Portal Vein System

It can be claimed that the portal vein system is the most important system of the internal liver structure, not only because it determines the course of other systems and the internal architecture of the liver, but also because it represents – together with the hepatic vein system – the basis for functional (surgical) liver anatomy. The valveless portal vein, a vein unique in the human body, which gathers practically all the blood from the stomach, small and large intestines, spleen and pancreas through the afferent superior and inferior mesenteric veins and the splenic vein, becomes the main afferent vessel to the liver after division in the hepatic porta. It seems that the hepatic artery mainly helps the portal vein to perfuse the liver by providing additional necessary pressure through its arterioles, thereby providing sufficient push to the blood in the liver sinusoids. Blood flow and the oxygenation of the liver tissue depend mainly on the portal vein.

Just before entering the liver, the portal vein divides into a left and right portal vein system. Thereupon, the difference between the right and left side becomes significant. On the right side, there are usually two sectorial branches (the anterior and posterior); while on the left side, there are two parts of the left portal vein (the left main portal branch) – the extrahepatic portion (pars horizontalis, i.e. the horizontal part) and the intrahepatic portion (pars umbilicalis, i.e. the umbilical part). Further on, the branching is similar on both sides. In fact, there seems to be a likeness predominantly evident between the right anterior sector – segments V and VIII – and the left median sector, composed of segments III and IV. According to Couinaud, segment II is the left lateral sector, and therefore its segmental branch may be regarded as a sectorial branch corresponding to the sectorial branch of the right posterior sector. However, in certain cases, there seems to be a symmetry between segments V and VIII on the right side and segment IV (a,b) on the left side, as well as between segments VI and VII in the right and segments III and II in the left liver.

In general, the sectorial branch divides into several segmental portal branches, which in turn supply segments. One segmental branch is usually found for segments VII, II and VI, and more rarely for segment III. Most of the time, segment VIII and subsegment IVa have two segmental branches each, while there are usually several veins entering segment V and subsegment IVb. Segmental veins are then divided into subsegmental branches and further into small veins leading to the portal venule of the liver acinus.

Portal Vein Branching in the Hepatic Porta

In the porta hepatitis, the portal vein divides into left and right portal veins, also known as the left and right main portal branch. Only very rarely is the bifurcation of the portal vein absent.

In about one-sixth of the population, the portal vein divides into one left and two right branches. In this case, the first right side branch is the vein for the posterior sector of the right liver and the second branch is for the anterior sector of the right liver. Portal trifurcation is present if three branches stem from the main portal trunk – posterior branch, anterior branch and left main branch.

Another possibility is that the posterior branch stems from the main portal trunk, while the anterior branch forms a bifurcation with the left portal vein.

*Illustration on page 19: Portal vein system – the portal tree – as drawn in Icones Anatomicae, the front cover of which is reproduced on the opposite page (Library of the Institute for Anatomy, MF Ljubljana).

E. M. Gadžijev et al., Atlas of Applied Internal Liver Anatomy © Springer-Verlag/Wien 1996*
There can be a quadrifurcation consisting of a branch for segment VII, a branch for segment VI, an anterior branch and a left main portal branch (left portal vein).

Less rarely, branches for the caudate lobe originate from the main portal trunk or its bifurcation.

In exceptional cases, a branch for subsegment IVb or an additional branch for segments VI, VII or even VIII may stem from the portal bifurcation.

**Right Main Portal Branch – The Right Portal Vein**

The right main portal branch (right portal vein) lies in front of the caudate process and is usually 0.5 – 1 cm long. Entering the liver tissue enveloped in a perivascular fibrous sheath hidden under the right hepatic duct and right hepatic artery, the vein divides into the right anterior (paramedian or anteromedian) sectorial branch and the right posterior (lateral or posterolateral) sectorial branch.

Usually one or two branches (although there can be up to four) originate from the right main portal branch and enter the caudate process of segment I or the right paracaval region (segment IX according to Couinaud). The right portal vein can be very short or even missing, in which case the following variations may be present:

a) immediate branching of the two right sectorial branches (posterior and anterior);

b) a trifurcation of the very short right portal vein into the right anterior sectorial branch and branches for segment VI and segment VII.

Sometimes the branch for segment VI originates from the right anterior sectorial branch, or the branch for segment VII arises from the right anterior sectorial branch.

There are several patterns of further portal branching in the right liver through anterior and posterior sectorial branches into the branches for segments V, VIII, VI and VII.

It is surgically important to be aware of the possibility of the right portal veins being very short or absent. In such cases, a vein which seems to be the right portal vein may actually be the vein for the posterior sector, and ligating or clamping will not prevent bleeding from a considerable portion of the right liver. When dissecting this right posterior portal branch the surgeon could easily injure the right anterior portal branch, causing considerable bleeding.

**Right Anterior Sectorial (Paramedian, Anteromedian) Branch**

This vein passes anteriorly towards the right frontolateral surface of the liver. It lies in a vertical (sagittal) plane dividing into posterior ascending branches for segment VIII and anterior descending branches for segment V.

The right anterior sectorial branch is sometimes presented as one strong branch providing tributaries downwards for segment V and upwards for segment VIII.

It can be divided into several branches at its top, providing veins to its segments. A similar distribution of branches for segments V and VIII can often be found in the distribution on the left side of the liver for subsegments IVb and IVa.

The right anterior sectorial branch is occasionally absent. In such cases, there are two branches stemming directly from the right portal vein. The first, more anteriorly positioned branch, may represent the segmental branch for segment V, while the second, more posteriorly positioned branch, is a segmental vein for segment VIII. Such a finding could also be interpreted as evidence of two branches for segment VIII – the anterior and posterior branches – with only a rudimentary or even absent segment V. From the surgical point of view, it is essentially irrelevant whether or not it belongs to segment VIII; what is important is the possibility for anatomical resection of that part of the liver.

Sometimes the right anterior sectorial branch arises from the left main portal branch or forms a bifurcation with it. In such cases it is important that this variation is recognised before performing a liver resection, such as a left hepatectomy. A surgeon