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Case Report
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# CT Evaluation of Anatomical Variants of Hepatic Arteries: Impact on Endovascular Treatment Planning

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## Abstract

The objective of this article is to examine the anatomical variants of hepatic arterial vascularization by 64-slice Angio-TC. When planning the treatment of patients with HCC that require surgery or endovascular therapy, it is useful to consider the variety of anatomical variants that are possible and it is the objective of this article to classify them using digital subtraction angiography (DSA) and CT. Examples of the application of these techniques in our hospital will also be illustrated. Angio-CT has the capability of visualizing these anatomical variants and therefore enabling the selection of an optimised surgical or endovascular treatment. Interventional radiology plays a key role in advanced endovascular treatment of liver tumours. The administration of drugs and/or chemo embolizing agents often requires super selective catheterization of arteries to the tumoral mass to preserve the healthy hepatic parenchyma.

**Keywords:** Anatomy; Hepatic artery; Multidetector computed tomography; Bolus tracking

## Introduction

The procedures of chemoembolization, intra-arterial hepatic chemotherapy and radioembolization require a precise knowledge of the anatomy of the hepatic artery and of its variants to establish and execute an optimum interventional plan and minimize the risks of intra and post-interventional complications. Embolization of the wrong arterial branches can lead to an incomplete treatment of the target lesion or to the exposure of the liver parenchyma and healthy organs [1] to the toxic treatment. Digital subtraction angiography (DSA) is an invasive procedure that represents the golden standard in the evaluation of vascular structures [2]. The advent of the 64 slices multidetector tomographic angiography (MDCTA) and modern programs of image reconstruction MIP (maximum intensity projections) and VR (volume rendering) with 3D representation are a valid option to the traditional method with the advantage of not being invasive [3].

The objective of this article is to describe the anatomy of the hepatic artery and its variants using 64-slices multidetector tomographic angiography (MDCTA) and to understand the implication of these variants in specific interventional radiology procedures and in traditional and video laparoscopic surgery.

## Case Study

In our centre, radiological investigations are performed using a 64-slices CT (Lightspeed VCT 64 slice, GE Healthcare, Chicago, Illinois, United States). To perform an Angio-CT of the thoracoabdominal aorta and its branches, it is necessary to place the patient on the TC bed in the supine position, headfirst. The venous access of the patient is connected to the injector. The scanogram is performed, after which direct acquisitions are collected following the intravenous injection of a non-ionic iodinated contrast agent with a high concentration of 320-400 mg/ml (injected volume of about 80-120 ml at a rate of 4 ml per second). The technique used for bolus synchronization is bolus tracking and its variant smart prep. Bolus tracking is an automatic technique that involves the use of specific software and takes place in two phases. The premonitory phase in which a test scan is acquired, to establish where to place the ROI (region of interest) in the lumen of the vessel of interest and the maximum value of HU sampled within the ROI. The monitoring phase consists in synchronizing the injections

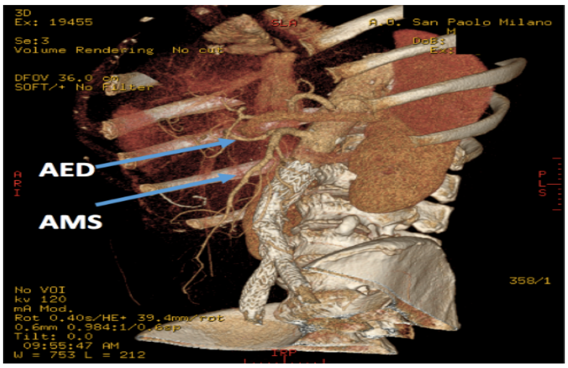


**Figure 1:** Patient no. 1: Type III of Michel's classification; Type III of Hiatt classification. 3D volume rendering reconstruction (VR). AED: Right Hepatic Artery; AMS: Superior Mesenteric Artery.

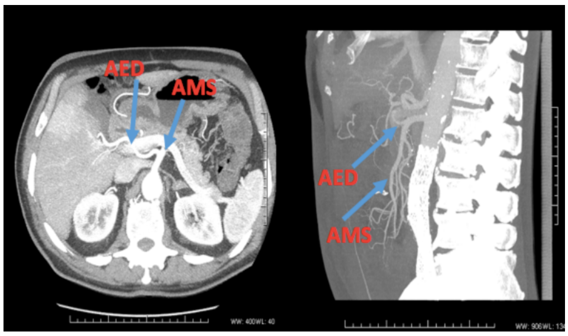


**Figure 2:** Patient no. 1: Right hepatic artery originating from superior mesenteric artery. Type III of Michel's classification; type III of Hiatt classification. Axial (left) and sagittal (right) MIP reconstructions. AED: Right Hepatic Artery; AMS: Superior Mesenteric Artery.

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with the dynamic sequential scans on the layer where the ROI has been positioned. Once the established threshold value has been reached, the contrast acquisition will start automatically. The variant of bolus tracking is the smart prep: a semi-automatic technique that involves the use of specific software available in General Electric systems. The pre-monitoring phase is like the one described above for bolus tracking. The monitoring phase is established by the operator who monitors the opacification of the ROI and decides when to start the scan.

The reconstructions set for the automatic submission to the PACS must have a thickness of 1 and 5 mm. The images can then be reconstructed with MIP and VR reconstruction methods using 3D representation.

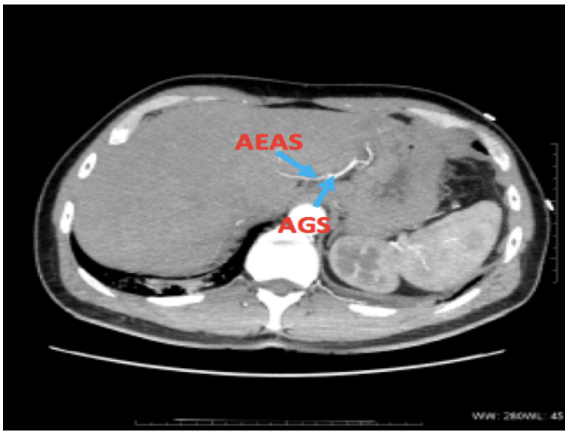


**Figure 3:** Patient no. 2. left accessory hepatic artery originating from the left gastric artery. Type V of Michel's classification, type IV of Hiatt classification. Axial CT. AEAS: Hepatic Artery Left Accessory. AGS: Left Gastric Artery.


**Figure 4:** Patient no. 2. Left accessory hepatic artery originating from left gastric artery. Type V of michels classification, type IV of Hiatt classification. Coronal MIP reconstruction. AEAS: Hepatic Artery Left Accessory. AGS: Left Gastric Artery.

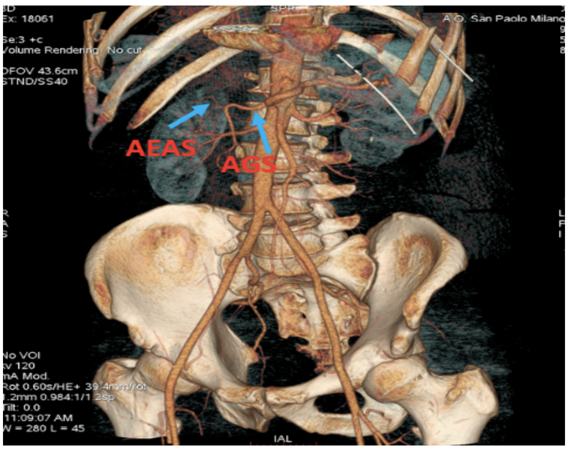


**Figure 5:** Patient no. 2. Left accessory hepatic artery originating from left gastric artery. Type V of Michel's classification, Type IV of hiatt classification. 3D volume rendering reconstruction (VR).

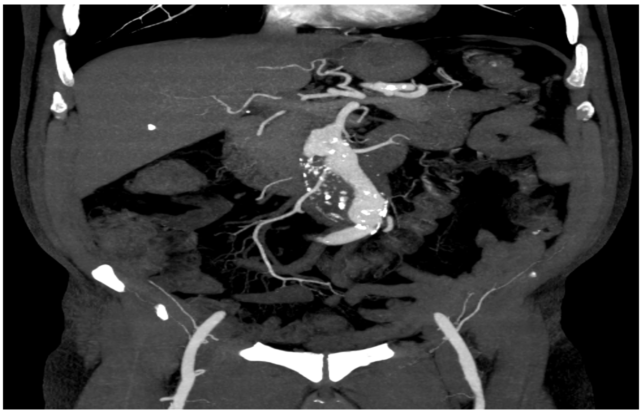

**Figure 6:** Patient no. 3. Left hepatic artery originating from left gastric artery. Type II of Michel's classification, type II of Hiatt classification. Coronal MIP reconstruction (Massimum Intensity Projection). AES: Left Hepatic Artery. AGS: Left Gastric Artery.

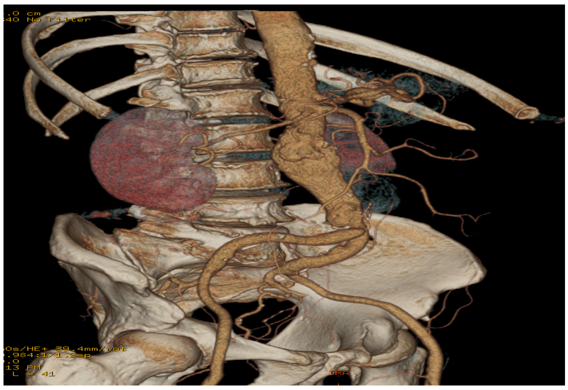

**Figure 7:** Patient no. 3. Left hepatic artery originating from left gastric artery. Type II of Michel's, Type II of Hiatt. Volume rendering reconstructions (VR). AES: Left Hepatic Artery. AGS: Left Gastric Artery.

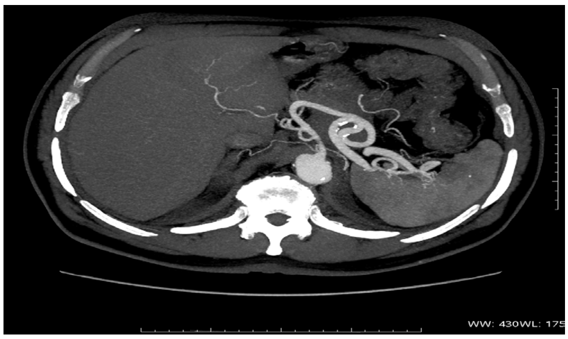


**Figure 8:** Patient no. 3. Left hepatic artery originating from the left gastric artery. Type II of Michel's classification, type II of Hiatt classification. axial CT. AES: Left Hepatic Artery. AGS: Left Gastric Artery.

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| Hepatic Artery Variation | Michel's Classification |
|---|---|
| Normal anatomy | Type I |
| Replaced left hepatic artery from left gastric artery | Type II |
| Right hepatic artery, originating in the superior mesenteric artery | Type III |
| Association of variants II and III | Type IV |
| Accessory left hepatic artery originating from the left gastric artery | Type V |
| Accessory right hepatic artery originating from the superior mesenteric artery | Type VI |
| Accessory left hepatic artery originating from left gastric artery artery and accessory right hepatic artery originating from the superior mesenteric artery | Type VII |
| Accessory left hepatic artery originating from left gastric artery | Type VIII |
| Common hepatic artery originates from the superior mesenteric artery | Type IX |
| Common hepatic artery originating from left gastric artery | Type X |

**Table 1:** Michel's classification.

| Hepatic Artery Variation | Hiatt Classification |
|---|---|
| Normal anatomy | Type I |
| Left hepatic artery or accessory left hepatic artery relocation | Type II |
| Right hepatic artery or accessory right hepatic artery relocation | Type III |
| Left hepatic artery or accessory left hepatic artery relocation and right hepatic artery or accessory right hepatic artery relocation | Type IV |
| Common hepatic artery originating from superior mesenteric artery | Type V |
| Common hepatic artery originating from the aorta | Type VI |

**Table 2:** Hiatt classification.

| Hepatic Artery Variation | Michel's Classification | Hiatt Classification |
|---|---|---|
| Normal anatomy | Type I | Type I |
| Replaced left hepatic artery originating from the left gastric artery | Type II | Type II |
| Replaced right hepatic artery originating from the superior mesenteric artery | Type III | Type III |
| Co-existence of Type II and III | Type IV | Type IV |
| Accessory left hepatic artery originating from the left gastric artery | Type V | Type II |
| Accessory right hepatic artery originating from the superior mesenteric artery | Type VI | Type III |
| Accessory left hepatic artery originating from the left gastric artery and accessory right hepatic artery originating from the superior mesenteric artery | Type VII | Type IV |
| Accessory left hepatic artery originating from the left gastric artery and replaced right hepatic artery originating from the superior mesenteric artery | Type VIII | Type IV |
| Common hepatic artery originating from the superior mesenteric artery | Type IX | Type V |
| Right and left hepatic arteries originating from the left gastric artery | Type X | NOD* |
| Common hepatic artery directly originating from the aorta | NOD* | Type VI |

**Table 3:** Hiatt and Michel's classifications in comparison. (*NOD: Not Otherwise Described).

## Discussion

The hepatic arterial anatomy has been the object of studies since the times of Aristotle and Galen. However, only in the eighteenth century was the correct hepatic vascularization described with the results of Jacques Benigne Winslow and Albert Haller, considered the fathers of modern angiology. Since then, many anatomical variants have been identified [4].

The celiac trunk is the first ventral branch of the abdominal aorta that arises at the level of the T12/L1 vertebral bodies. It measures between 1.5 and 2 cm in length and is divided into the left gastric artery, common hepatic artery and splenic artery [5]. The common hepatic artery is an arterial segment that goes from the celiac axis to the point where the gastroduodenal artery rises, beyond which it becomes its own hepatic artery [6]. This is the classic scheme of trifurcation of the celiac tripod and accounts for 55 to 76%, depending on the study [1]. The anatomical variants develop during embryogenesis, because there is permanence of the vitelline artery [7] and there are several of them.

In this article the classifications of Michel's and Hiatt are described. In 1966, Michel's classified the anatomical variants into 10 categories after having performed 200 dissections [7] (Table 1). In Michels' classification, Type I represent the normal conformation of the hepatic artery. In type II the left hepatic artery originates from the left gastric artery [8]. In type III the right hepatic artery originates from the superior mesenteric artery (Figures 1 and 2). Type IV corresponds to the association of variants II and III, with the presence of a right hepatic artery for the right liver and a left hepatic artery that feeds the left liver. The celiac tripod does not have the common hepatic artery, but feeds directly into the gastroduodenal artery. In type V, Michel describes the presence of a left hepatic artery originating from the left gastric artery in addition to the left branch of the hepatic artery (Figures 3-5). Type VI associates the right hepatic artery originating from the superior mesenteric artery and the right branch of the hepatic artery (Figures 6-8).

In type VII, we find the association of variants V and VI, in the association of the proper hepatic artery with the right and left branches, plus the right hepatic artery originating from the superior mesenteric artery, plus the left hepatic artery that originates from the left gastric artery. In type VIII the right liver is fed only by the right hepatic artery, while there is a double vascularization of the left liver through the main hepatic artery and the left hepatic artery. In type IX the common hepatic artery originates from the superior mesenteric artery and in type X it originates from the left gastric artery.

The classification of Hiatt, described in 1994, is an angiographic classification and represents a simplification of the Michel's classification. It does not describe the variant of type X and reunites under the same heading the type II with the type V and the type III with the type VI of the Michel's classification, because from an angiographic point of view, it is difficult to distinguish an accessory hepatic artery from one that originates respectively from the left gastric artery or from the superior mesenteric artery [2] (Table 2). Hiatt classification is therefore more practical in angiographic studies. The most frequent variant is Type I of both classifications, followed by type III for the Michel's classification and type II for the Hiatt classification [2] (Table 3).

## Conclusion

In conclusion, MDCTA provides an accurate and descriptive analysis of the configuration of the hepatic artery. Normal arterial patterns and variants should be carefully observed due to their importance in planning treatment options and performing various radiological and surgical procedures.

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