The Ductus Venosus
Der Ductus venosus

Author
Markus Born

Affiliation
Department of Radiology, Division of Pediatric Radiology, University Hospital Bonn, Germany

Key words
ductus venosus, portosystemic shunt, umbilical vein catheter

received 11.05.2020
accepted 18.09.2020
published online 05.11.2020

Bibliography
Fortschr Röntgenstr 2021; 193: 521–526
DOI 10.1055/a-1275-0984
ISSN 1438-9029
© 2020. Thieme. All rights reserved.

Correspondence
Dr. Markus Born
Radiology, Pediatric Radiology, University of Bonn, Venusberg-Campus 1, 53127 Bonn, Deutschland
Tel.: +49/228/28 73 32 25
Fax: +49/228/28 73 35 66
mark.born@ukbonn.de

ABSTRACT

Background the ductus venosus (DV) is not well known in general radiology, but it plays a role in the daily work of pediatric radiologists. Consequently all general radiologists who also care for a pediatric department should be familiar with the physiological and pathological findings related to the DV.

Methods: Literature research in Medline, using the keywords “ductus venosus” and “umbilical vein catheter”.

Results and conclusions In the first weeks of life the DV is regularly still patent. It should be recognized as DV and not be mistaken for a pathological portosystemic shunt. The ductus venosus is the lead structure for umbilical vein catheters. Radiologists should be able to assess the correct catheter position. Radiologically important findings of an umbilical vein catheter are mainly malposition and intrahepatic extravasation. Agenesis of the DV can lead to intra- or extrahepatic compensatory portosystemic shunts, in which as well as in the case of persistent patency of the DV, there may be the necessity for radiological-interventional or surgical occlusion.

Key points:
• In the first weeks of life in infants the Ductus venosus is regularly still patent.
• The Ductus venosus should not be mistaken for a pathological portosystemic shunt.
• An umbilical vein catheter should project onto the Ductus venosus and end caudal to the right atrium.
• Intrahepatic portosystemic shunts in DV agenesis show a high rate of spontaneous closure postnatally.

Citation Format
• Born M. The Ductus Venosus. Fortschr Röntgenstr 2021; 193: 521–526

ZUSAMMENFASSUNG

Hintergrund Der Ductus venosus ist in der Allgemeinradiologie wenig bekannt, spielt aber in der kinderradiologischen Diagnostik durchaus eine Rolle, sodass auch Allgemeinradiologen, die eine pädiatrische Abteilung mitversorgen, die physiologischen und pathologischen Befunde im Zusammenhang mit dem D. venosus kennen sollten. Methoden: Literatursuche in MEDLINE nach den Stichwörtern „ductus venosus“ und „umbilical venous catheter“.

The Ductus Venosus

The ductus venosus (DV) plays only a minor role in general radiology, as it is a fetal structure that obliterates postnataally and is usually no longer present in adult physiology. For pediatric radiologists, on the other hand, questions requiring knowledge of the anatomy of the ductus venosus are part of everyday diagnostic practice. However, such issues can also be confronted in particular by general radiologists who also serve a pediatric facility. Thus knowledge of radiological imaging of the venous duct can also be important for general radiologists.

There are various issues that radiologists may face in connection with the ductus venosus. On the one hand, the ductus venosus is important in the postpartum placement of an umbilical vein catheter, where it serves as a guiding structure. Its position can be assessed by the radiologist on a conventional X-ray of the upper abdomen. Misplacement and other complications should be detected. On the other hand, due to the increasing use of MRI and CT, the patent DV is occasionally visualised as a secondary finding in neonates. It should be recognized as such and not be confused with a pathological portosystemic shunt. Also sonographically the DV should be reliably recognized. Thirdly, the radiologist can be called upon to assess pathologies of the ductus venosus, for example duct agenesis with the possible formation of compensatory intra- or extrahepatic shunt connections or a failing spontaneous closure of the ductus venosus.

The present article aims to provide an overview of the above mentioned imaging issues relating to the ductus venosus.

A literature search was carried out in Medline using the keywords “umbilical vein catheter” and “ductus venosus”. The studies thus found were used as a source of evidence for the quantitative data given in this article.

Anatomy and Physiology

The ductus venosus arantii, named after the Italian anatomist Giulio Cesare Aranzi (1530–1589), is a venous fetal intrahepatic shunt connection from the left portal vein to the inferior vena cava or the orifice of the left or middle hepatic vein. Its function is prenatal transport of oxygen-rich umbilical vein blood to the right atrium. The blood from the umbilical cord passes through the umbilical vein to the so-called recessus umbilicalis of the left portal vein, whence it connects to the DV (Fig. 1). The DV may be slightly offset to the right compared to the umbilical vein in the left portal vein. In the human fetus, about 20–40 % of the umbilical venous blood reach the DV in the second half of pregnancy [1–3]. Due to anatomical and hemodynamic conditions, the blood flow from the ductus venosus hardly mixes within the inferior vena cava with the blood coming from the lower half of the body and is channeled directly to the foramen ovale. Through this it reaches the left atrium and enters the systemic circulation where it supplies the developing brain of the fetus with oxygen-rich blood from the placenta [4]. The blood supplying the lower half of the fetus body is less rich in oxygen because it mixes caudal to the aortic arch with the less oxygenated blood from the ductus arteriosus [4].

After birth, the umbilical vein and ductus venosus are initially still patent and sonographically well recognizable in a slightly left-turned sagittal view (Fig. 2).

Due to the pressure gradient between the portal vein and the inferior vena cava, the flow in the DV derived via Doppler sonography is directed outwards from the liver with a relatively constant, only slightly modulated amplitude. It differs significantly from the stronger undulating flow in the hepatic veins influenced by cardiac activity as illustrated in Fig. 3. The flow in the hepatic veins can undulate even more than shown.

In full-term neonates, the DV closes in the first days or weeks after birth. According to literature it is closed after 7 days in 60 to 75 % of cases, after 18 days in 89 to 100 % [5, 6]. In premature infants, however, DV seems to close with a slight delay [7, 8].

Due to this early postpartum closure, the DV is rarely visible on MRI. With the increasing use of MRI in full-term and premature infants, however, it is sometimes shown as a patent shunt connection and should then be correctly recognized as a DV and not misinterpreted as a pathological portosystemic shunt (Fig. 4).
**Umbilical Venous Catheter**

The open DV enables the neonatologist to apply a central venous catheter postpartum via the umbilical vein (umbilical venous catheter = UVC), which should be identified as such by the radiologist and its position assessed. The catheter tip should project onto the inferior vena cava in the transition to the right atrium (Fig. 5a) [9].

In addition to the occurrence of infections for which the catheter can serve as an entry portal, the main complications of a UVC are primary or migration-induced malpositions, thrombosis, perforations and catheter breaks [10, 11] (Fig. 5, 6).

**Intrahepatic malposition**

If the UVC is advanced too far, it reaches the right atrium; if advanced even further, it can reach the right ventricle, the superior vena cava, the coronary sinus or the left atrium via the still open oval foramen (Fig. 5, 6). Cardiac malpositions carry the risk of arrhythmias, intracardiac thrombus formation, myocardial perforations with pericardial tamponade, etc., and should therefore be avoided [10].

Intrahepatic malposition occurs when the catheter is not advanced far enough or does not enter the DV but deviates into the left or right branch of the portal vein (Fig. 5, 6).

Due to the numerous possibilities of catheter malposition and potentially resulting complications, an X-ray is taken after each umbilical vein catheterization in order to assess the catheter position and correct it if necessary. However, catheter migration is frequently observed over time and can lead to a secondary catheter malposition after initial proper positioning [12, 13].

**Perforations**

Intrahepatic malpositions of the UVC predestine a perforation of the vascular system [14]. If this occurs intrahepatically, the...
infused substances are extravasated into the liver parenchyma, which results in an image of an inhomogeneous, irregularly delimited mass (▶ Fig. 5) [9]. Depending on the infused fluid and the course over time, it can be echogenic or hypoechoic [9]. Sometimes communication with the umbilical vein can be detected, and over time this extravasation can calcify. If a perforation occurs in the umbilical vein, the infusion solutions applied through the catheter can lead to sonographically detectable free intra-abdominal fluid [11, 15, 16]. Likewise, intra-abdominal hemorrhages have been described [17].

Thrombi

Another complication that can occur after the application of a UVC is the formation of thrombi. Such thrombi can occur in the umbilical vein or in the ductus venosus [9]. Since these two vessels physiologically close after birth, thrombi are of no importance here. They can calcify over time and remain sonographically recognizable as linear echogenic structures (▶ Fig. 5). In the literature, however, thrombus formation after UVC placement is also described in other veins such as one of the portal vein branches [11, 18], in both portal vein branches or in the main portal vein trunk [10]. Although thrombi of the portal vein branches as a result of umbilical vein catheterization often recede [10, 18], portal hypertension can develop in the absence of spontaneous recanalization, with the corresponding consequences. Thromboembolic events also occur [10, 18].

Catheter breakage

Umbilical vein catheter breakage is uncommon, but is described in the literature. The remaining intracorporeal catheter fragment can usually be retrieved with radiographic support via a femoral venous access from the right atrium or via the umbilical vein, but surgical catheter retrieval is also described [19–21].

DV pathologies mainly include agenesia and failing closure.

Ductus venosus agenesia

There are no exact data regarding the frequency of DV agenesia. Agenesia of the DV can be completely asymptomatic in about 20% of cases and has a good prognosis in these cases [2], but it may also be associated with various other pathological changes including cardiac defects, chromosomal anomalies, the formation of portacaval shunts or portal vein agenesia [2]. The consequences may be fetal hydrops and fetal heart failure, so the prognosis in these cases is poor, and prenatal mortality, including the number of iatrogenic terminations of pregnancy, is high. In the case of DV agenesia, frequently associated abnormalities of the vascular system can be observed, through which the umbilical cord blood reaches the systemic circulation of the fetus. The umbilical vein can connect directly to the intrahepatic inferior vena cava instead of the left branch of the portal vein (▶ Fig. 7), or intrahepatic or extrahepatic portosystemic shunt connections can form. The frequency of a congenital portosystemic shunt is reported to be 1:30 000 births regardless of DV pathology [22]. In general, portosystemic shunts can be classified according to Morgan and Superina [23].

Intrahepatic portosystemic shunts can be well-visualized post-natally (▶ Fig. 8), and have a high spontaneous closure rate [2, 24–26]. However, they should be checked at greater intervals, since in the case of failing spontaneous closure, interventional or surgical closure may be necessary [2, 24]. A need for intervention arises if a shunt becomes symptomatic and leads to increasing levels of ammonia or galactose in the serum or to cardiological stress due to the shunt volume. Extrahepatic portosystemic shunts can close spontaneously, but may also have to be closed interventionaly or surgically, depending on the symptoms.

Persistent DV

There are few reports in the literature regarding failing spontaneous closure of the DV within the first weeks of life [27]. Possible symptoms are: increased liver enzymes, increased levels of direct bilirubin, galactosemia, hyperammonemia and liver dysfunction up to and including liver failure and increased cardiac stress [27, 28]. An association with cardiac defects, especially pulmonary arterial hypertension, is also observed in up to 25% of
cases [27]. Apparently prostaglandin medication and altered hemodynamics in pulmonary arterial hypertension contribute to keeping the DV patent [8, 27]. An association with liver masses has also been described [27].

Depending on the accompanying symptoms, a patent DV must be closed either by intervention or surgery. A multi-stage procedure may be necessary to avoid portal hypertension. Measurement of the portal venous pressure increase after temporary occlusion can be helpful here [29]. Interventional and surgical occlusion of persistent DV beyond infancy even through adulthood are also described in the literature with good success and normalization of liver enzymes and serum bilirubin or ammonia levels [29–31].

Conflict of Interest

The authors declare that they have no conflict of interest.

Literatur


