

HEPATIC VEINS AND LIVER SEGMENTATION IN OVINE (*Ovis aries*)*

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SUMMARY: The hepatic veins and their sectors of drainage have been studied in 40 livers of ovines. In 35 organs the venous system was injected with "Neoprene Latex 650" and then dissected; in the other 5 it was injected with vinyl acetate (different colors) in order to obtain plastic models. The authors observed that hepatic lobes and their sectors were drained by the following hepatic veins and their tributaries. Major hepatic veins (left hepatic vein, middle hepatic vein, right hepatic vein(s), hepatic vein of the caudate process and hepatic vein of the papillary process), and minor hepatic veins. The left and the middle hepatic veins were the main vessels to drain the blood from the liver of *Ovis aries* and ended independently into the caudal vena cava. The right hepatic vein(s) terminated in the caudal vena cava only in 57.1% of the cases as it joined the vein of the caudate process or of the papillary process in 31.4% one or more right hepatic vein(s) occurred in 88.6% of the cases, a single vein being more frequent (51.4%) than two (22.9%) or three (14.3%) veins. In a few cases the vein of the caudate process formed a trunk with the right hepatic vein and/or the vein of the papillary process (11.4%). Alone or in conjunction with others the vein of the caudate process terminated into the caudal vena cava. The vein of the papillary process ended independently into the caudal vena cava,

in 71.4% of the cases. Alone or in conjunction with the vein of the caudate process and/or the right hepatic vein, it ended into the caudal vena cava. Minor hepatic vein, opening directly into the caudal vena cava, completed the drainage of the dorsal and medial sectors of the right lobe and the supraportal portion of the caudate lobe. In the vast majority of cases there were no large anastomoses between veins of adjacent anatomicosurgical segments, limited by avascular or paucivascular areas. The venous drainage network was independent and intertwined with the portobilioarterial network. The venous drainage network included in the majority of cases the following anatomicosurgical segments: a) segment of the left hepatic vein (left lobe); b) segment of the middle hepatic vein (quadrate lobe, the supraportal portion of the caudate lobe, the lateral and intermediate sectors of the right lobe); c) segment of the right hepatic vein(s), typically represented by the dorsal sector of the right lobe; d) segment of the vein of the caudate process; e) segment of the vein of the papillary process. The medial sector of the right lobe is drained by the minor hepatic veins.

UNTERMS: Anatomy of sheep; Liver; Veins

INTRODUCTION AND LITERATURE

The liver in ovines, similarly to that of humans (ARNAUTOVIC; KREMAR¹, 1964), is classified as non-lobated by MEYER (1911) apud NETTELBLAD⁷ 1954 as opposed to 1954 the lobated ones in the majority of mammals. Our study of the hepatic veins in a series of *Ovis aries* is intended to answer, at least partially, HJORTSJÖ's⁵ (1948) question on how the different portions of the human liver correspond to the lobated liver lobes separated by deep fissures and to what extent this subdivision would be useful to the lobated liver. We will deal, in particular, with the major divisions of the liver into lobes and sectors, defined as plurisegmental portions, and segments defined as isolated parenchymal territories, susceptible of anatomicosurgical separation, based upon their vascularization.

The bibliographic search yielded scant information, which was mainly related to ruminants, and no especial paper on major and minor hepatic veins in *Ovis aries*. The only publication dealing with the "hepatic portion of the caudal vena cava", where the hepatic veins end, in ovines, was authored by NASCIMENTO; GODINHO⁶ (1960). The publication by FEITOSA FILHO³ (1972) on the hepatic veins of *Capra*

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hircus will be used to compare our results with a close species within the group of small ruminants.

The primary goals of this paper are: (1) to know the distribution of the hepatic veins in ovines; (2) to compare the arrangement of these vessels with that of caprines; (3) to correlate its disposition with those of the portal vein, hepatic artery and biliary ducts;* and (4). to establish the basis for the identification of hepatic anatomical segments.

MATERIAL AND METHOD

The material comprised 40 livers of ovines, without defined race, whose age ranged from 4 to 18 months. There were 34 males and 6 females, obtained from the slaughterhouse of the city of Poá, State of São Paulo, and from the Faculdade de Ciências Agrárias e Veterinárias (City of Jaboticabal), Universidade Estadual de São Paulo.

Each specimen was reduced to liver, part of the diaphragm and the "hepatic portion of the caudal vena cava". After washing with tap water, the caudal vena cava of 35 specimens (29 males and 6 females) was cannulated from its thoracic end and ligated at the opposite end. The cranial and caudal phrenic veins were also ligated, before the injection of the hepatic veins with "Neoprene latex 650", containing a special pigment. The livers were fixed in 10% formaldehyde solution for at least 24 hours then dissected from the visceral aspect. After the dissection the hepatic veins were identified and drawn.

In 3 specimens (males) an additional injection of the hepatic artery, portal vein and biliary ducts was made with vinyl acetate (different colors). In the last 2 specimens (males) the left and middle hepatic veins were directly injected with vinyl acetate (different colors). The latter 5 specimens were subjected to corrosion by 30% H₂SO₄ solution for 8 to 10 days.

The best corrosion specimens were photographed and some used as illustrations.

RESULTS

The lobes of the liver were divided into sectors as follows: A) the left lobe comprised the I) medial, II) intermediomedial, III) intermediolateral and IV) lateral sectors; B) the right lobe comprised the I) medial, II) dorsal, III) intermediate and IV) lateral sectors; C) the quadrate lobe; D) the caudate lobe comprised the caudate process, the papillary process and the supraportal portion.

Draining the above mentioned lobes and their sectors the following hepatic veins and their tributaries were recognized:

A - Major hepatic veins:

- 1) Left hepatic vein, resulting from the confluence of veins originated from the medial, intermediomedial, intermediolateral and lateral sectors of the left lobe and, sometimes, also from the quadrate lobe.
- 2) Middle hepatic vein, formed by the convergence of veins draining the quadrate lobe, the dorsal, intermediate and lateral sectors of the right lobe, and the supraportal portion of the caudate lobe.
- 3) Right hepatic vein or veins, draining the medial, dorsal and intermediate sectors of the right lobe.
- 4) Hepatic vein of the caudate process, which received tributaries from the medial, dorsal and intermediate sectors of the right lobe and from the papillary process.
- 5) Hepatic vein of the papillary process, which besides draining the papillary process rarely received veins from the supraportal portion of the caudate lobe.

B - Minor hepatic veins:

These veins completed the drainage of the supraportal portion of the caudate lobe, the medial and dorsal sectors of the right lobe, and terminated directly into the caudal vena cava.

A - Major hepatic veins

The left and middle hepatic veins have a greater diameter than the others and drain large sectors. Each was divided into portions: a proximal portion, represented by a variable number of roots, which converge to form a single trunk, that is, the distal portion, which ends in the caudal vena cava.

- 1) The left hepatic veins - VHL - (Fig. 1) appeared without major tributaries (31/35 cases, i.e., 88.6% ± 5.3) or with major tributaries (4 cases, i.e., 11.4% ± 5.3).

When a single trunk, the left hepatic vein was biradicular (23/35 cases, i.e., 65.7%) more frequently than triradicular (8 cases, i.e., 22.8%).

The left hepatic vein had a tributary (2/35 cases, i.e., 5.7%) or two (2 cases, i.e., 5.7%).

Minor affluents, originating from the medial sector (100%), from the intermediomedial sector (94.3%), from the intermediolateral sector (22.9%), from the lateral sector (51.4%) of the left lobe and from the quadrate lobe (31.4%) were found.

- 2) The middle hepatic vein - VHM - (Fig. 2) was observed as a trunk without major tributaries (100%), with two roots (15/35 cases, i.e., 42.8%) or three roots (20/35 cases, i.e., 57.2%).

The middle hepatic vein received minor tributaries from the caudate lobe (82.8%), from the quadrate lobe (20%) and from the medial (8.6%) and dorsal sector (2.9%) of the right lobe.

- 3) The right hepatic vein or veins (Fig. 3) were present in 31/35 cases, i.e., 88.6% and absent in 4/35, i.e., 11.4%. When present there was a single right hepatic vein in 18/35 cases, i.e., 51.4%, there were two right hepatic veins in 8/35 i.e., 22.9% and three right hepatic veins in 5/35, i.e., 14.3%.

The right hepatic vein drained the dorsal sector of the right lobe (71.4%) and sometimes the medial (17.1%) and the intermediate sector (5.7%).

The right hepatic terminated directly into the caudal vena cava in 20/35 cases, i.e., 57.1% or after joining another hepatic vein in 11/35, i.e., 31.4%, the latter being the vein of the caudate or of the papillary process.

- 4) The vein of the caudate process (Fig. 4) drained exclusively this process in 13/35 cases, i.e., 37.1%; it received minor tributaries from the medial, dorsal and intermediate sectors of the right lobe and supraportal portion of the caudate lobe in 18/35 cases, i.e., 51.4%, and formed a trunk with the right hepatic vein and/or the vein of the papillary process in 4/35 cases, i.e., 11.4%. The vein of the caudate process, alone or in conjunction with others, ended into the caudal vena cava (vcd).

- 5) The vein of the papillary process (Fig. 5) drained exclusively this process in 27/35 cases, i.e., 71.4% and joined the vein of the caudate process and/or the right hepatic vein in 4/35 cases, i.e., 11.4%. In the remaining 4 cases (11.4%) it was absent. The vein of the papillary process was a direct tributary of the caudal vena cava (vcd).

B - Minor hepatic veins

The minor hepatic veins, variable in number and diameter, drained the dorsal and medial sectors of the right lobe and the supraportal portion of the caudate lobe (100% of the cases) and they terminated directly in the caudal vena cava (Fig. 6).

Anastomoses between rootlets of the hepatic veins were found in only 10/35 cases, i.e., 28.6%. In 71.4% of the cases (25/35) there were no anastomoses that could be visualized with the naked eye, as the boundaries between adjacent territories or anatomicosurgical segments appeared as avascular or paucivascular areas (Fig. 7).

Corrosion casts, obtained after the injection of different colored vinyl acetate in each hepatic vein, showed that the left and middle hepatic vein drain large territories or venous drainage anatomicosurgical segments of the liver. These segments had the same or different size, sometimes with predominance of the left (Fig. 8) or of the middle.

The other veins, that is, the right hepatic vein(s), vein of the caudate process, vein of the papillary process and minor hepatic veins drain much smaller segments.

The multiple injection of vessels (arteries and veins) and ducts allowed to observe that there were two networks: one represented by the similar distribution of the portal vein, hepatic artery and biliary ducts and the other network made up of the hepatic veins that drain the liver parenchyma toward the caudal vena cava. These two networks appeared intertwined as it occurs in humans.

DISCUSSION

From the preceding observations, the expected similarity between the intraparenchymatous distribution of non-lobated livers, such as those of ovines and humans, was only partial. In fact, only the left and the middle hepatic veins drain large territories (ARNAUTOVIC; KREMAR¹, 1964) recognizable as typical, anatomicosurgical segments, whereas the other hepatic veins correspond to smaller segments.

Analyzing the data obtained from the study of each vein, we noted that *the left hepatic vein* drained the left lobe (100%) and, in 14.3% the cases, also the adjacent portion of the quadrate lobe. The drainage of the quadrate lobe, by the left hepatic vein, found in our cases, was not observed by ARNAUTOVIC; KREMAR¹ (1964) in ovines, by FEITOSA FILHO³ (1972) in caprines, by HABEL⁴ (1975) in ruminants and by BRIKAS; TSIAMITAS² (1980) in caprines.

The left hepatic vein ended independently and directly in the caudal vena cava, next to the

esophageal impression. The orifice of termination of the left hepatic vein was the most distal as related to those of the other hepatic veins. The ostium of the right hepatic vein was just proximal to that of the left vein.

The middle hepatic vein, similarly to the left, is a conspicuous vessel (NETTELBLAD⁷, 1954), drains a large anatomicosurgical segment, which includes the quadrate lobe, a portion of the right lobe and the supraportal portion of the caudate lobe. Such an extension of the venous drainage corresponds to a larger area indicated by HABEL⁴ (1975), who limited it to the quadrate and caudate lobes.

Confirming HABEL's⁴ (1975) description, in our cases the middle hepatic vein ended into the caudal vena cava next to the left hepatic vein and the middle hepatic vein ended in the caudal vena cava next to the ostium of the left hepatic vein.

The two large hepatic veins and two small ones considered by ARNAUTOVIC; KREMAR¹ (1964) in ovines could be identified in our cases as the left and middle hepatic veins (the large ones) and the right hepatic veins (the small ones). Similar statement had been made by BRIKAS; TSIAMITAS² (1980) regarding the presence of two right hepatic veins, although only one corresponded to our description, as one was recognized in our cases as the vein of the caudate process. In fact, confirming HABEL's⁴ (1975) description, we found in 31.4% two veins, one being the right hepatic and the other the vein of the caudate process, joining each other and forming a single trunk.

When absent (11.4% of the cases), the drainage of the segment of the right hepatic vein was performed by minor veins, which varied in number and diameter, ending directly into the caudal vena cava and/or by means of the middle hepatic vein.

The vein of the caudate process was mentioned by ARNAUTOVIC; KREMAR¹ (1964) in ovines and FEITOSA FILHO³ (1972) in caprines, adding that such a vein drained also the lateral and dorsal area of the mentioned process. In our cases, the corresponding veins drained the medial, dorsal and intermediate sectors of the right lobe and, occasionally, the supraportal portion of the caudate lobe. The vein of the caudate process terminated directly into the caudal vena cava or after forming a trunk with the right hepatic vein and/or the vein of the papillary process.

The vein of the papillary process appeared in 88.6% of the cases. No numerical data on its incidence was found in the literature, precluding a comparison. The cases in which this vein ended directly in the caudal vena cava (77.2%) are more frequently than those in which it joined the vein of the caudate process or the right hepatic vein (11.4%).

Minor hepatic veins had been described by NETTELBLAD⁷ (1954), ARNAUTOVIC; KREMAR¹ (1964) and by FEITOSA FILHO³ (1972) without indication of their respective area of drainage. In our cases, we noted that these small veins drain the dorsal and medial sectors of the right lobe and the supraportal portion of the caudate lobe. The direct opening of these numerous minor hepatic veins into the caudal vena cava occupied a relatively long portion of the caudal vena cava embedded in the hepatic parenchyma as it had been described by NASCIMENTO; GODINHO⁶ (1960).

The relatively low incidence (28.6% of the cases) of anastomoses between hepatic veins and their small caliber supported our concept of anatomicosurgical segments. In fact these segments can be anatomically recognized and surgically removed in a large percentage of cases (71.4%) without having to ligate anastomoses found at the level of their boundaries. Only in a few cases (28.6%) such surgical removal is performed with the sectioning and ligation of the small anastomoses. Our observations indicated that the hepatic venous drainage segments are limited or separated by avascular or paucivascular areas.

Summing up, our observations detected: (1) a hepatic venous drainage network and a portobilioarterial network, which are intertwined and (2) that hepatic venous drainage occurs in the majority of the cases by areas recognizable as anatomicosurgical segments. These segments can be divided into major segments (left and middle) and minor segments (right, caudate process and papillary process). From these observations, we can answer HJORTSJÖ's⁵ (1948) question as follows: these seems to be a correspondence between portions of the ovine non-lobated liver and those of the lobated liver and that there is a segmentation in both lobated and non-lobated liver.

CONCLUSIONS

- 1) The left and the middle hepatic veins are the main vessels to drain the blood from the liver of *Ovis aries*. The left hepatic vein was always present without major tributaries (88.6% of the cases) and as a single, biradicular trunk (66.7%). The middle hepatic vein was also always present without major tributaries (100%) and its trunk appeared with two (42.8%) or three (58.2%) roots.
- 2) The territory or anatomicosurgical segment drained by the left hepatic vein included the left lobe of the liver and sometimes (14.3%) an adjacent narrow area of the quadrate lobe.

- 3) The territory or anatomical segment drained by the middle hepatic vein included the quadrate lobe, the lateral and intermediate sectors of the right lobe (80%) the caudate lobe (82.8%) and sometimes the medial sector (8.6%) and the dorsal sector (2.9%) of the right lobe.
- 4) One or more right hepatic vein(s) occurred in 88.6% of the cases; a single vein being more frequent (51.4%) than two (22.9%) or three (14.3%) veins.
- 5) While the left and middle hepatic veins ended independently into the caudal vena cava, the right hepatic vein(s) terminated in the caudal vena cava only in 57.1% of the cases as it joined the vein of the caudate process or of the papillary process in 31.4%.
- 6) The territory or anatomical segment drained by the right hepatic vein(s) included the dorsal sector of the right lobe (71.4%) and sometimes the medial sector (17.1%) and the intermediate sector (5.7%).
- 7) The caudate process represented a small anatomical segment in 37.1% of the cases, when it was drained by its exclusive vein. This vein received tributaries from the medial, dorsal and intermediate sectors of the right lobe and supraportal portion of the caudate lobe in 51.4%. In a few cases the vein of the caudate process formed a trunk with the right hepatic vein and/or the vein of the papillary process (11.4%). Alone or in conjunction with others the vein of the caudate process terminated into the caudal vena cava.
- 8) Another small anatomical segment was represented by the territory drained exclusively by the vein of the papillary process in 71.4% of the cases. Alone or in conjunction with the vein of the caudate process and/or the right hepatic vein, it ended into the caudal vena cava.
- 9) Minor hepatic veins, opening directly into the caudal vena cava, completed the drainage of the dorsal and medial sectors of the right lobe and the supraportal portion of the caudate lobe.
- 10) In the vast majority of cases there were no large anastomoses between veins of adjacent anatomical segments, limited by avascular or paucivascular areas.
- 11) The venous drainage network was independent and intertwined with the portobilioarterial network.

The venous drainage network included in the majority of cases the following anatomical segments: a) segment of the left hepatic vein (left lobe); b) segment of the middle hepatic vein (quadrate lobe, the supraportal portion of the caudate lobe, the lateral and intermediate sectors of the right lobe); c) segment of the right hepatic vein(s), typically represented by the dorsal sector of the right lobe; d) segment of the vein of the caudate process; e) segment of the vein of the papillary process.

The medial sector of the right lobe is drained by the minor hepatic veins.

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RESUMO: As veias hepáticas e seus setores de drenagem foram estudados em 40 fígados de ovinos. Em 35 órgãos o sistema venoso foi injetado com Neoprene Latex "650" e em seguida dissecado; nos outros 5 órgãos injetou-se acetato de vinyl (cores diferentes) para obtenção de moldes. Foram observados os lobos hepáticos e seus setores de drenagem das seguintes veias hepáticas e suas tributárias: veias hepáticas maiores (veia hepática esquerda, veia hepática média, veia hepática direita, veia hepática do processo caudado e veia hepática do processo papilar) e veias hepáticas menores. As veias hepáticas esquerda e média são os principais vasos de drenagem do sangue do fígado de *Ovis aries*, desembocando independentemente na veia cava caudal. A veia hepática direita termina na veia cava caudal como vaso único em 57,1% dos casos e junta-se à veia hepática do processo caudado ou veia hepática do processo papilar em 31,4% dos casos. A veia hepática direita ocorre em 88,6% dos casos, sendo em número de uma em maior frequência (51,4%), de duas (22,9%) ou de três (14,3%) veias. Em alguns casos a veia hepática do processo caudado forma um tronco com a veia hepática direita e/ou a veia hepática do processo papilar (11,4%). Sozinha ou em conjunto com outras, a veia do processo caudado termina na veia cava caudal. A veia hepática do processo papilar chega independentemente na veia cava caudal em 71,4% dos casos. Sozinha ou em conjunto com a veia hepática do processo caudado e/ou a veia hepática direita, desemboca na veia cava caudal. Veias hepáticas menores, chegam diretamente à veia cava caudal, completando a drenagem dos setores dorsal e medial do lobo direito e da porção supraportal do lobo caudado. Em grande maioria dos casos existem anastomoses entre veias de segmentos

anatomo-cirúrgicos adjacentes, limitados por regiões avasculares ou paucivasculares. A drenagem venosa hepática é formada por vasos independentes mas, interpostos com os vasos integrantes da rede portobiloarterial. A drenagem venosa inclui na maioria dos casos os seguintes anatomo-cirúrgicos: a) segmento da veia hepática esquerda (lobo esquerdo); b) segmento da veia hepática média (lobo quadrado, porção supraportal do lobo caudado e setores intermédio e lateral do lobo direito); c) segmento da veia hepática direita, tipicamente representado pelo setor dorsal do lobo direito; d) segmento da veia hepática do processo caudado; e) segmento da veia hepática do processo papilar. O setor medial do lobo direito é drenado pelas veias hepáticas menores.

UNTERMOS: Anatomia, ovinos; Fígado; Veias

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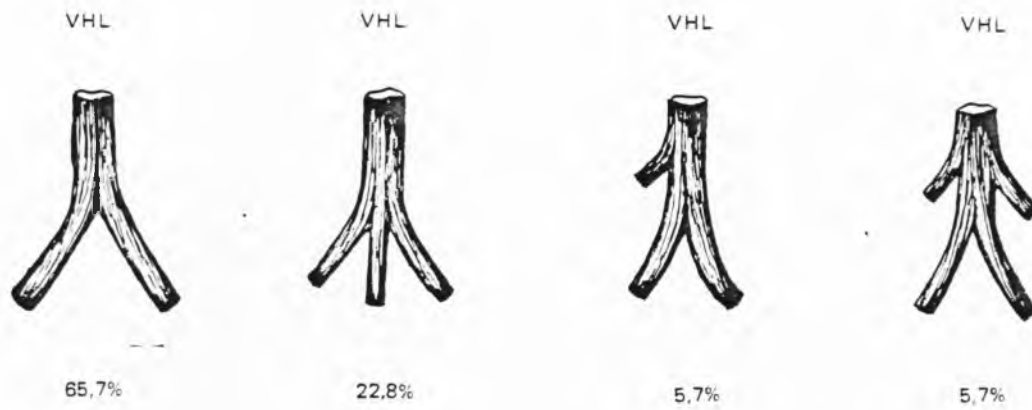


FIGURE 1

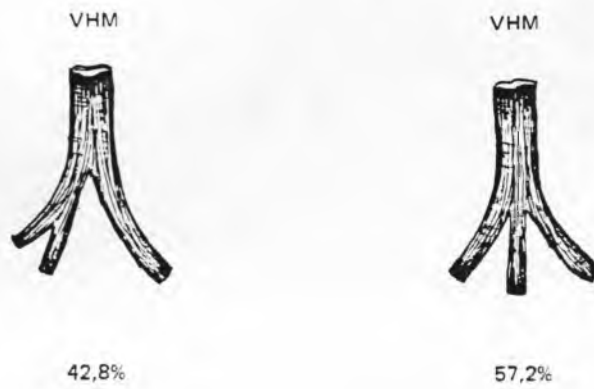


FIGURE 2

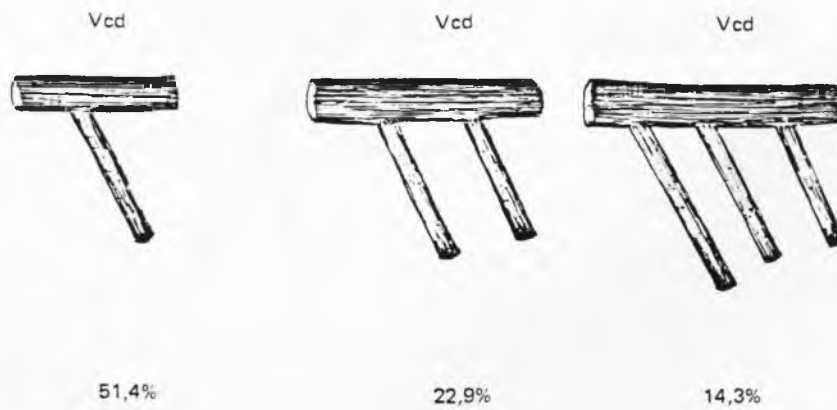


FIGURE 3



FIGURE 4

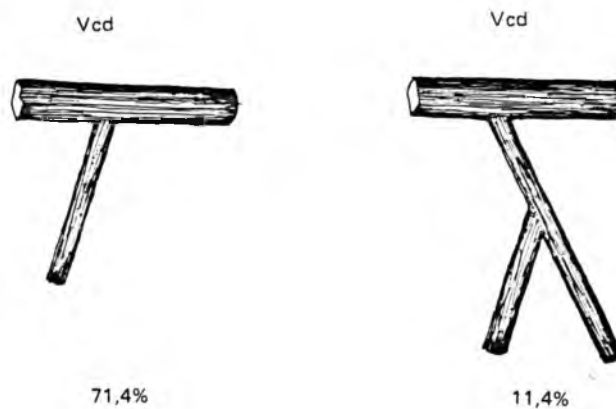


FIGURE 5

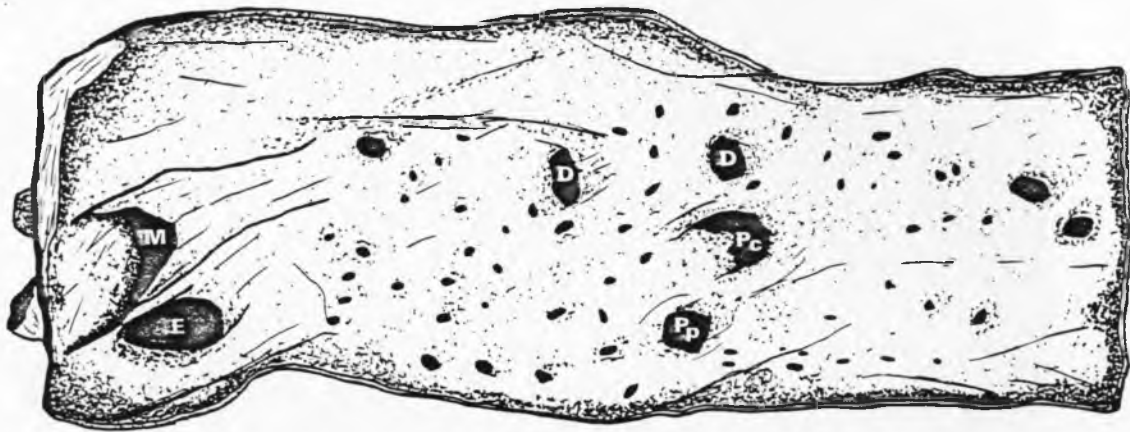


FIGURE 6 — Photograph of the internal surface of a segment of the caudal vena cava of ovine, to show the opening of hepatic veins, that is, the left hepatic vein (E), the middle hepatic vein (M), the right hepatic vein (D), that is, represented, in this case, by two vessels, hepatic veins of the caudate (Pc) and papillary (Pp) processes of the caudate lobe yonder numerous minor hepatic veins.

- E — left hepatic vein
- M — middle hepatic vein
- D — right hepatic vein
- Pc — hepatic vein of the caudate process
- Pp — hepatic vein of the papillary process



FIGURE 7 – Photograph of a partially dissected liver of *Ovis aries* (OBS. 16, male, adult animal), seen from the visceral aspect, to show the injected venous drainage of the hepatic parenchyma. The caudal vena cava (Vcd) receives the left hepatic vein (E), the middle hepatic vein (M) and the veins of the papillary (Pp) and caudate (Pc) processes of the caudate lobe. The ductus venosus (dv) appears joining the distal portion of the left hepatic vein. The anatomicosurgical segments of the left, middle, caudate process and papillary processes appear separated by paucivascular areas or by fissures.

- Vcd – caudal vena cava
- E – left hepatic vein
- M – middle hepatic vein
- D – right hepatic vein
- Pc – hepatic vein of the caudate process
- Pp – hepatic vein of the papillary process
- dv – ductus venosus

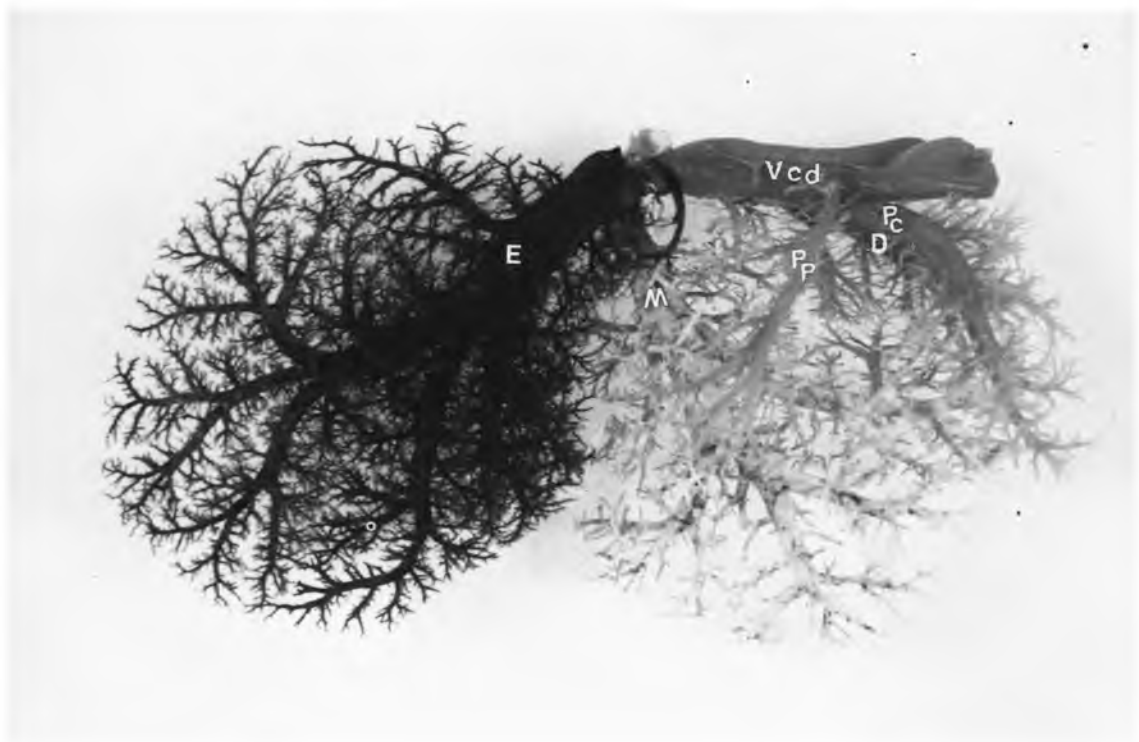


FIGURE 8 – Photograph of a vinyl acetate cast of the hepatic veins and tract of the caudal vena cava of ovine (OBS. 36) seen from the visceral aspect, to show the large vascular, complexes formed by the left hepatic vein (E), and by the middle hepatic vein (M). These segments had the some or different size. In this case predominates the left.

- E – Left hepatic vein
- M – Middle hepatic vein
- Vcd – Caudal vena cava
- D – Right hepatic vein
- Pc – Hepatic vein of the caudate process
- Pp – Hepatic vein of the papillary process