

## Vascularization of the Liver in the European Bison. 1. Hepatic Veins

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Examination was made of the course and division of hepatic veins in 13 livers, either fresh or fixed, of European bison (*Bison bonasus* Linnaeus, 1758) of different sex and age. Before preparation the veins were filled with vinyl superchloride »Vinoflex NP — 400«. A large number of characteristic features were found in hepatic veins, frequently connected with the formation of the liver typical of European bison. There are four large veins in the strongly developed right lobe: the right dorsal, middle and ventral hepatic veins and the accessory hepatic vein. The trunk of the middle hepatic vein is twice as long as that in domestic cattle. The hepatic vein of the caudate process, as a weak vein, most often carries blood from the caudate process only. The left hepatic vein has a relatively small diameter due to the weak development of the left lobe of the liver in European bison.

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### I. INTRODUCTION

The liver in the European bison exhibits many specific features in its external formation (Pytel & Węgrzyn, 1976), and therefore attention was given to the course and division of intrahepatic blood vessels, since it was anticipated that there also would be differences from those found in domestic cattle, the species most closely related to the European bison. In the first place examination was made of hepatic veins. There is little to be found in literature on these veins, even in relation to domestic ruminants (only the studies made by Podkovyrov, 1949, 1952 being more comprehensive), and in well-known textbooks on anatomy (Ellenberger-Baum, 1943; Martin & Schauder, 1938; Sisson & Grosman, 1960; Akajevskij & Lebiediev, 1971; Akajewski, 1973; Nickiel, Schummer & Seiferle, 1976) there is only brief mention of the hepatic veins, giving only the names as draining into the caudal vena cava.

## II. MATERIAL AND METHODS

Studies were made on 13 European bison livers from animals of different age (from one day old to 23 years old) and different sex (6 ♂♂, 7 ♀♀) registered in the Bison Pedigree Book (Zabiński, 1947). The livers were taken from bison fixed by intraarterial injection (Pilariski *et al.*, 1967) or from fresh carcasses. In the latter cases the veins were injected with vinyl superchloride (»Vinoflex NP — 400«) dissolved in aceton in parts of 1:1. 10% phthalate dibutyl was used as plastifier. The hepatic veins were injected through the caudal *v. cava*.

The diameter of the veins was calculated from the equation:  $\text{circumference} = 2\pi r$ , after previous measurement of the circumference of the vein. Measurements were made on four fixed livers of adult<sup>1</sup> bison (2 females and 2 males).

## III. RESULTS

The hepatic veins, *venae hepaticae*, in the European bison, as in other mammals, run completely hidden in the liver parenchyma and drain blood from it to the caudal *v. cava*.

Part of the caudal vena cava, *v. cava caudalis*, connected with the liver (Fig. 1, 2—1) runs downwards from the level of the I lumbar vertebra and forwards to foramen *venae cavae* of the diaphragm. In its course through the liver its lateral and ventral walls adhere to the visceral surface of the right lobe and the caudate process, then it runs downwards along the medial border in a deep fossa on the caudate lobe of the liver. It is this last-mentioned part which is covered from the lateral anterior and posterior side by the liver parenchyma. Further along in adult individuals the caudal *vena cava* runs over a short section about 5 cm long on the diaphragmatic surface of the liver and enters the thoracic cavity. The vessels given in the diagram below, in addition to small branches, open into it:

Caudal vena cava

- hepatic vein of caudate process
- accessory hepatic vein of the right lobe
- hepatic vein of papillary process
- right intermedial hepatic vein
- middle hepatic vein
- accessory hepatic vein of the right lobe
- right ventral hepatic vein
- hepatic vein of the quadrate lobe
- accessory hepatic vein of the quadrate lobe
- venosus duct (part active as hepatic vein)
- left hepatic vein

<sup>1</sup> Bison which had completed the 5th year of life were considered as adults (Empel & Roskosz, 1963).

- left intermedial hepatic vein
- left intermedial hepatic vein
- left ventral hepatic vein

The right dorsal hepatic vein, *v. hepatica dorsalis dextra* (Fig. 1—2) is approx. 12 mm in diameter at the outlet in males and 7 mm in females. It begins with two branches (visceral and diaphragmatic) in the upper

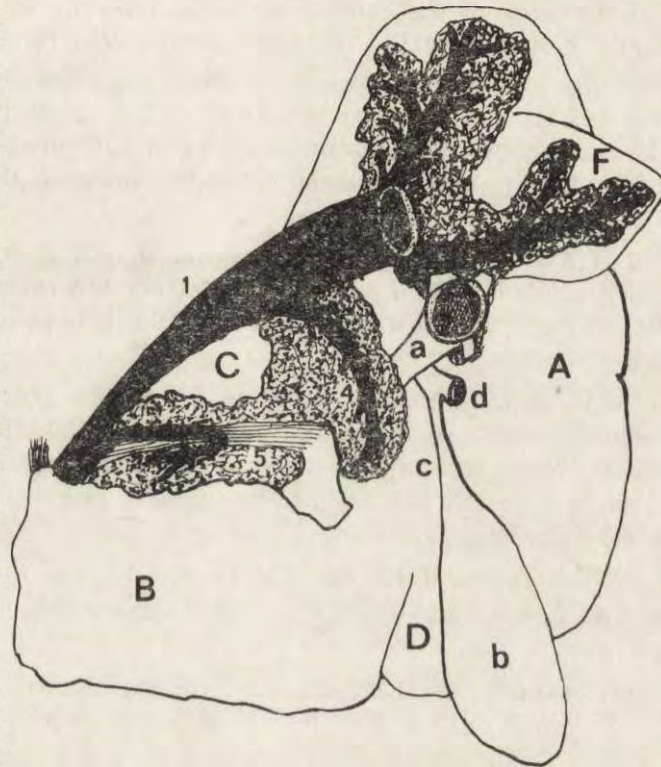


Fig. 1. Diagram of the liver in European bison: view from the side of the visceral surface (part of the parenchyma has been removed to show the hepatic veins).

1 — caudal vena cava, 2 — right dorsal hepatic vein, 3 — hepatic vein of the caudate process, 4 — hepatic vein of *processus papillaris*, 5 — venous duct (occluded part), 5' — venous duct (functioning part as hepatic vein), a — portal vein, b — gall bladder, c — vesicular duct, d — bile duct (sectioned), A — right lobe, B — left lobe, C — caudate lobe, D — quadrate lobe, F — caudate process.

right lobe, runs near the visceral surface of the liver in a forwards and downwards direction and drains into the caudal vena cava slightly above the level of the upper porta of the liver. These vessels conduct blood through numerous branches from the upper part of the right lobe.

Variants. In two cases out of 13 the right dorsal hepatic vein began

near the caudal border of the liver and at first ran dorsal, then downwards and medially, that is in the form of an upturned arch. In two other cases this vessel was double one and both trunks drained independently side by side into the caudal vena cava.

The hepatic vein of the caudate process, *v. hepatica proc. caudatus* (Fig. 1—3) attains a diameter of about 13 mm. It begins with two branches from the apex of the caudate process and runs in it near its visceral surface, at first near the caudate process vein (branch of the portal vein) and the caudate process artery, then runs independently and drains into the caudal vena cava at the level of the upper part of the porta of the liver. Stronger dorsal branches, 3—4 in number, 1—2 ventral branches and numerous small vessels from the area of the caudate process open into it.

Variants. In 4 cases a further fairly strong diaphragmatic branch (5 to 8 mm in diameter), which carried blood from the middle part of the right lobe, opened into the terminal part of the hepatic vein of the caudate process.

The hepatic vein of the papillary process, *v. hepatica proc. papillaris* (Fig. 1—4), about 8 mm in diameter, begins from the apex of the papillary process, runs in an arch directed upwards and backwards, enters the caudate lobe and drains into the caudal vena cava slightly below the vessel described above.

Numerous small branches drain into the hepatic vein of the papillary process from this process and from the region of the visceral surface of the caudate lobe.

The right intermedial hepatic vein, *v. hepatica dextra intermedia* (Fig. 2—2) has a diameter of about 16 mm in males and 7 mm in females. It begins with two branches in the right lobe near the upper part of the caudal border of the liver (below the dorsal angle of the right lobe). It runs in a forward and downward direction and slightly pericentrally in the right lobe, enters the caudate lobe and drains into the right wall of the caudal vena cava at the level of half the height of the porta of the liver. In addition to small branches it has stronger branches — 2 ventral, 1 diaphragmatic and 2 dorsal branches, which carry blood from the dorsal part of the right lobe and the caudate lobe.

Variants. In one case the right intermedial hepatic vein was double. One of its trunks (diameter about 12 mm) ran close to the visceral surface, and the second (diameter about 14 mm) closer to the diaphragmatic surface of the liver: both drained independently into the caudal vena cava at an identical level. In two cases this vein did not occur, and it was then supplemented by strong branches of the right

dorsal hepatic vein and chiefly by the accessory hepatic vein of the right lobe.

The middle hepatic vein, *v. hepatica media* (Fig. 2—3) is about 31 mm in diameter in males and 24 mm in females, and is the thickest vein carrying blood from the liver in the European bison. The middle hepatic vein arises from the liver parenchyma, forwards from the porta of the liver, from the connection of the right ventral hepatic vein and hepatic vein of the quadrate lobe. This vessel, from 7—10 cm long, run in a downwards direction, to the right and forwards through the caudate

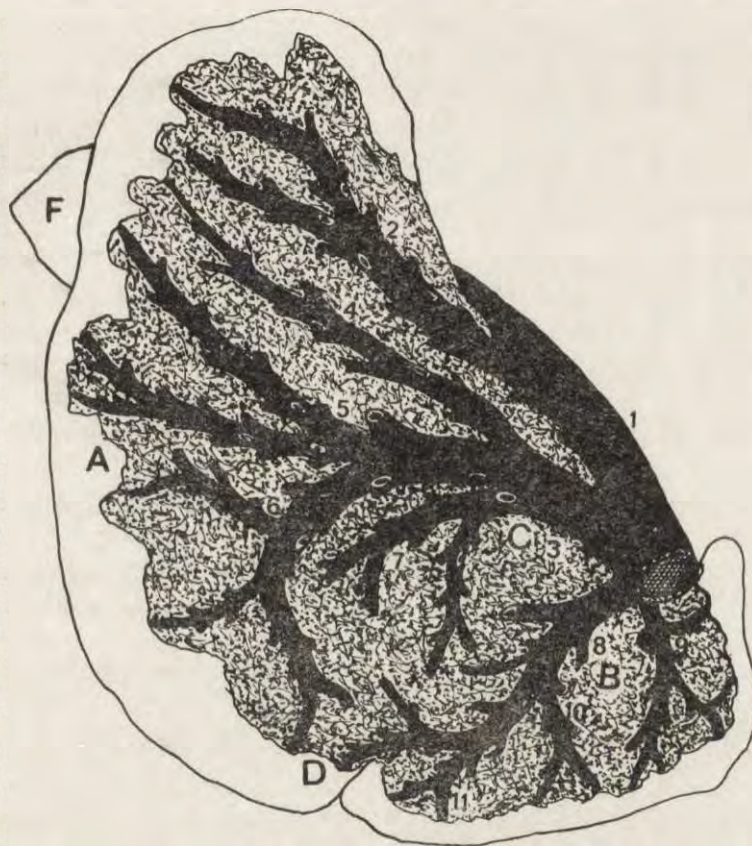


Fig. 2. Diagram of the liver in European bison — view from the side of the diaphragmatic surface (the superficial layer of parenchyma has been removed to show the hepatic veins).

1—caudal vena cava, 2—right middle hepatic vein, 3—middle hepatic vein, 4—accessory hepatic vein of the right lobe, 5—right ventral hepatic vein, 6—hepatic vein of the quadrate lobe, 7—accessory hepatic vein of the quadrate lobe, 8—left hepatic vein, 9—left dorsal hepatic vein, 10—left intermedial hepatic vein, 11—left ventral hepatic vein, A—right lobe, B—left lobe, C—caudate lobe, D—quadrate lobe, E—caudate process.

lobe, and open into the caudal vena cava below the porta of the liver. Veins not constantly occurring open into the middle hepatic vein in addition to those given above — the accessory hepatic vein of the right lobe and accessory hepatic vein of the quadrate lobe.

1. The accessory hepatic vein of the right lobe, *v. hepatica accessoris lobi dextri* (Fig. 2—4) exhibits different degree of development and in males may reach a diameter of about 10 mm. In cases of strong development it begins near the caudal border of the liver in the right lobe, but varies in its course closer either to the diaphragmatic surface or the visceral surface of the liver, in a forwards and downwards direction and to the right, through the right lobe and caudal lobe. It most often opens (8 cases) into the middle hepatic vein. In addition to small vessels it is joined by 1—3 stronger diaphragmatic branches, 1—2 visceral branches, from the dorsal and middle part of the right lobe and from the caudate lobe. When weakly developed the accessory hepatic vein of the right lobe limits its range to the caudate lobe only. In such cases branches from the right ventral hepatic vein and a strong diaphragmatic branch of the hepatic vein of the caudate process enter into the area of the right lobe usually vascularized by this vein.

Variants. In three cases the accessory hepatic vein of the right lobe opened directly into the caudal vena cava, and in two others did not occur at all.

2. The right ventral hepatic vein, *v. hepatica dextra ventralis* (Fig. 2—5) is approx. 19 mm in diameter in males and 14 mm in females. It begins from the caudal border of the liver with two strong branches — dorsal and ventral, which run forwards and downwards and pericentrally through the right lobe and combine in a trunk of varying length opening into the middle hepatic vein, giving rise to the following stronger branches in addition to small ones: 1—3 dorsal, 2—3 ventral, 2—3 visceral and 1—2 diaphragmatic. They carry blood from the lower part of the right lobe.

Variants. In one case weak development of this vein was observed, and then the accessory hepatic vein of the right lobe was stronger.

3. The hepatic vein of the quadrate lobe, *v. hepatica lobi quadrati* (Fig. 2—6) is approx. 18 mm in diameter in males and 13 mm in females. It is formed from small branches, near the fissure for the round ligament in the lower part of the quadrate lobe, in which it arches upwards and opens into the middle hepatic vein. Along its course it receives branches from the quadrate lobe and from the lower part of the right lobe and a fairly strong (diameter about 12 mm) accessory hepatic vein of the quadrate lobe (fig. 2—7). It carries blood from the lower part of the quadrate lobe by means of three strong and numerous small branches.

Variants. In three cases the accessory hepatic vein of the quadrate lobe opens into the middle hepatic vein, and in one case even into the left hepatic vein.

The left hepatic vein, *v. hepatica sinistra* (Fig. 2—8) exhibits varying degrees of development depending on the size of the left lobe of the liver, and consequently its diameter varies within limits of 14—20 mm. The left hepatic vein begins in the lower part of the left lobe, near the fissure for the round ligament, runs pericentrally and slightly dorsally through the whole lobe and opens into the caudal vena cava below the opening into it of the middle hepatic vein. Branches of different size (depending on the size of the left lobe), the left dorsal hepatic vein, intermedial and ventral vein, carrying blood from the lower part of the left lobe, and also numerous small and stronger (2—3) branches from the upper part of the left lobe, open into this vein.

Variants. In three cases stronger development of the left dorsal hepatic vein was observed. In such cases it began near the beginning of the left hepatic vein and ran parallel to it through the whole of the left lobe, receiving along its course small branches from its lower part.

The venosus duct, *ductus venosus (Arantii)* most often (8 cases) undergoes obliteration only over a short section (fig. 1—5) near the portal vein. In such cases its distal end, changed in form, functions as a hepatic vein (Fig. 1—5') into which small branches from the caudate lobe and left lobe open. It must be added here that in the three calves examined, from 1 to 3 days old, the venosus duct functioned over its whole length and its course formed an arch directed upwards.

#### IV. DISCUSSION

In adult European bison the liver is differently shaped from that in domestic cattle. It is characterized by strong development and thickening of the right lobe and reduction, frequently very marked, of the left lobe (Pytel & Węgrzyn, 1976). The specific shape of the liver in the species studied exerts a distinct influence on the size, course and division of hepatic veins.

In the right lobe in European bison there are as many as four large hepatic veins: the right dorsal, intermedial, ventral and accessory. In cattle and sheep Rex (1888), Klages (1931), Martin & Schauder (1932) and Podkovyrov (1952) describe only one large right ventral hepatic vein and a weak vein which corresponds to the right dorsal hepatic vein described by me for the European bison. This vein carry blood in all the above-mentioned species from the dorsal part of the

right lobe, situated above the caudal vena cava. The right intermedial hepatic vein and accessory hepatic vein of the right lobe have not been described in cattle, but are strongly formed in European bison on account of the marked development of the right lobe of the liver.

The middle hepatic vein in European bison and cattle are approximately similar in diameter, but there is a distinct difference in its length — in European bison the trunk of the middle hepatic vein is longer (7—10 cm) than in cattle (4—5 cm).

The accessory hepatic vein of the quadrate lobe in the bison opens either into the middle hepatic vein or the hepatic vein of the quadrate lobe, whereas in cattle it opens only into the latter (Podkovyrov, 1952).

The hepatic vein of the caudate process is far thinner in the European bison (diameter about 13 mm), as a consequence of the weaker development of the caudate process of the liver in this species (in the cattle diameter equals 20—25 mm). In cattle a fairly strong diaphragmatic branch from the right lobe opens into the hepatic vein of the caudate process. The occurrence of a corresponding branch in bison was found only in 30% of the cases examined. In the remaining 70% of cases these veins were replaced by the strongly developed hepatic veins of the right lobe.

The left hepatic vein in the cases examined exhibited weaker development (diameter about 15—20 mm) than the analogical vein in cattle (diameter 20—25 mm), which is undoubtedly connected with the weaker development of the left lobe of the liver in the European bison. The course and division of the left hepatic veins — dorsal, intermedial and ventral — were very similar in both the species compared.

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#### UNACZYNIENIE WĄTROBY ŻUBRA. I. ŻYŁY WĄTROBOWE

##### Streszczenie

Badano przebieg i podział żył wątrobowych na 13 wątrobach świeżych i utrwalonych żubrów, różnej płci i różnego wieku. Naczynia żyłne przed preparacją wypełniano superchlorkiem winylu „Vinoflex NP—400”. Stwierdzono obecność wielu cech charakterystycznych w żyłach wątrobowych, często powiązanych z typowym dla żubra ukształtowaniem wątroby.

W silnie rozwiniętym płacie prawym występują cztery duże żyły: wątrobowa prawa górna, średnia, i dolna oraz żyła wątrobowa dodatkowa. Pień żyły wątrobowej środkowej (Ryc. 2) jest dwukrotnie dłuższy niż u bydła. Żyła wątrobowa wyrostka ogoniastego, jako słabe naczynie (Ryc. 1) najczęściej odprowadza krew tylko z wyrostka ogoniastego. Stosunkowo małą średnicę ma żyła wątrobowa lewa (Ryc. 2) co wiąże się ze słabym rozwojem u żubra płata lewego wątroby.