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An Overview on Classifications of Hepatic Artery Variants

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Abstract:

Background: Hepatic arterial anatomy exhibits considerable anatomical variability, making accurate recognition and classification of hepatic artery variants essential for radiological assessment and surgical planning. Several classification systems have been developed to describe these variations. Michels' classification, based on cadaveric dissections, describes ten types of hepatic arterial anatomy, whereas Hiatt's classification provides a simplified system of six categories derived from surgical cases. These systems remain fundamental for understanding hepatic arterial variability and its surgical relevance. More recently, the CRL classification was introduced to describe the origins of the common hepatic artery, right hepatic artery, and left hepatic artery, including replaced and accessory vessels, and to cover a wider range of arterial variants. However, some rare patterns cannot be categorized adequately by the CRL system. Consequently, the extended CRL (ex-CRL) classification was developed to systematically categorize uncommon hepatic arterial origins and complex variants that were previously described mainly in individual case reports.

Keywords: Hepatic artery; Anatomical variations; Michels classification; Hiatt classification; CRL classification; ex-CRL classification; Replaced hepatic artery; Accessory hepatic artery.

Introduction:

In recent years, with the wide application of three-dimensional (3D) visualization technology **(1). Yan et al. (8)** presented the CRL classification, which concisely describes the hepatic artery and its branches and covers a wider range of arterial variants.

Among many introduced classifications of the variations of the hepatic arteries, the classic classifications are Michel's and Hiatt's classification **(3,4)**. Michels' classification, published in 1955, is based on 200 cadaver dissections and describes ten types of hepatic arterial anatomy, ranging from the classic pattern (Type I) to multiple replaced or accessory arteries (Types II–X) (**Table 1**) **(Figure 1)**. Michel's classification remained a fundamental reference in hepatobiliary surgery **(2,3)**.

Hiatt and colleagues later proposed a simplified classification in 1994, derived from 1000 surgical cases, reducing Michels' ten types into six categories. Hiatt's classification is widely used in clinical practice because of its clarity and correlation with incidence rates (**Table 1**). Together, these two systems provide the foundation for understanding hepatic arterial variability and its surgical relevance **(2,5)**.

Table (1): Michels' and Hiatt's classifications of hepatic artery variations (6).

Hepatic arterial anatomy	Michels' classification	Hiatt classification
Normal anatomy	Type I	Type I
LHA branch LGA	Type II	Type II
RHA branch SMA	Type III	Type III
Type I and II association	Type IV	Type IV

Hepatic arterial anatomy	Michels' classification	Hiatt classification
LHA accessory LGA	Type V	Type II
RHA accessory SMA	Type VI	Type III
LHA accessory LGA + RHA accessory SMA	Type VII	Type IV
LHA accessory LGA + RHA branch SMA	Type VIII	Type IV
CHA branch SMA	Type IX	Type V
RHA and LHA branch LGA	Type X	—
CHA aortic branch	—	Type VI

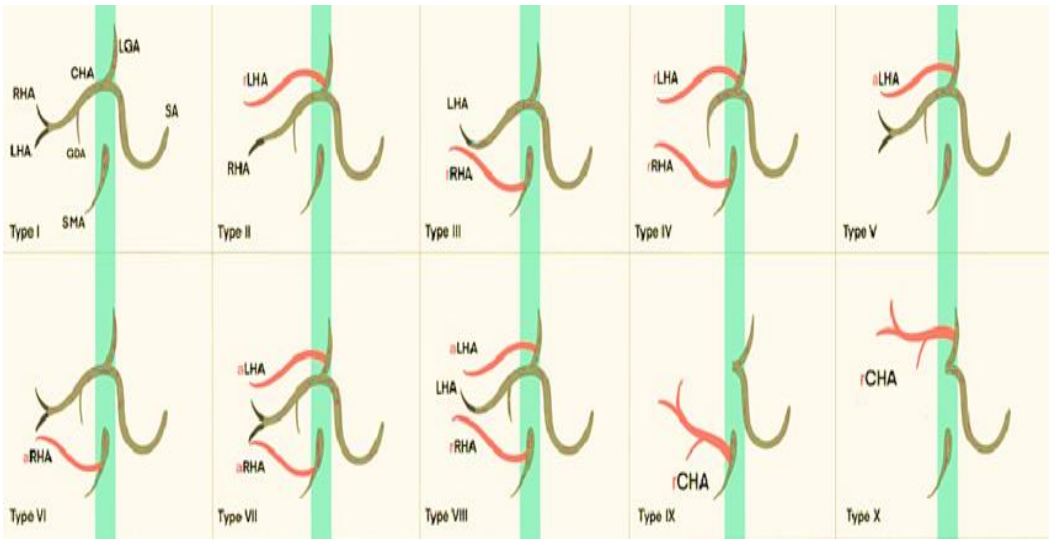

Figure 1: Schematic diagram of Michels' classification system (7).

Recently, a new classification, called the CRL classification, was presented. This classification concisely describes the anatomy of hepatic arteries covering a wider range of arterial variants. It describes the origin of CHA, RHA, and LHA, with (CRL) being the abbreviation of their initials (**Table 1**) **(2,8)**.

The CRL classification describes normal origins, for example, CHA originates from celiac artery (CA), while RHA and LHA originate from PHA. Thereafter, the origins of other arteries are marked with capital letters corresponding to their arteries. For example, CSRL means that the origin of CHA has changed, not from CA but from SMA, while the origins of RHA and LHA remain unchanged (**Table 2**) (**Figure 2**) **(2)**.

The replaced or accessory hepatic arteries need to be represented by lowercase letters "r" or "a". For example, CRrGLaA means that CHA originates from CT, rRHA originates from GDA, and aLHA originates from the AA (**Table 2**) (**Figure 2**) (**2**).

However, some rare variants still cannot be categorized by the CRL classification, and these variations are more likely to be unidentified and injured. These rare types have been reported in the form of individual cases for many years, lacking systematic classification and generalization **(8)**.

Table 2: Types in CRL classification system (2,8).

Classification	Description
Type 1 (CRL)	CHA from coeliac trunk; LHA and RHA from PHA
Type 2 (CRr-L)	Replaced RHA only
2a (CRrAL)	rRHA from aorta
2c (CRrcL)	rRHA from coeliac trunk
2g (CRrgL)	rRHA from GDA
2s (CRrsL)	rRHA from SMA
2o (CRroL)	rRHA from other arteries
Type 3 (CRa-L)	Accessory RHA only
3a (CRaA_L)	aRHA from aorta
3c (CRaCL)	aRHA from coeliac trunk
3g (CRaGL)	aRHA from GDA
3s (CRaSL)	aRHA from SMA
3o (CRaOL)	aRHA from other arteries
Type 4 (CRLr-)	Replaced LHA only
4g (CRLrG)	rLHA from GDA
4l (CRLrL)	rLHA from LGA
4o (CRLrO)	rLHA from other arteries
Type 5 (CRLa-)	Accessory LHA only
5g (CRLaG)	aLHA from GDA
5l (CRLaL)	aLHA from LGA
5o (CRLaO)	aLHA from other arteries
Type 6 (CRr-Lr-)	Replaced RHA and LHA (Type 2 + Type 4)
CR--Lr--	rRHA from aorta, coeliac trunk, GDA, SMA or other arteries; rLHA from GDA, LGA or other arteries
Type 7 (CRr-La- or CRa-Lr-)	rRHA and aLHA (Type 2 + Type 5), or aRHA and rLHA (Type 3 + Type 4)
7a (CRr-La-)	rRHA from aorta, coeliac trunk, GDA, SMA or other arteries; aLHA from GDA, LGA or other arteries

Classification	Description
7r (CRa-Lr-)	aRHA from aorta, coeliac trunk, GDA, SMA or other arteries; rLHA from GDA, LGA or other arteries
Type 8 (CRa-La-)	aRHA and aLHA (Type 3 + Type 5)
CRa-La-	aRHA from aorta, coeliac trunk, GDA, SMA or other arteries; aLHA from GDA, LGA or other arteries
Type 9 (C-RL)	rCHA not from coeliac trunk
9a (CARL)	CHA from aorta
9l (CLRL)	CHA from LGA
9s (CSRL)	CHA from SMA
9o (CORL)	CHA from other arteries

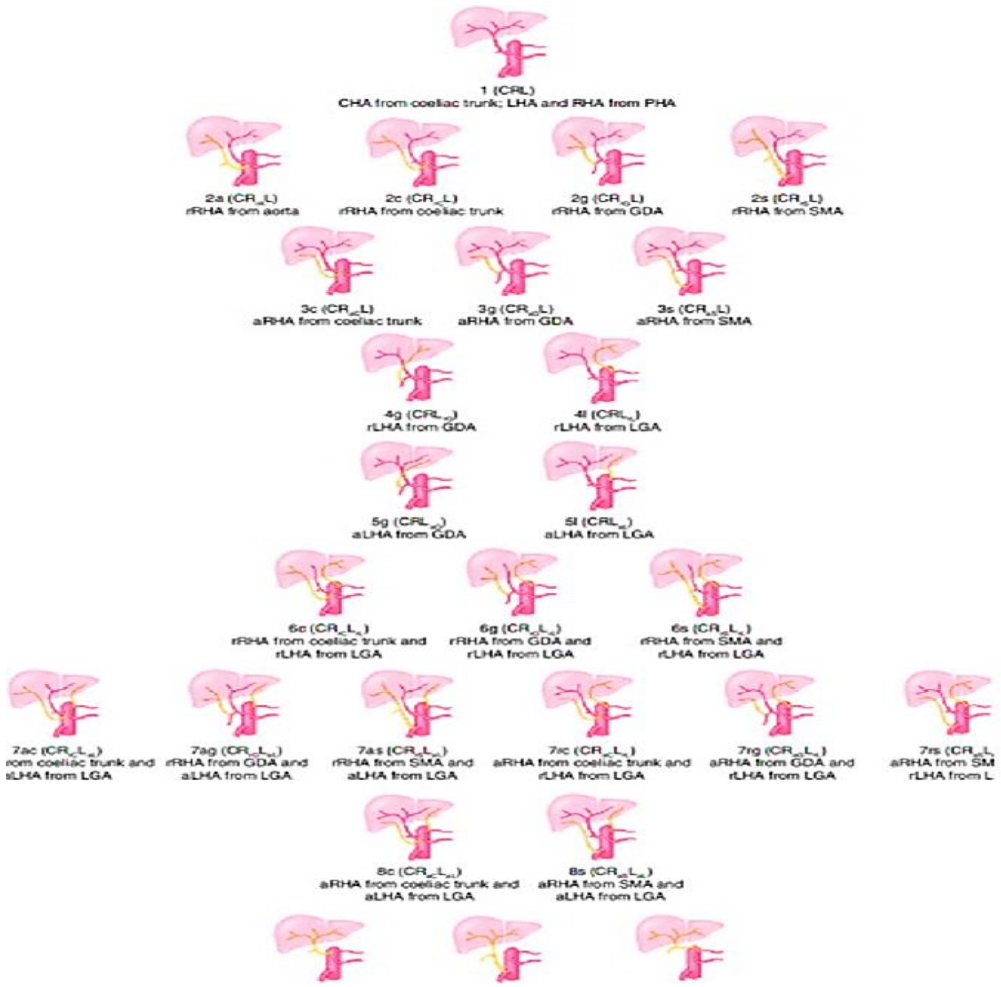

Figure 2: Schematic diagram of CRL classification system (8).

The ex-CRL classification

Based on the CRL classification, an extended framework (the ex-CRL classification) was established to categorize rare hepatic arterial variations that traditional systems do not cover. This update aims to organize variants that were previously limited to scattered case reports. Under this extended system, rare anatomical presentations are systematically structured **(8).** (**Table 3**) (**Figure 3**)

The ex-CRL classification is suitable for a small number of variants outside the CRL classification. Other arteries in the CRL classification are uniformly represented by "O". For example, CRaOL indicates that aRHA originates from other arteries other than AA, CA, PHA, LGA, GDA, or SMA **(8).** (**Table 3**) (**Figure 3**)

The ex-CRL classification subdivides other arteries that have appeared in the past, such as "OR", which indicates origin from the renal artery; "OP", from the phrenic artery; "OS", from the splenic artery; "OC", from CHA; "OD", from the pancreaticoduodenal artery; "OM", from the inferior mesenteric artery; and "ODP" from the dorsal pancreatic artery **(8)** (**Table 3**) (**Figure 3**)

Table 3: Types in the ex-CRL classification system (**8)**.

Classification	**Description**
CORL (CRL Type 9)	CHA from other arteries
CORRL	CHA from the renal artery
COPRL	CHA from the phrenic artery
COSRL	CHA from the splenic artery
CODRL	CHA from the pancreaticoduodenal artery
COMRL	CHA from the inferior mesenteric artery
CODPRL	CHA from the dorsal pancreatic artery
CRrOL (CRL Type2o)	rRHA from other arteries
CRrORL	rRHA from the renal artery
CRrOPL	rRHA from the phrenic artery
CRrOSL	rRHA from the splenic artery
CRrOCL	rRHA from the CHA
CRrODL	rRHA from the pancreaticoduodenal artery
CRrOML	rRHA from the inferior mesenteric artery
CRrODPL	rRHA from the dorsal pancreatic artery
CRaOL (CRL Type3o)	aRHA from other arteries
CRaORL	aRHA from the renal artery
CRaOPL	aRHA from the phrenic artery
CRaOSL	aRHA from the splenic artery

Classification	Description
CRaOCL	aRHA from the CHA
CRaODL	aRHA from the pancreaticoduodenal artery
CRaOML	aRHA from the inferior mesenteric artery
CRaODPL	aRHA from the dorsal pancreatic artery
CRLrO (CRL Type4o)	rLHA from other arteries
CRLrOR	rLHA from the renal artery
CRLrOP	rLHA from the phrenic artery
CRLrOS	rLHA from the splenic artery
CRLrOC	rLHA from the CHA
CRLrOD	rLHA from the pancreaticoduodenal artery
CRLrOM	rLHA from the inferior mesenteric artery
CRLrODP	rLHA from the dorsal pancreatic artery
CRLaO (CRL Type5o)	aLHA from other arteries
CRLaOR	aLHA from the renal artery
CRLaOP	aLHA from the phrenic artery
CRLaOS	aLHA from the splenic artery
CRLaOC	aLHA from the CHA
CRLaOD	aLHA from the pancreaticoduodenal artery
CRLaOM	aLHA from the inferior mesenteric artery
CRLaODP	aLHA from the dorsal pancreatic artery
Combinatorial variation	Two or more accessory artery, replaced artery or middle hepatic artery

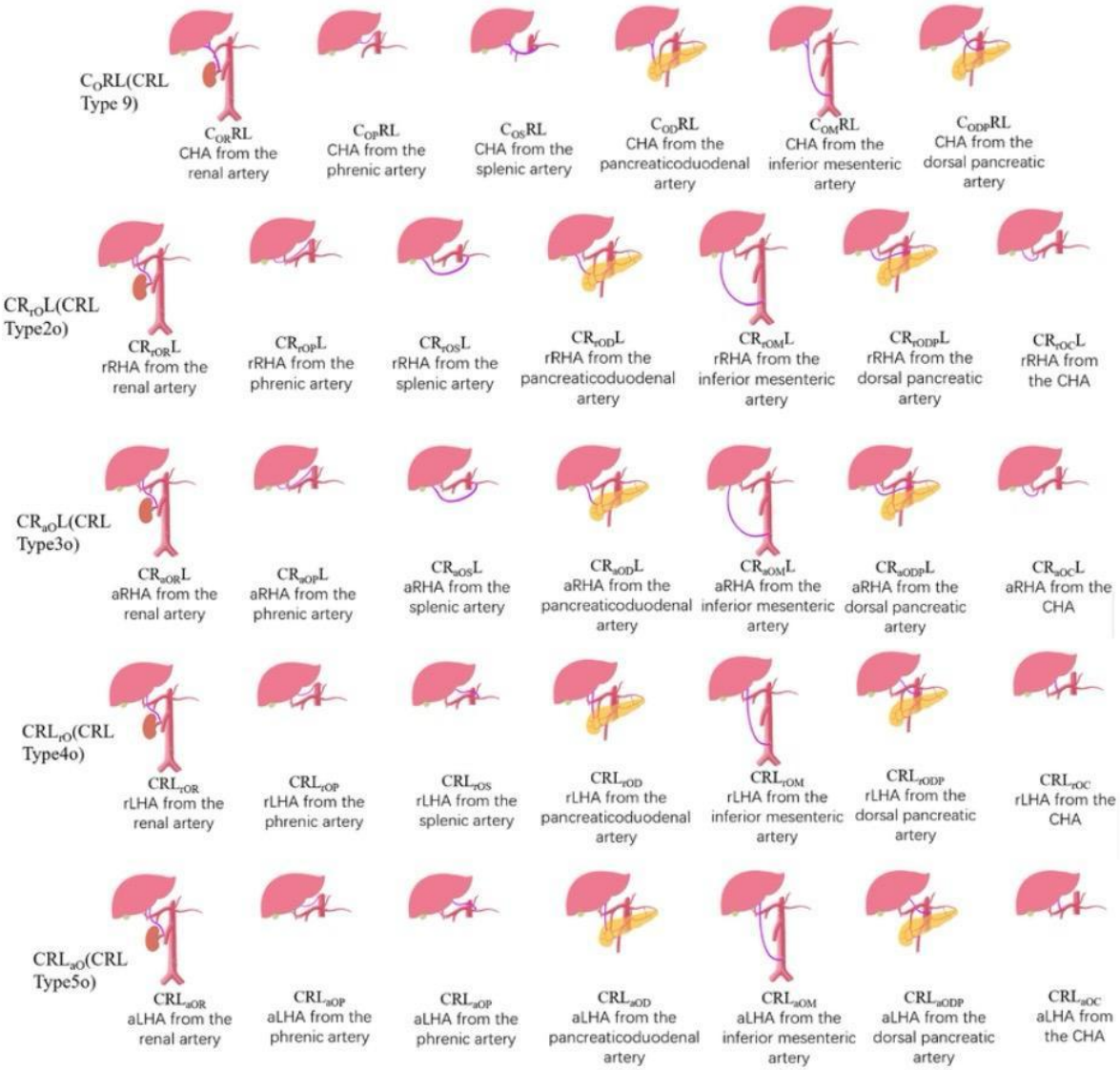

Figure 3: Schematic diagram of the ex-CRL classification system (8).

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