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VENOUS SYSTEM ASSOCIATED WITH THE LIVER OF A 6-MM. PIG EMBRYO

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SIX FIGURES

INTRODUCTION

This report is based chiefly upon a sagittal series of a 6-mm. pig embryo, first used by Professor Allen in the preparation of a pedagogical paper. The sections are 10 μ thick and are stained with carmine. Serial sections of other pig embryos of 3.5 to 12 mm. in length were examined to determine the constancy of structures.

Blotting-paper models of the liver region were constructed from the 6-mm. series, somewhat after the methods of Gage and Schaeffer. The model shown in the plates represents the blood vessels cast solid. The portal vein with its branches was removed before photographing the model. Photographs of a model of hepatic tissue and adjacent structures, used in tracing the course of some of the smaller vessels, are not shown.[1]

RELATION OF LARGER VESSELS TO SINUSOIDS

In this embryo the course of the main hepatic channels represents a stage midway between Bradley's nineteen-day-old and 8-mm. pig embryos. The development is further advanced than the 4.9-mm. human embryo of Ingalls, and although the similarity between the two embryos is close,

[1]A more detailed report, including several additional figures, is contained in a thesis presented to the Graduate Council of the University of Oregon, as part of the required work toward a Master of Arts degree, 1923.

there are certain marked differences. As seen in figure 1, the left umbilical vein is larger than the right and there is an anastomosis between the two veins within the septum transversum. The ductus venosus is well formed and the caudal portion of the left omphalomesenteric vein has been separated from the liver by the body cavity. Omphalomesenteric venous rings, about the intestinal tract, so prominent in earlier stages, have practically disappeared in this embryo. No large anastomosis between the left umbilical vein and the right omphalomesenteric vein is found, although it is a fairly constant structure in other embryos, as described by Bradley. Only the right mesenteric vein connects with

ABBREVIATIONS

a, aorta
als, portal anastomosis with left subcardinal vein
ars, portal anastomosis with right subcardinal vein
at, atrium
bc, body cavity
c, constriction between sinus reuniens and posterior superior sinusoid
db, dorsal branch of ventral division of left umbilical vein
dlu, dorsal division of left umbilical vein
dv, ductus venosus
lcc, left common cardinal vein
lcs, left central group of sinusoids
lls, large sinusoid in left lateral lobe
lh, left horn of sinus venosus
lhv, left hepatic vein
lom, left omphalomesenteric vein
lu, left umbilical vein
lvv, left vitelline vein
mc, median communication between left umbilical vein and sinus venosus
mn, mesonephros
mv, mesenteric vein
mvs, medioventral sinusoids
o, opening of right umbilical vein into portal vein
olu, extrahepatic course of left umbilical vein
oru, extrahepatic course of right umbilical vein
pc, postcardinal vein
ps, sinusoid from portal vein to ductus venosus
pv, portal vein
rcc, right common cardinal vein
rcs, right central sinusoids
rh, right horn of sinus venosus
rhv, right hepatic vein
rls, right lateral sinusoids
rom, right omphalomesenteric vein
rp, right posterior sinusoid
ru, right umbilical vein
rvv, right vitelline vein
sao, sino-auricular opening
sc, subcardinal vein
sn, vein ventral to mesenephros
sr, sinus reuniens
sv, sinus venosus
ua, umbilical anastomosis
uab, branch to medioventral sinusoids
vb, veins of Broman
vc, vena cava inferior
vlu, ventral division of left umbilical vein
vm, union of vitelline and mesenteric veins

the vitelline. Vestiges of the early, extrahepatic course of the left and right umbilical veins still remain (fig. 1, *oru* and *olu*).

The hepatic sinusoids vary from mere capillaries, 10 μ in diameter, to large spaces such as the right posterior sinusoid (fig. 1, *rp*) which has a vertical diameter of 160 μ. Five sinusoidal groups are apparent in the model: one in each lateral lobe, three in the central lobe. The right and left lateral groups of sinusoids (fig. 3, *rls* and *lls*) are in relation

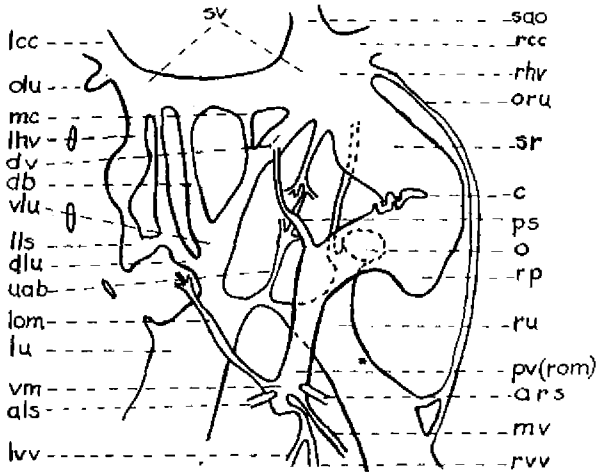

Fig. 1 Sketch of chief venous channels of liver, 6-mm. pig embryo.

to the right and left omphalomesenteric veins; the right and left central groups (fig. 2, *rcs* and *lcs*) to the two umbilical veins, and the fifth, or medioventral group (fig. 2, *mvs*) to a vessel (*uab*) running from the anastomosis between the two umbilical veins. A few capillaries in the septum transversum communicate with sinusoids of the left central group. These may later become transformed into hepatic sinusoids, as suggested by Mollier, Schulte, and Bremer.

Left umbilical vein. A slender mesenchymal band, covered by endothelium, extends dorsomediad and slightly cephalad across the lumen of the left umbilical vein near its entrance

into the septum transversum. This band does not appear in the figures. There is no corresponding band in the right vein, nor in the umbilical veins of other embryos studied. Entering the septum transversum, the left umbilical vein becomes abruptly reduced in caliber, then turning mediad, it anastomoses with the right (figs. 1, 2, 3). From this anastomosis arises a small vessel (*uab*) which supplies the medioventral group of sinusoids and ends in the ductus venosus. The medioventral sinuoids (fig. 2, *mvs*) lie ventral and cephalic to the gall bladder; they communicate with the right central group, of which they may be a part, and with the right posterior sinusoid.

Within the liver, the left umbilical vein (fig. 1, *lu*) separates into its dorsal and ventral divisions. Assuming a course dorsocephalad, the dorsal division (fig. 1, *dlu*) sends a short, wide branch to a prominent sinusoid (fig. 1, *lls*) in the left lateral lobe, communicates freely with the capillary sinusoids of the left lateral group, and continues cephalad as a small channel which terminates in the sinus venosus. The prominent sinusoid in the left lateral lobe, designated as the left lateral sinusoid (fig. 1, *lls*), receives the branch from the left umbilical vein near its blind caudal end. This sinusoid extends the length of the liver, communicating with the smaller sinusoids of the left lateral and left central lobes, and ends as the left hepatic vein (*lhv*) in the sinus venosus. Bradley suggests that the left lateral sinusoid may be a remnant of the left omphalomesenteric vein. The ventral division of the left umbilical vein (*vlu*), like the dorsal, is intimately connected with the hepatic sinusoids. It divides into two main branches. A small dorsolateral branch (fig. 1, *db*), the chief supply for the left central group of sinusoids (fig. 2, *lcs*), continues cephalad to end in the sinus venosus. The left central group is composed of freely anastomosing capillary sinusoids, lying largely to the right of the left umbilical vein. The major branch of the ventral division (fig. 5, *vlu*) may represent that portion which is to lie in the falciform ligament. This branch communicates with the sinus venosus in the median

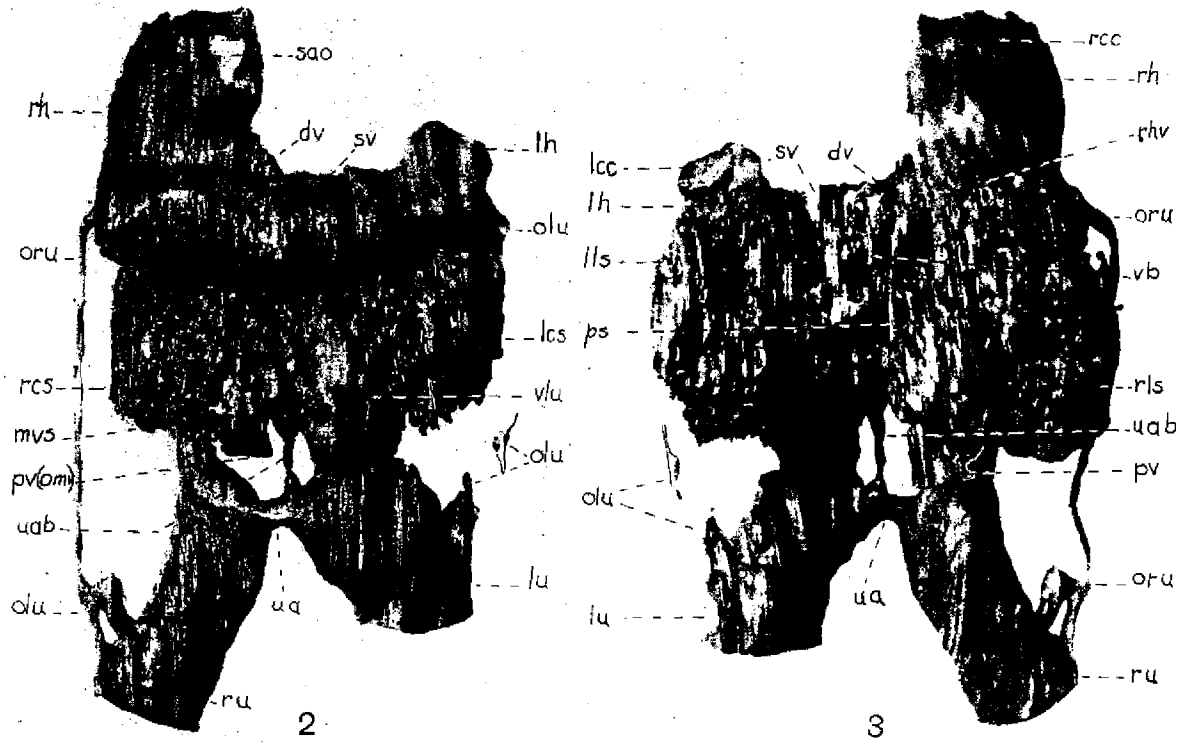

Fig. 2 Photograph. Model of liver sinusoids and veins. Ventral view. 6-mm. pig embryo.
Fig. 3 Photograph. Model of liver sinusoids and veins. Dorsal view. 6-mm. pig embryo.

plane (fig. 1, *mc*), then turns to the right and dorsally, forming the ductus venosus (*dv*). In its course the ductus venosus receives blood from the medioventral sinusoids and from the portal vein through other small sinusoids (fig. 1, *ps*).

The figures show the diameter of the right umbilical vein diminishing abruptly within the septum transversum. Beyond the anastomosis with the left umbilical vein, the right umbilical vein gives off a slender branch to the medioventral sinusoids. Upon entering the liver, the right umbilical vein enlarges and sends a short, wide branch dorsad to join the portal vein (right omphalomesenteric vein). Then, as a narrow sinusoid, it passes through the liver, supplying the right central lobe and ending in the right hepatic vein. Capillary sinusoids surrounding the right umbilical vein comprise the right central group (fig. 4, *rcs*); the body cavity partly separates the right central from the right lateral group.

Portal system. The paired vitelline veins unite in the umbilical stalk ventral to, and to the right of, the intestine. At the caudal extremity of the dorsal pancreas, the common vitelline vein expands into a large blood channel (fig. 1, *vm*) which has developed from the dorsal plexus between the caudal and cephalic omphalomesenteric rings of earlier stages. This channel receives the right mesenteric vein (fig. 1, *mv*) and anastomotic branches from the right and left subcardinal veins (*ars* and *als*). Allen mentions the anastomosis between the subcardinal and the portal system. This anastomosis is not an anomaly, for it is present in pig embryos of 6, 7, and 8 mm. It is clear that the right limb of the caudal omphalomesenteric ring has disappeared, while the left limb of the cephalic ring persists as a mere plexus of veins (fig. 1, *lom*) to the left of the dorsal pancreas. From the point of anastomosis with the right subcardinal vein, the right omphalomesenteric vein, or portal vein, continues cephalad as a vessel of 90 to 100 μ in diameter. It turns sharply to the right within the liver to join with the right umbilical vein in forming the right lateral sinusoid (fig. 1, *rp* and *sr*) which His interprets as a portion of the right omphalo-

mesenteric vein which has not broken up into smaller sinusoids, or which has been reopened. The right lateral sinusoid is constricted (fig. 1, *c*) into two parts, the right posterior sinusoid (*rp*) and the sinus reuniens (*sr*; vena hepatica revehens of Hochstetter; sinus S of Allen) which ends in the right hepatic vein.

Small sinusoids ventral to the stomach connect the right and left lateral lobes. These sinusoids, together with the cephalic portion of the ductus venosus, seem to be remnants of the cranial ring of the omphalomesenteric veins described by Hochstetter, Ingalls, and others. Figure 4 shows the veins of Broman (*vb*) to be intimately associated with these structures.

Sinus venosus. The transverse trunk (figs. 1 and 2, *sv*) of the sinus venosus (saccus sinus reuniens of His) is prominent between the heart and liver. It receives blood from the cardinals and from the dorsal division of the left umbilical vein. The greater portion of the blood passing through the liver, coming from the right umbilical vein, portal system, and ventral division of the left umbilical vein, pours into the right horn of the sinus venosus. Figure 2 reveals the sino-atrial opening (*sao*) in the ventral part of the right horn.

OTHER VESSELS

Since certain other veins, not so intimately associated with the liver, occur in the models, a brief description of them may be of interest. The inferior vena cava is not completely formed at this stage. It is a minute vessel which can be traced cephalad in the mesentery from the right subcardinal vein almost to the region of the veins of Broman. Paired veins (figs. 4, 5 and 6, *sn*), hitherto not mentioned in the literature, arise from the ventral wall of the posterior cardinal veins, immediately cephalad of the mesonephros. Each vein extends caudally, ventral to the Wolffian body, from which arise its tributaries. The paired veins are not to be confused with the subcardinals, which are medial to the Wolffian bodies in the 6-mm. stage. Figure 6 sketches roughly the development of these veins, now being investigated in more detail by Prof. C. F. W. McClure.

SUMMARY

As a result of a study of models of the liver region of a 6-mm. pig embryo, the following points were noted.

1. The sinusoids within the liver are divisible into five groups: left and right lateral, left and right central, and medioventral.

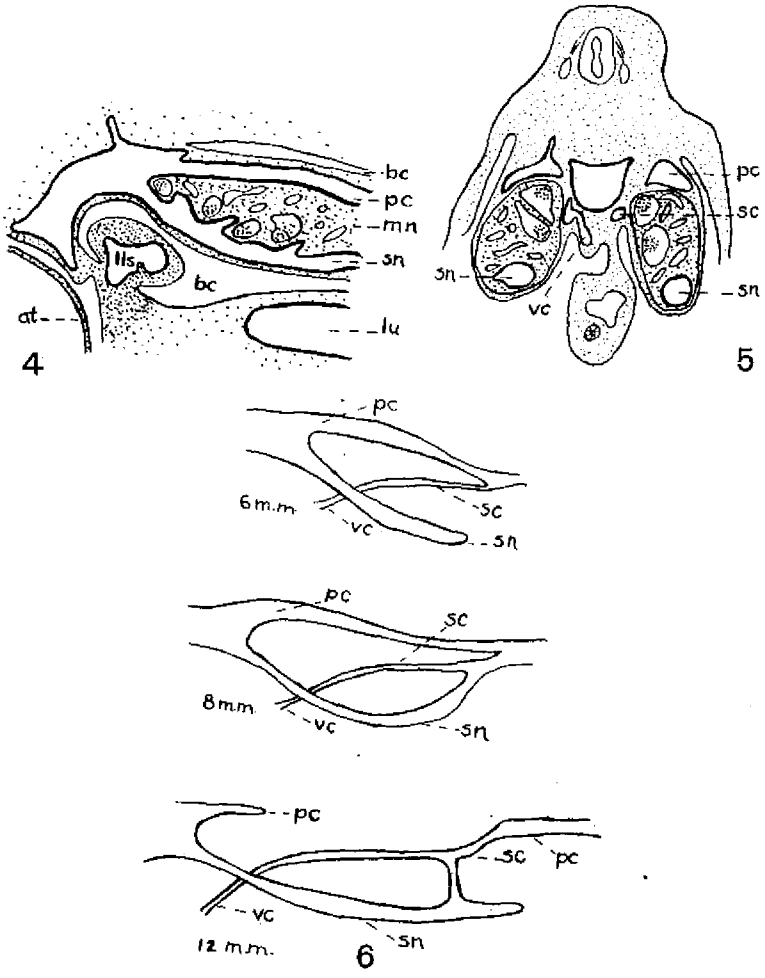

Fig. 4 Camera-lucida drawing. Sagittal section through left mesonephros. 6-mm. pig embryo.

Fig. 5 Camera-lucida drawing. Transverse section. 6.5-mm. pig embryo.

Fig. 6 Sketch of development of branch of postcardinal vein running ventral to mesonephros.

2. The left umbilical vein anastomoses with the right upon entering the septum transversum.

3. Within the liver the left umbilical vein breaks up into a dorsal division and a ventral division; the dorsal supplies the left lateral lobe through its communication with a large left lateral sinusoid, the ventral division supplies the left central lobe and forms the ductus venosus.

4. The extrahepatic course of the original left umbilical vein has almost disappeared; there is, however, an unbroken channel to the right of the liver marking the path of the original right umbilical vein.

5. The right umbilical vein enters the liver and joins the portal vein in forming a large sinusoid which occupies most of the right lateral lobe of the liver. This large sinusoid unites with the ductus venosus to form the right hepatic vein.

6. The portal system receives communicating branches from both the subcardinal veins.

7. It is the right horn of the sinus venosus which receives most of the blood from the liver.

8. At this stage the vena cava has not tapped the hepatic sinusoids.

9. A hitherto unreported branch of the postcardinal vein, ventral to the mesonephros, has been briefly described.

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