Anatomical and experimental study of the ductus venosus

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Summary. The authors report an anatomical study of the ductus venosus in the stillborn fetus based on resin-corrosion casts and angiography. Study in adult material was done by dissection. In the first part of this paper the classical anatomy of the ductus venosus is described and an anomalous case of a hepatic parenchymal bridge between the left and caudate lobes of the liver is reported. In the second part of this paper study of patency and dilation of the ligamentum venosum to a diameter exceeding 10 mm in adult cadavers is presented. A brief study of portal flow demonstrated that an increase in flow of 30% can be obtained by experimental induction of patency. A patent ligamentum venosum was grafted onto the abdominal aorta in the rabbit. The transplanted segment was fully patent and competent immediately after grafting, but showed thrombosis when the animal was sacrificed two months after the operation. In the opinion of the authors, it may be possible to use the patent ductus venosus in man once the problems of long term resistance and patency have been solved. The latter problems are currently under investigation in our laboratory.

Key words: Ductus venosus – Anatomy – Experimental porto-systemic shunt

The ductus venosus (ductus venosus Arantii) (DV) is an embryonic anastomosis between the portal vein (vena portae) (VP) and inferior vena cava (VCI). During embryonic life, the ductus venosus acts as a porto-systemic venous shunt, thereby significantly reducing umbilical circulation to the liver.

The DV appears during the second month of intrauterine life. Lying within the septum transversum, the DV corresponds to the segment of the left umbilical vein (vena umbilicalis) (VU) which has not been dissociated by the proliferation of entoblastic tissue into hepatic sinusoids (Laurent 1981). At birth, the DV and VU become obliterated, thereby forming the ligamentum venosum (LV) of the liver.

Study of the DV is of interest for 2 major reasons. First, the recent development of new investigative techniques (ultrasonography, computerized tomography) will undoubtedly lead to an increased rate of identification of spontaneous patency of the DV. Neumaier et al. (1983) reported two such cases. Second, from the surgical standpoint, patency of the DV may constitute an alternative method for achieving an intra-hepatic porto-systemic shunt in the treatment of portal hypertension, as proposed by Ascuncion and Silva (1971).

Reported in this paper are an anatomical study of the ductus venosus and an experimental study of its dilation and patency.
Material and methods

In the period from January 1981 to January 1984, 25 livers (hepar) were obtained for study: 8 were from 32 to 36 week old fetuses and 17 were from adults (two of them died of liver cirrhosis).

Anatomical study

Resin-corrosion casts were made in 6 fetuses. The resin used was a plastic polymer (Altulite). Prior to resin injection, the selected vein was rinsed with 20 ml of acetone. In three cases, the VCI was ligated above the hepatic veins (vena hepaticae) (VH) and then injected. In the three other cases resin was injected via the VU. After injection, the material was immersed in water for 48 h and then in a bath of acetic acid for 15 days, after which the material was washed. The main vascular axes were then painted different colors.

In two other fetal livers, the VU was injected with radio-contrast material followed by angiographic study. The 10 adult livers were studied by dissection. Histological study was also done in 7 of these cases.

Experimental induction of patency

This part of the study was done in 7 cases (5 in anatomical specimens, 2 in situ). For this purpose, a canula was introduced into the terminal part of the round ligament of the liver (ligamentum teres hepatis). Once the canula had reached the left branch of the VP, it was directed along the axis of the LV. Introduction of the canula into the LV leads to destruction of its venous wall as the instrument is pushed within the LV up to its termination. The VCI was then perforated by the canula at the point of convergence of the left hepatic vein (v. hepatica sinistra) (VHS) and left inferior phrenic vein (v. phrenica inferiores sinistra) (VPIS). Next, the LV was dilated using an infusion catheter and dilator sounds.

In two cases, portal flow was measured before and after dilatation of the LV. Measurements were made by infusion of saline into the VP under a physiological pressure of 13 mmHg.

In one case a dilated LV was transplanted as a side-to-side shunt onto the abdominal aorta (aorta abdominalis) of a rabbit. The LV had been taken from an adult cadaver and was kept in normal saline at 4 °C for 24 h prior to its transplantation. The rabbit was sacrificed two months after the operation (Fig. 1). The purpose of this experiment was to study the short and long term patency and resistance of the implanted LV.

Results

Anatomical study

In the fetus: the ductus venosus was consistently patent in the fetal material. It lies on the inferior surface of the liver and appears as a bluish venous cord stretching from the portal hepatic to the VCI (Fig. 2). The ductus venosus originates from the VP along with the left stem of the VP at a point 2 to 4 mm to the right of the termination of the VU. The course of the DV on the inferior surface of the liver is between the left hepatic lobe and caudate lobe (Spiegel’s lobe). In this area its course is clearly upward, backward and slightly oblique to the left side, i.e. in a practically sagittal plane. On angiographic films, the DV projects over the left margin of the anterior surface of the 10th through 12th thoracic vertebrae (Fig. 3).

The termination of the DV was variable in our material. In 5 cases it terminated in the VCI, in 2 cases in the VHS and in 1 case in the VPIS. The axis of the terminal of the DV, along with that of the VU running obliquely upwards, backwards and to the right, describes a bayonet-like course in the coronal plane (as seen on the resin corrosion casts). Despite this finding, the catheterization of the DV via the VU was always easily achieved under the condition that the tip of the catheter was oriented in an upward direction.

The size of the DV was relatively constant in our study (length 2 cm; diameter 2 mm). The diameter of the DV was equivalent to that of the left branch of the VP.

In the adult: the DV was easily identified near the inferior surface of the posterior part of the hepatic pedicle. The obliterated DV was seen as a whitish-grey fibrous cord, i.e. the ligamentum venosum (LV) (Fig. 4).

The origin of the LV on the left branch of the VP was at a point 1 cm to the right of the extended axis of the round ligament. The area of the embryological origin of the DV on the left branch of the VP was seen as a whitish stellate cicatrix in 8 cases, and as a shallow (1 mm deep) depression in 2 other cases.

From its origin the LV runs along the posterior longitudinal fissure of the liver between the left and