

Development of the (supra-) hepatic portion of the inferior caval vein

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Background Textbooks describe the (supra-) hepatic portion of the inferior caval vein as developing from the junctions of the distal portion of the vitelline veins with the venous sinus, while the distal portions of the umbilical veins would disappear without trace.

Methods We investigated the (supra-) hepatic inferior caval vein in human and pig embryos between Carnegie Stages (CS) 10 and CS15, using Amira 3D reconstruction and Cinema 4D remodelling software.

Results At CS10 the vitelline and umbilical veins joined the venous pole of the heart via a common trunk, the hepatocardiac channel, while the common cardinal veins only appeared at CS12. The liver bud began to expand into the transverse septum at CS12 and enveloped the vitelline veins at CS13. The vitelline veins remained identifiable as wide, dorsally bent conduits during CS13, with the right side being wider than the left. At this stage, the pig embryo differed from the human in that its liver consisted of a single ventromedial lobe overlying the gall bladder and two dorsolateral lobes containing the vitelline conduits. The expanding ventromedial liver lobe surrounded the umbilical veins during CS14. The umbilical veins remained identifiable as conduits up to the junction with the dorsolateral lobes, but the left vein was much wider than the right. The diameter of the right-sided venous sinus and the hepatocardiac channel that drained on it acquired a much larger diameter during CS14 than the corresponding left-sided structures, which become Marshall's ligament and disappear, respectively. The distal portions of both umbilical veins temporarily persisted in the lateral body wall through CS14 and continued to drain into the venous sinus via the hepatocardiac channels and became enveloped by the dorsolateral lobes during CS15. The portal vein now entered the right dorsolateral lobe via the duodenal inter-vitelline anastomosis and continued as the persisting dorsally bent conduit to the right hepatocardiac channel. At this stage, the portal sinus appeared as anastomosis between the right-sided vitelline conduit and the left-sided umbilical conduit.

Conclusions The developmental transformation of the vitelline and umbilical veins proceeds according to a strict temporo-spatial plan. The embryonic pig liver has a more distinct bauplan than the human. Vitelline and umbilical veins develop ~2 CS earlier than the common cardinal veins and drain via hepatocardiac channels into the venous sinus. Left-right asymmetry in hepatocardiac channel development probably arises from the right-sided position of the sinoatrial junction and the decline of the left-sided portion of the venous sinus. Left-right anastomoses inside the liver develop at the junction of the ventromedial and dorsolateral lobes.