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Case Report

Delivery of selective internal radiation therapy complicated by variant hepatic vascular anatomy

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ARTICLE INFO

Article history:

Received 3 March 2019

Revised 6 March 2019

Accepted 6 March 2019

Available online 23 March 2019

Keywords:

TARE

HCC

Vascular anatomy

Anatomic variants

ABSTRACT

“Difficult vascular anatomy” is a challenge for Interventional Radiologists especially in liver directed therapies such as trans arterial radio embolization.

Trans arterial radio embolization is a long and difficult procedure in which the basic knowledge of hepatic and gastro-enteric vascularization, with its high degree of variations, is very important in order to correctly administer the therapeutic drug selectively.

In this report, we present a case of an atypical patient affected by an unresectable hepatocellular carcinoma, candidate for Radio-embolization treatment.

His vascular anatomy was very difficult to manage, but the Interventional Radiologist was not only able to go over the “difficult anatomy,” but also to take advantage of it.

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Introduction

Trans arterial radio embolization (TARE) is a difficult interventional procedure in which the high degree of variations

of both hepatic and gastro intestinal vascularizations can be a challenge for Interventional Radiologist. Now more than ever, the aim of Interventional Radiologists is to achieve a correct and safe administration of Y90 microspheres through the liver targeted areas, avoiding unintended reflux into the

Conflict of Interest: Authors declare that they have no conflict of interest. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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<https://doi.org/10.1016/j.radcr.2019.03.009>

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Fig. 1 – CT exam performed before and after intravenous infusion of contrast medium, documented the presence of a large and infiltrative hepatic mass in the VIII-VII hepatic segment (axial plane).

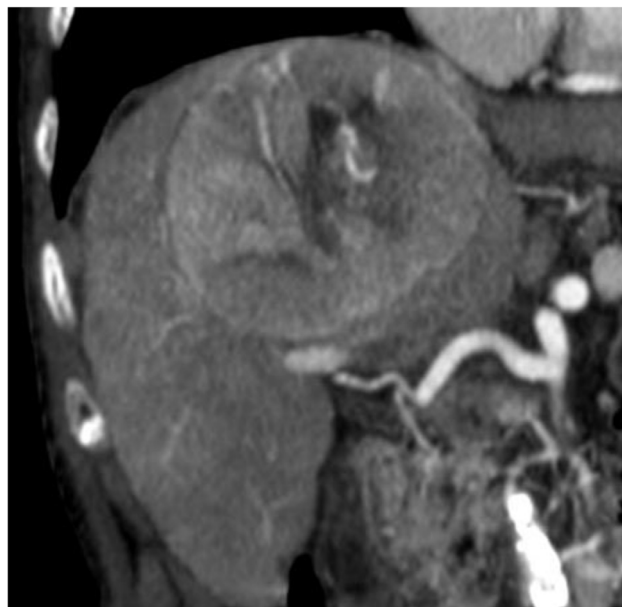


Fig. 2 – Hepatic lesion on the sagittal plane.

gastro intestinal district. The correct administration of Y90 microspheres requires the catheterization of a single vessel feeding the tumor in order to achieve good results safely. With tumor neoangiogenesis and common and uncommon vascularization variants this possibility is not always guaranteed.

This brief report describes how a patient affected by hepatocellular carcinoma (HCC) with a particular and complicated vascular anatomy consisting of several replaced hepatic arteries, was successfully managed, allowing a correct radio-embolization treatment.

Neoplastic tissue within the liver was significantly reduced after the procedure and patient did not have any complication as a consequence of this specific managing of its abdominal arteries.

Case

A 55-year-old man with no history of underlying liver disease presented with 6 months of vague abdominal pain, back pain and weight loss.

Multislice abdomen CT showed a large, expansive, and infiltrative hepatic nodule in the VIII-VII segment (Figs. 1 and 2; morphologic sizes on multiplanar reconstruction: $89 \times 78 \times 76$ mm). The nodule showed a significant wash-in in the arterial phase (Fig. 3) followed by a rapid wash-out in the venous phase (Fig. 4). The CT characteristics of this lesion were suggestive for HCC. The diagnosis was confirmed with 18g needle biopsy.

The nodule was not suitable for surgery, therefore the patient was referred to TARE. The step-by-step process for TARE-Y90 planning, therapy, and clinical follow-up is described below.

Both at the CT examination and at the angiography before treatment, there is evidence of some vascular anomalies that made this case extremely difficult. First of all, the CT scan showed the presence of a calcific plaque on the anterior wall of abdominal aorta which caused stenosis of the celiac trunk and dilatation of the vessel beyond the stenosis (Fig. 5).

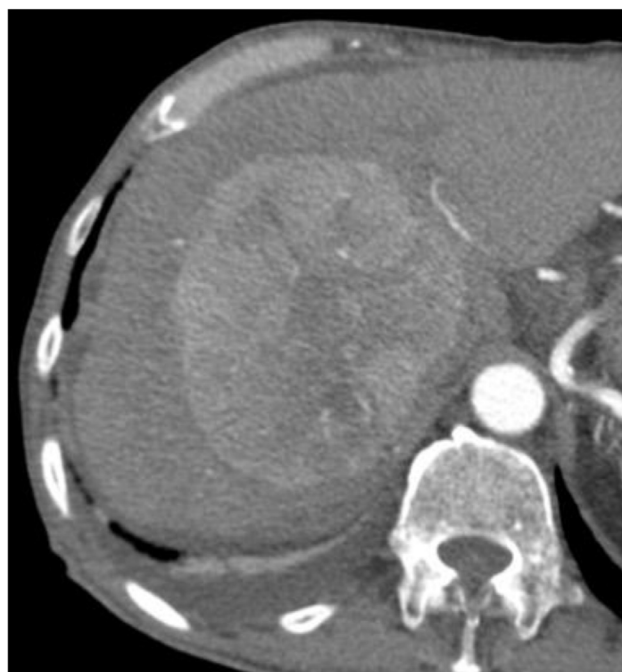


Fig. 3 – In the arterial phase of CT exam, the lesion has an early enhancement with centripetal pattern.

On the sagittal plane (Fig. 6), the Radiologist documented a very close origin of the celiac trunk and superior mesenteric artery from the abdominal aorta associated with a slight “attraction” of the celiac trunk caudally (toward the superior mesenteric artery) determined by the calcific plaque. The 2 vessels, therefore, had a separate but extremely close origin from the abdominal aorta.



Fig. 4 – In the venous phase of CT exam, the lesion has a rapid wash-out. The CT pattern is suggestive for hepatocarcinoma.

In addition, the angiographic exam shows an anatomic variation of the celiac trunk. The splenic artery, the left gastric artery, the diaphragmatic, and pancreatic branches originate from the celiac trunk (Fig. 7), whereas the common hepatic artery (CHA)—together with superior GDA—originates from the superior mesenteric artery (Fig. 8). Furthermore, the right hepatic artery (RHA) splits early in an anterior (efferent vessel for VIII segment) and a posterior branch (efferent vessel for VII, VI, and V segments).

During the angiographic survey, the Interventional Radiologist proceeded with selective catheterization of CHA. The angiographic examination, showed 2 median arteries arising from the posterior branch of the RHA. From the hepatic median arteries the right gastric artery and efferent vessels to V, VI, and VII hepatic segments arise (involved in the pathologic process; Fig. 9).

In this case not only there is the transposition of common liver artery on the upper mesenteric artery, but also the absence of the hepatic proper artery and a direct origin of upper GDA and 2 right liver branches (anterior and posterior). The left hepatic artery—on the other hand—arises from the left gastric artery (LGA).

In the angiography before treatment – moreover – the interventional radiologist detected some little vessels which connected median hepatic arteries with the left hepatic artery (LHA) (and – as a consequence – with LGA; Fig. 10). Administration of Y90 microspheres just from the CHA – then – would have meant a high risk of migration of Y90 particles in the gastric vascular district.

The angiographic survey before treatment ends with the embolization of the upper GDA with micro-coils (3 × 3 mm—, Boston Scientific) and injection of macro-albumin marked with technetium⁹⁹ (MAA^{Tc}) from each branch of RHA.



Fig. 5 – On the CT exam, there was evidence of a calcific plaque on the anterior wall of abdominal aorta with associated stenosis of the celiac trunk.



Fig. 6 – On the sagittal plane of CT exam, there was evidence of a close origin of the celiac trunk and superior mesenteric artery (SMA) from the aorta. Moreover, the celiac trunk has a slight attraction toward SMA.

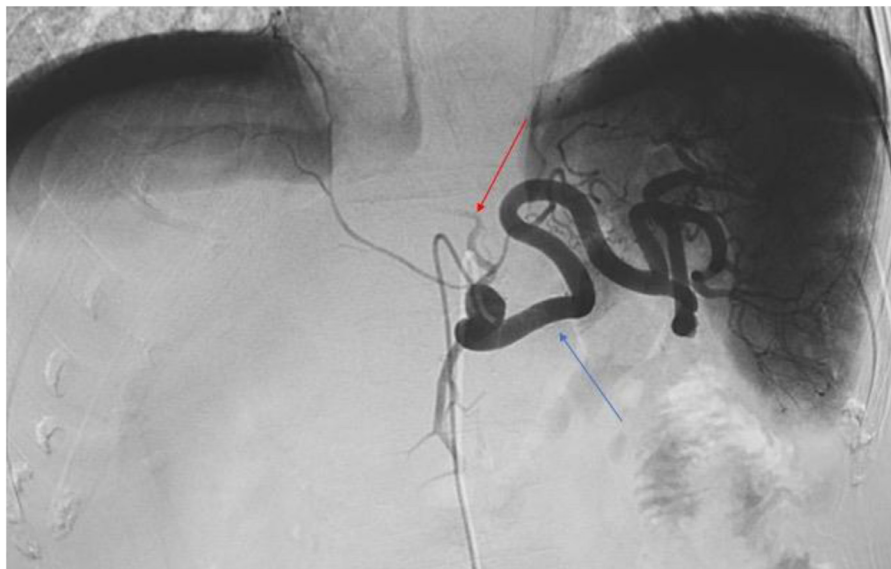


Fig. 7 – Anatomy of the celiac trunk. After selective catheterization, the angiography documented the presence of only the splenic artery (blue arrow) and the left gastric artery (red arrow). (Color version of figure is available online.)



Fig. 8 – Anatomy of SMA. After selective catheterization, the angiography documented the presence of common hepatic (blue arrow) and superior gastro-duodenal (red arrow) arteries. (Color version of figure is available online.)

SPECT examination performed after angiography, demonstrates the distribution of macro-albumin/⁹⁹technetium not only in the pathologic areas, but also in the stomach and in the spleen (Fig. 11).

This distribution was the consequence of an “active” role of median hepatic arteries and of the shunt between median hepatic arteries and the LHA. No significant pulmonary shunt (< 15%) was detected.

The second session treatment started with super-selective catheterization of the LGA and the LHA, through the celiac trunk (Fig. 12). The first goal of the operator was to close the arterial vessels connected with the median hepatic arteries (Fig. 12, red arrows). Embolization of 2 vessels originating from LHA—was performed with microcoils (2 × 3 mm, Boston Scientific; Fig. 13).

After catheterization of the upper mesenteric artery and right liver artery, the interventional radiologist performed an angiographic check (Figs. 14 and 15). The angiography detected the presence of active shunts between left liver artery and some little arterial vessels originating from the 2 median hepatic branches.

Despite the previous embolization of the 2 major branches of the left liver artery, it was necessary to close these thin vessels so as to exclude—as much as possible—any direct and indirect shunt between the vascular area of the RHA and the LHA (remember: the LHA was directly connected with the LGA).

The operator performed super-selective catheterization with microcatheter (2.7 Fr; Terumo-Progreat) of each median hepatic artery and—therefore—embolization with micro-coils (2 × 2 mm, Boston Scientific) of each vessel connected with the LHA (Fig. 16).

Another angiographic check with contrast injection from CHA was performed.

This check was useful to demonstrate the efficacy of a correct embolization with the exclusion of all the vascular shunts between the vascular branches of the right and the LHA.

In conclusion, the interventional radiologist not only stopped any direct and indirect shunt between the 2 vascular areas (and, as a consequence, the para-physiological shunt between the liver and the stomach) but – thanks to the selective embolization – created a preferential significant hemodynamic flow diversion to the right liver and to pathologic area (Fig. 17).

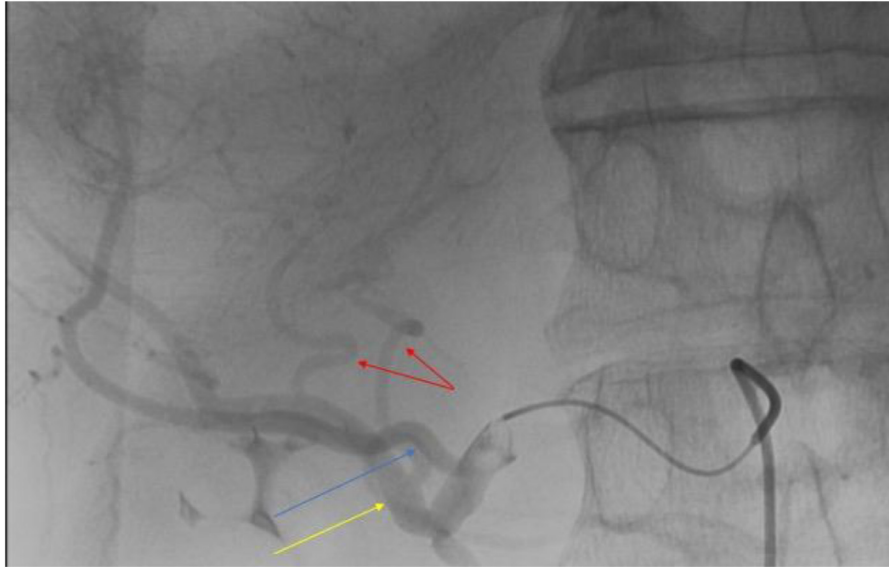


Fig. 9 – Anatomy of the arterial hepatic district. After selective catheterization of the common hepatic artery, the angiography documented a right hepatic artery which splits early in an anterior (blue arrow) and posterior branch (yellow arrow). From the posterior branch, 2 median arteries originate (red arrows). (Color version of figure is available online.)

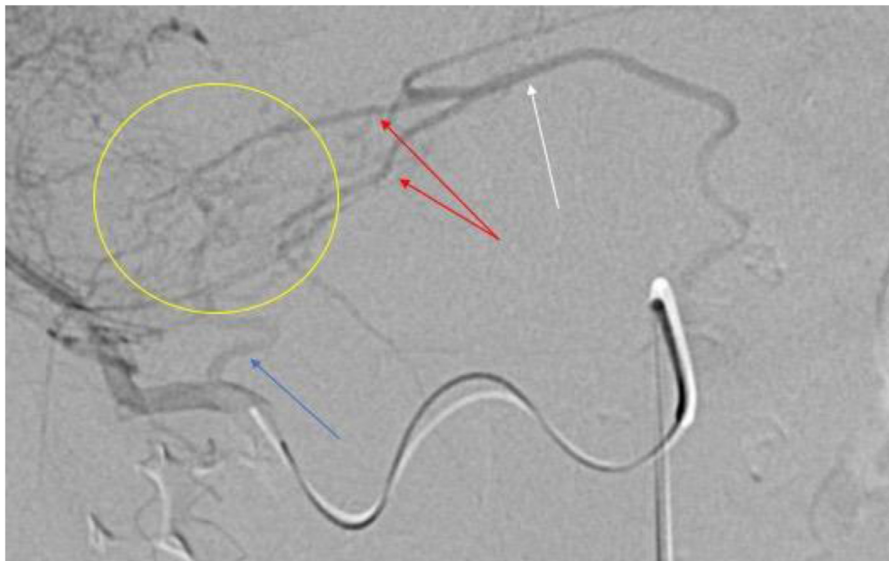


Fig. 10 – In the angiography before treatment, the interventional radiologist detected some little vessels (yellow round) connecting median hepatic arteries (blue arrow) to the left hepatic artery (red arrows). (Color version of figure is available online.)

Before treatment, the Interventional Radiologist considered to ask for another SPECT exam after a second administration of MAA^{Tc} . The SPECT exam confirmed not only the good distribution of MAA^{Tc} , but also the complete absence of anomalous distribution in other nontargeted areas (Fig. 18).

After the SPECT examination, the patient came back at the Angiographic suite and Y90-spheres were equally splitted and administered through each RHA.

SPECT test performed soon after TARE, confirmed the good distribution of resin-microspheres (well spread in the tumor nodule) and the absence of anomalous shunts.

Five days after treatment, the patient went back home with a radiological and clinical follow-up schedule for the following months.

In the CT exam performed 1 month after treatment (Fig. 19), the Radiologist documented a large necrotic compo-

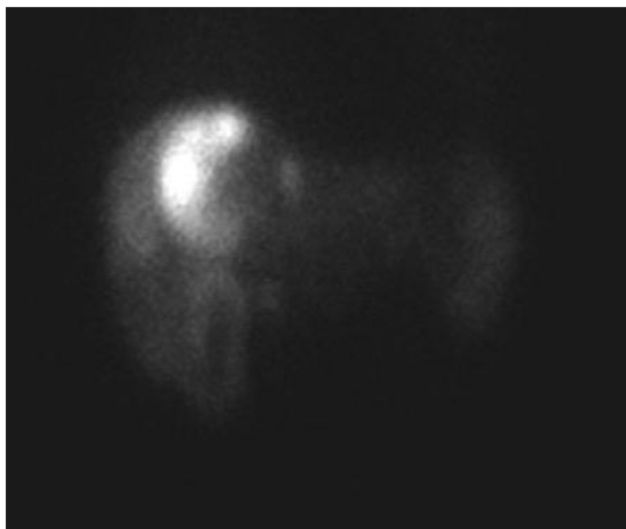


Fig. 11 – SPECT: macroalbumin aggregates spread not only to the liver but also to the stomach and spleen.

ment in the context of the neoplastic nodule associated with a little vital tissue in the nodule peripheral side. The result of the treatment was considered extremely positive, with a neoplastic necrosis estimated as greater than 85% of the total volume. Not only the efficacy of therapy, but also the right preparation of an adequate vascular area made the procedure extremely effective and safe.

Discussion

Radio-embolization of HCC is a multistep, minimally invasive procedure that aims to super-selectively deliver a dose of radiation using an intra-arterial infusion of microspheres loaded with the radionuclide ^{90}Y .

An important angiographic characteristic of malignant hepatic neoplasms, especially for HCC, is the occurrence of arteriovenous shunts within the tumor vascularization [1]. Evaluation of changes to regional perfusion in presence of liver tumors, together with the evaluation of shunts (arteriovenous and arterio-arterial) to the lungs and abdominal viscera is fundamental to minimize the risk of radiation-induced lesions (pneumonitis, pancreatitis, gastric ulcer, etc.). The amount of shunting to the lungs is one of the most important factors to determine whether the patient is a good candidate for radio-embolization treatment and its evaluation allows the calculation of ^{90}Y -microsphere dose to administer.

As a consequence, the interventional radiologists need a preoperative vascular evaluation of the hepatic lesion and of the most important abdominal visceral vessels (celiac trunk and superior mesenteric artery, first of all). All the radio-embolization treatment—as a consequence—need a previous angiographic simulation study through infusion of a macroalbumine marked with technetium⁹⁹ ($^{99\text{m}}\text{Tc}$ -MAA).

An important goal of the $^{99\text{m}}\text{Tc}$ -MAA hepatic perfusion study is to identify sites of potential nontargeted delivery of ^{90}Y -microspheres [2]. If angiography before treatment shows significant extrahepatic $^{99\text{m}}\text{Tc}$ -MAA activity, the non-

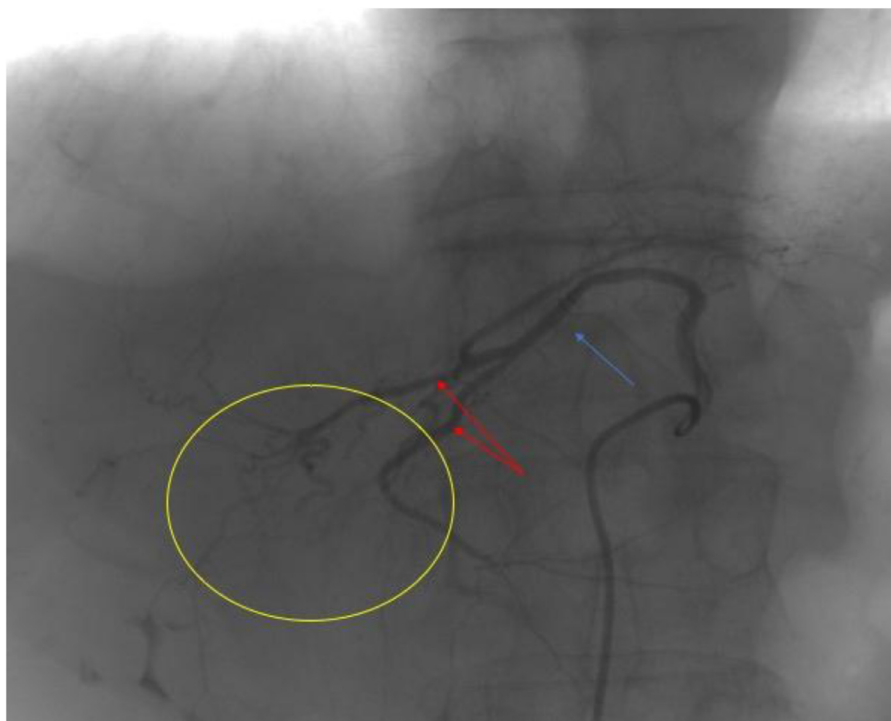


Fig. 12 – Treatment started with selective catheterization of the left gastric artery (blue arrow). The angiographic check documented the presence of the left hepatic arteries (red arrows), and little hepatic vessels that shunt with median hepatic arteries (yellow round). (Color version of figure is available online.)

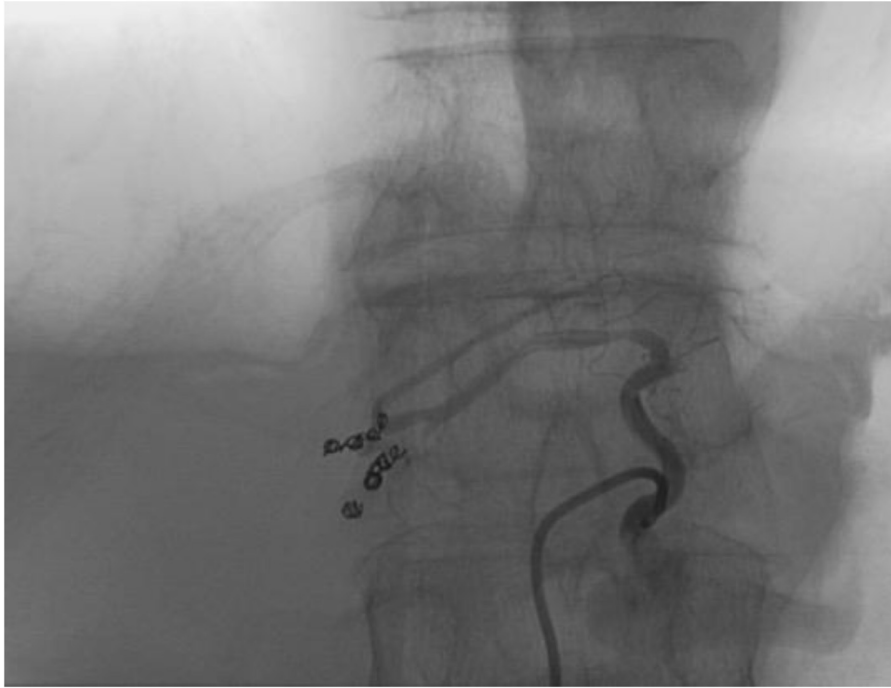


Fig. 13 - The interventional radiologist closed left hepatic arteries with microcoils.



Fig. 14 - Selective catheterization of the SMA documented the "active" role of the median hepatic arteries.



Fig. 15 – Despite the previous embolization, the angiographic check documented the presence of shunts between the left hepatic arteries and the median hepatic arteries (yellow round). (Color version of figure is available online.)

target sites can usually be excluded safely by endovascular embolization.

The treatment is based on transcatheteral ^{90}Y -microspheres administration. Two ^{90}Y -microsphere products are commercially available for clinical use: SIR-Spheres (Sirtex Medical) and Thera-Spheres (Nordion).

Variations from the normal vascular anatomy are common and could further increase the degree of difficulty to lead a successful procedure, especially in the hepatic district. Anatomic variants can be encountered in 40% of patients.

The variations typically involve:

- a replaced artery: a vessel that substitutes the typical vessel emerging from a different vascular territory,
- an accessory artery: an additional vessel for the target in a standard vasculature.

Difficult anatomy could be the worst enemy for the interventional radiologist, and the experience and a good embolization technique is key to perform a successful procedure [3].

In the standard hepatic arterial anatomy, the CHA originates from the celiac trunk and continues in the proper hepatic artery (PHA) toward the liver. PHA divides into the RHA and the LHA. RHA and LHA divide into segmental hep-

atic arteries for each segment of the liver. There are a lot of vascular shunts between LHA and RHA. The GDA arises from CHA.

The middle hepatic artery could arise from the RHA or from the PHA to provide a blood supply to the fourth segment.

In the anatomic and surgical literature, many classification systems describe the most common variations of hepatic arterial vasculature [2].

Based on the original classification of Michel, there are 10 anatomic variations of the main hepatic vasculature. Obviously, every interventional radiologist could encounter unique arterial patterns not included in this classification.

- Type 1: standard anatomy.
- Type 2: consists of a replaced LHA which arises from the LGA. This variant frequently has many vascular branches to the stomach, esophagus, and diaphragm. Detection of these branches is important, because they need to be excluded from the treated arterial territory with pretreatment embolization.
- Type 3: consists of a replaced RHA from the SMA.
- Type 4: consists of a replaced LHA from the LGA and a replaced RHA from the SMA.

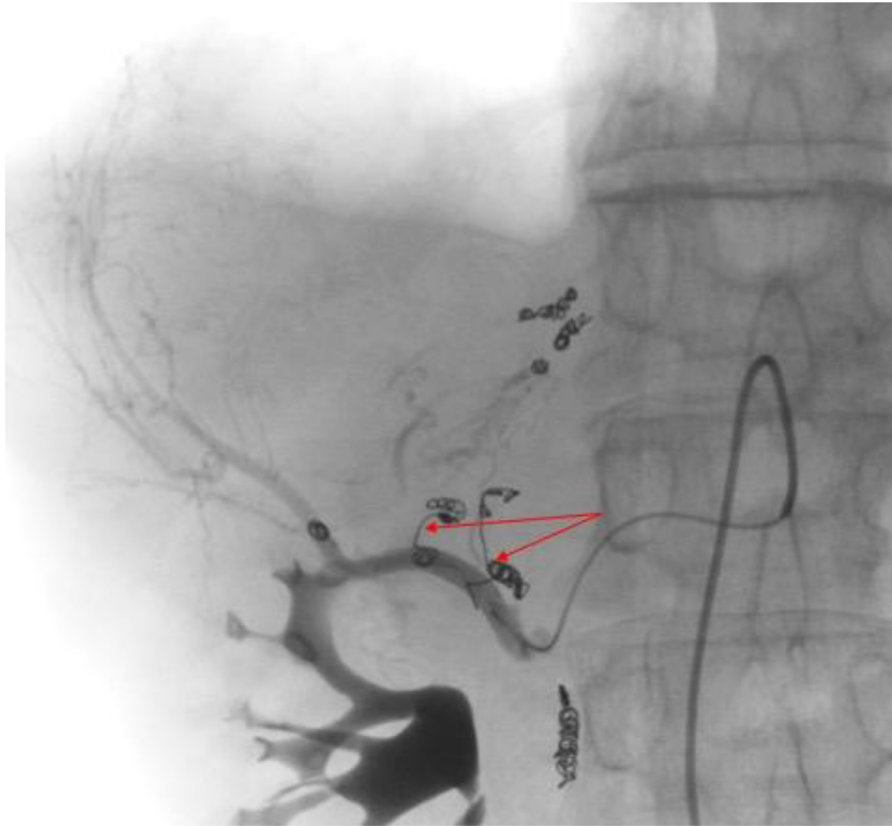


Fig. 16 – Embolization of hepatic median arteries (red arrows) was performed with microcoils.

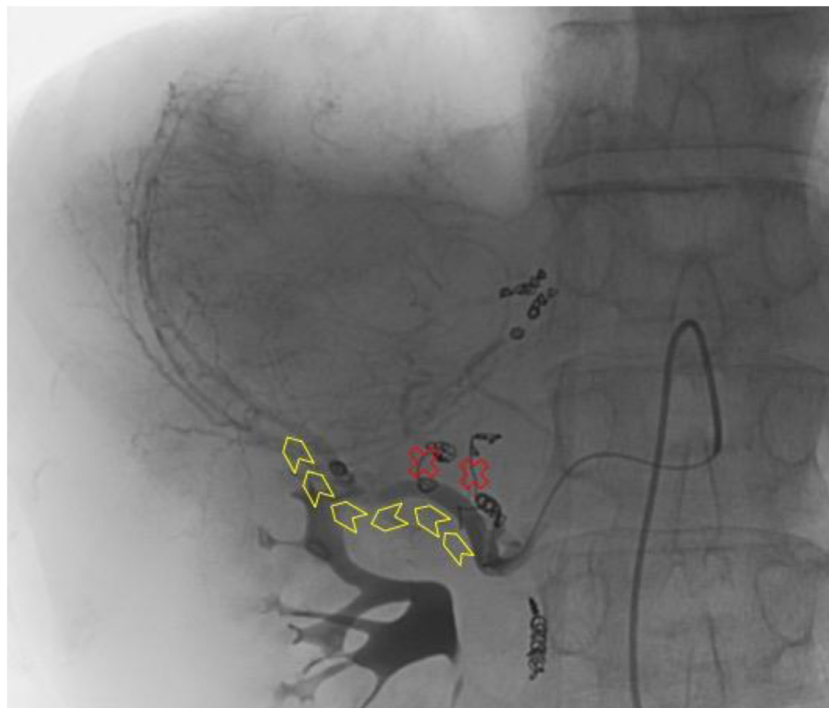


Fig. 17 – In another angiographic check, the interventional radiologist documented not only the exclusion of all vascular shunts between the vascular branches of the right and the left hepatic artery, but also the creation—thanks to previous selective embolization—of a preferential hemodynamic flow toward the lesion.

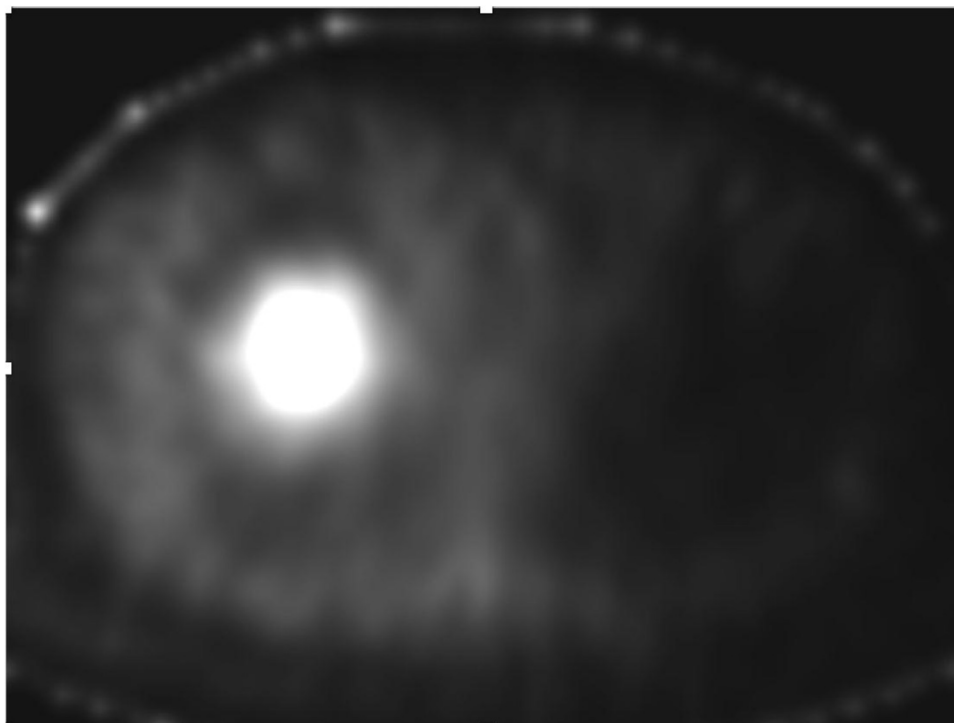


Fig. 18 – In the second SPECT exam before treatment, a very good spread of MAA^{Tc} in the hepatic lesion was documented, without off target uptake.



Fig. 19 – CT exam performed 1 month after treatment. In the arterial (on the left) and in the venous phase (on the centre), the Radiologist documented a huge necrotic component in the context of the mass. A little vital tissue was detected in the peripheral zone. In the coronal plane (on the right) the necrosis is 85% of the total volume.

- > Type 5: consists of an accessory LHA emerging from the LGA.
 - > Type 6: consists of an accessory RHA emerging from the SMA, which provides a blood supply to segments 5 and 8.
 - > Type 7: consists of an accessory LHA and an accessory RHA.
 - > Type 8: consists of a replaced LHA emerging from the LGA and an accessory RHA emerging from SMA.
 - > Type 9: consists of a replaced CHA emerging from the SMA.
 - > Type 10: consists of a replaced CHA emerging from the LGA.
- Other patterns not described in the original Michel classification have been reported in a large series of surgical, angiographic, and imaging reviews of the hepatic arterial anatomy, such as:
- > a direct origin of the CHA from the aorta,
 - > a replaced PHA or CHA from the SMA with or without an accessory LHA from the LGA.

In the diagnostic study for radio-embolization, the interventional radiologist has 5 goals:

1. Identification of hepatic arterial blood supply.
2. Identification of every vascular variant.
3. Prophylactic embolization of selected vessels for abdominal organs (typically the GDA and the right gastric artery—RGA).
4. Embolization of additional extrahepatic vessels emerging from the hepatic vasculature in order to avoid off target radiation.
5. Injection of the ^{99m}Tc -MAA particles simulating ^{90}Y -microspheres flow dynamics.

The knowledge of the most common anatomic variants and their detection during pretreatment angiography is the base of a good planning for liver radio-embolization.

Conclusion

Difficult anatomy could be the worst enemy for interventional radiologist. Only the cleverness and the experience of the operator can cope with the difficulties of a super-selective catheterization of pathologic vessels. Before every radio-embolization treatment, it is very important to be aware of vascular liver anatomy and its variations, planning ahead how to manage the different vascular anomalies so as to reach successful results.

In conclusion, the Interventional Radiologist should be able not only to go over the “difficult anatomy,” but also to take advantage of it, according with Julius Caesar said many centuries ago: “Si non potes inimicum tuum vincere, habes eum amicum” (If you cannot win your enemy, have his friend).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.radcr.2019.03.009](https://doi.org/10.1016/j.radcr.2019.03.009).

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