located in the S7, contact with the diaphragm, previous chemoembolization [56-58].

- **Anatomy:** originates mostly from celiac trunk and abdominal aorta (40 and 38% for the right phrenic artery) by a common trunk or separately. Can also arise from renal arteries, left gastric artery or CHA. Frequent anastomosis with internal thoracic artery, intercostal and adrenals arteries. May supply part of the inferior oesophagus, inferior vena cava wall or adrenal gland [62].

- **Easily identified on CT-scan** (Fig. 14). Not visible on celiac trunk injection due to proximal origins. Catheterism with "Shepherd-hook" or "S" shaped catheter is easier (Fig. 15)

- **Issues:** risks of suboptimal treatment if significant tumor is fed by this artery in case of non obstruction

- **Management:** Distal occlusion by coils to eliminates parasitic perfusion and restore intrahepatic blood supply is mostly recommended (Fig. 16) Re-establishment of anterograde blood flow through hepatic main artery can be confirmed by DSA or Tc99 scintigraphy, showing uptake in tumors previously fed by PA.

b) Other parasitic arteries

- Omental artery, Intercostal arteries, cystic artery, internal mammary artery and superior mesenteric artery branch are the most encountered.

- Most of the time thin arteries without significant lesion blood supply.

- In cases of significant feeding, occlusion to restore intrahepatic blood supply is recommended

III) Main anatomical variants

a) Replaced right hepatic artery and accessory right hepatic artery
• Most common variation: right hepatic artery arising from superior mesenteric artery. This artery is called replaced RHA if it is the only feeding trunk of the right liver (3%) and accessory RHA if the RHA persists (10 - 12%) [20][65].

• Sometimes arise from GDA, caeliac trunk or phrenic artery

• Easily identified on CT-scan.

• Management: 1) Infusion Y90 microspheres through the replaced RHA after assessment of the volume of the liver fed by the artery 2) Occlusion by coils or plug to open intrahepatic anastomosis and re-establish the anterograde blood flow through PHA.

b) Replaced left hepatic artery and accessory left hepatic artery

• Left hepatic artery arising from left gastric artery called replaced LHA or accessory LHA when LHA arising from PHA is present. Also called gastrohepatic trunk [20].

• Supplies most commonly to segments 2 & 3 but sometimes also segment 4.

• Easily identified prospectively on CT-scan in the ligamentum venosum fissure

• Issues: branches such as inferior oesophageal, inferior phrenic, accessory left gastric carrying risk of non target embolization when Y90 spheres are infused through. Identification of the coronary vein during injection of the gastrohepatic trunk is a sign of extrahepatic flow.

• Management : 1) Reestablishment of anterograde blood flow through main hepatic vasculature by occlusion of the replaced/accessory LHA is recommended (figure) 2) Radioembolization through this artery is possible after occlusion of all extrahepatic vessels.

• Special attention is required during catheterisation of this artery due to its spasm and dissection propensity [2][21].

Images for this section:
Fig. 1: Maximum Intensity Projection of Coronal CT-scan reconstruction: Gastroduodenal artery (arrowhead) arise from CHA
Fig. 2: Common hepatic artery injection: Gastroduodenal artery (arrowhead). Cystic artery arising from GDA (arrow)
Fig. 3: (a) CHA injection identifies the GDA (arrowhead) and superior pancreaticoduodenal artery (SPDA) (arrow). (b) Anchoring the first coil in the SPDA (arrow) Previous right gastric artery coilin (double arrow). (c) Achieving coil embolization without packing migration (arrowhead). (d) Occlusion of the GDA
**Fig. 4:** (a) GDA (arrowheads) injection with previous RGA embolization (arrow). (b) Plug deployment in the GDA. (c) Occlusion of the GDA (arrow). Note the arterioportal shunt (double arrow)

![Fig. 4](image1)

**Fig. 5:** (a) Axial MIP CT and (b) Coronal MIP CT demonstrate left hepatic artery (arrowhead) and right gastric artery (arrow)

![Fig. 5](image2)

**Fig. 6:** (a) CHA injection identifies large right gastric artery (RGA) (arrows) arising from PHA. Previous left hepatectomy (arrowheads) (b) Lesser gastric curvature (arrows) from RGA (arrowhead) to LGA (large arrow) (c) Occlusion of both RGA and GDA

![Fig. 6](image3)
Fig. 7: Technetium 99 scintigraphy after work-up without occlusion of the right gastric artery, showing large uptake on the antropyloric region
Fig. 8: (a,b) Axial and coronal MIP CT with RGA (arrows). (c) Coronal oblique MIP CT reconstruction "rolling out" the RGA (arrow) and make easier the catheterization of the RGA (d).
Fig. 9: (a, b, c) Selective catheterization of the LGA (arrow) toward the proximal segment of the RGA (double arrow). (d) Occlusion of the RGA
Fig. 10: (a) Injection of the CHA and (b, c) the LHA (arrowhead) identifying a thin RGA (arrows). Because of failure to catheterize the RGA, a remodeling balloon (arrowhead) is inflated in front of its origin. Y-90 administration is realized downstream through a microcatheter (arrow). Balloon microwire extremity double arrow)
**Fig. 11:** (a) Coronal MIP CT. GDA (arrowhead), CA (large arrow) and its two branches (arrows). (b) Opacification of the CHA demonstrates the CA (arrowhead) and a parasitic artery feeding the liver developed from the CA (arrow).

![Fig. 11](image)

**Fig. 12:** (a) Catheterization of the CA (double arrow) and temporary occlusion by remodeling balloon (b) (same patient as Fig. 11)
Fig. 13: CHA injection identifies a thin falciform artery originating from S4
**Fig. 14:** (a) Axial and (b) Coronal MIP CT identifies inferior right phrenic artery (arrows) close to segment II lesion (arrowhead)

**Fig. 15:** Catheterization of a common trunk of right and left inferior phrenic arteries
Fig. 16: (a) Injection and (b) occlusion of the inferior right phrenic artery.
Fig. 17: (a) Injection of the accessory left hepatic artery (aLHA) (arrow) arising from a gastrohepatic trunk. (b) Occlusion of the aLHA by coils. Withdrawal of the microcatheter (arrowhead) and injection identifying the left gastric artery (double arrow), secondary catheterized (c). Note the RGA proximal segment (arrow) arising from PHA (double arrow). (d) Anterograde flow in the accessory left hepatic artery through main LHA.
Conclusion

Work-up is a key step in radioembolization procedure. The technique is based on practical knowledge of hepatic vasculature and variations. Meticulous pretreatment procedure is required in order to provide the safest and most effective treatment.

Personal information

Special thanks to the "Société d'imagerie abdominale et digestive" (SIAD)

Fig. 18
References: SIAD

Images for this section:
References


